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World Bank
Bangladesh Water Development Board
Ministry of Irrigation, Water Development and Flood Control
Government of the People's Republic of Bangladesh

South East Region
Water Resources Development Programme
BGD/86/037

(FAP 5)

Regional Plan Report
Volume 2
Part 2 - The Regional Water Plan

August, 1993

Sir M MacDonald and Partners Limited, UK
in association with
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Resources Development Consultants Limited
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PART 2 - THE REGIONAL WATER PLAN

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CHAPTER 1

REGIONAL OVERVIEW

1.1 Introduction

Part II of this report aims to define the characteristics of the South-east region (SER) in terms of their relevance to water development planning and to national objectives, to set out the physical, financial, environmental, institutional and other constraints imposing limits to development and to develop a planning strategy for the region. This strategy is then used to develop ranking criteria for identified projects taking into account all the above mentioned constraints and applying a rational system of priorities.

The results of the ranking process are then developed in a formal but flexible plan which allows for simultaneous developments of several projects which can be implemented by stages if necessary.

1.2 Regional Physical and Flood Regime Characteristics

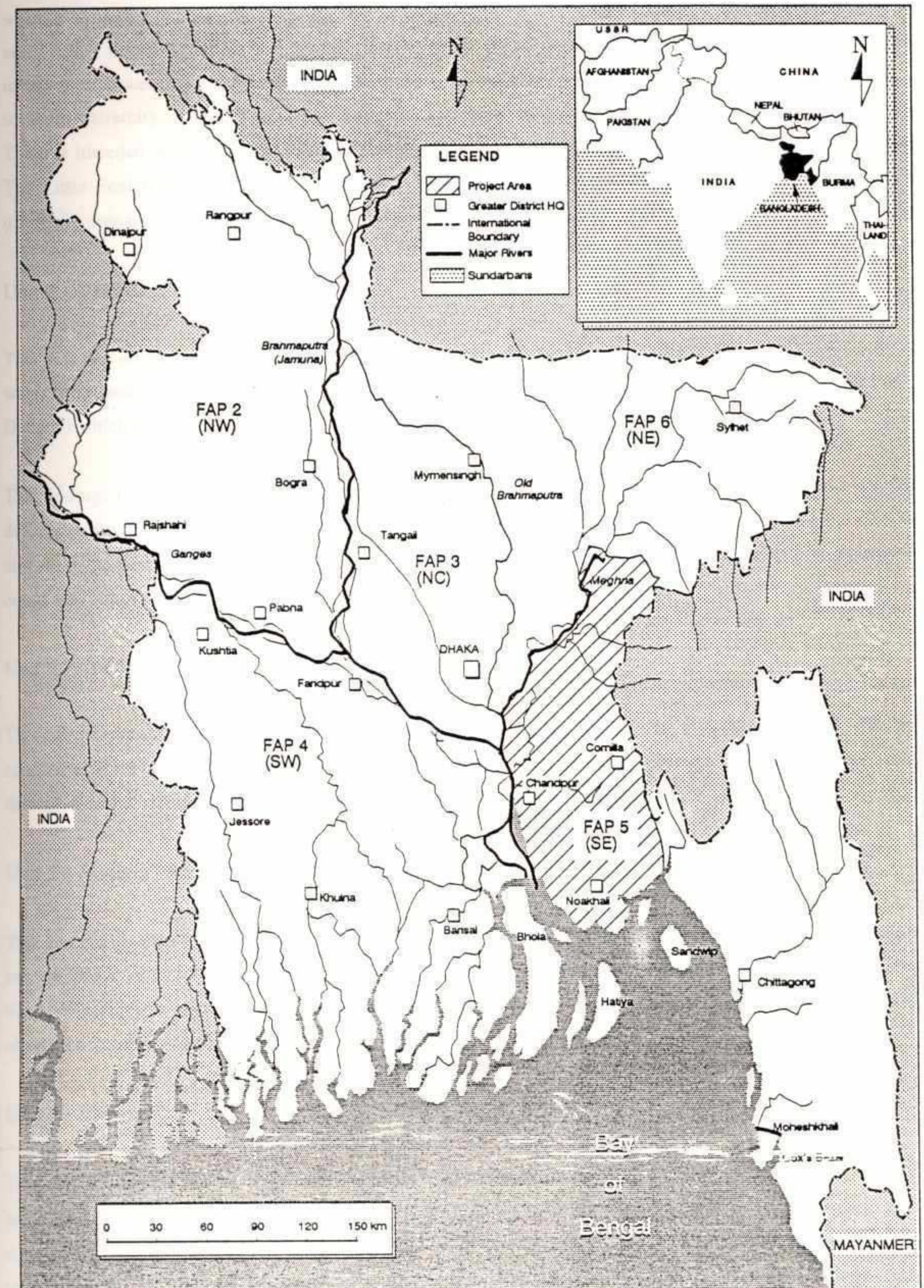
A basic topographic map of the area of the south east region covered by the study is given in Figure 1.1. The south east region lies entirely to the east of all the main river systems of Bangladesh. The region has been divided into sub-regions by considering topographical and water resources factors. In the northern subregion river levels are high in the monsoon season relative to flood plain levels resulting in substantial overbank spillage and prolonged deep flooding (See Figure 1.2). As the river enters the middle subregion the relative levels converge and overbank spillage decreases and eventually virtually ceases except during extreme events. Existing Flood Embankments are continuous and effective from Chandpur to the estuary except for gaps in the embankment of polder 59/2. Upstream of Chandpur the Meghna-Dhonagoda FCDI scheme's embankments have proved problematic and no other major river embankments on the Meghna exist upstream of this scheme. The southern part of the region can be characterised as recently accreted land at the mouth of the Lower Meghna. This sub-region is subject to tidal, cyclone and salinity effects and natural drainage is to the south but is restricted by polder embankments and congested drainage due to sedimentation of estuaries as accretion continues. The middle sub-region suffers medium to deep flooding but, in large part, this is caused by rainfall and run-off from the Tripura hills rather than from over-bank spillage from the Lower Meghna. This land was once coastal but has now been cut-off from the sea and suffers from extended drainage routes which result in worsening flooding conditions. This sub-region now tends to drain westwards into the Lower Meghna.

Upstream of the junction with the Padma the area is bounded to the west by the Meghna river and this northern subregion is severely affected by overbank spillage from the Meghna. Natural drainage is well defined with flashy rivers flowing north west into the River Meghna.

The SER is one of the highest rainfall areas of all the regions in Bangladesh but has only relatively small over-border catchments apart from the Gumti River.

Almost the entire region lies below the 8.0 m contour, the exception being the Lalmai hills to the south west of Comilla, just north of Laksham.

Figure 1.1
South-East Region, Bangladesh



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Unit 4 - Little Feni

This unit forms the eastern boundary of the area from the hills north of Laksham to the Bay of Bengal. The western boundary is a natural ridge but this is cut through by a number of khals. The Little Feni river drains small flashy streams from the Tripura hills and suffers some sediment deposition. This accumulation of material in the river channel is used as building sand by licensed extraction from the river bed of tributaries. The southern extremity of the channel has a regulator to keep out saline water and to facilitate local irrigation. There is impeded drainage to the south of this regulator caused by tidal upwashing of sediments from the Bay. The Little Feni river would form an essential link in the Meghna-Muhuri transfer proposals which were originally prepared in the early 1960s.

Unit 5 - Dakatia

This unit lies in the centre of the region and is drained to the west by the Dakatia river. It receives inflow of water from lands and khals to the north and also some flow from the headreaches of the River Little Feni (Old Dakatia) which sometimes changes direction due to siltation.

The findings of the study mean that the unit is largely discarded as a planning unit for flood control and drainage owing to the results of studies of the Noakhali North area (Unit 3). However the Dakatia river would still form the first part of the Meghna-Muhuri transfer scheme and is therefore an important waterway and it could also supply part of the Noakhali drainage area with irrigation supplies.

Unit 6 - Chandpur Irrigation Scheme

This unit comprises the whole of the Chandpur Irrigation Project which was completed in 1977. The project comprises flood control measures and a mixture of gravity and pumped drainage. Irrigation water supply is through a major pump station abstracting water from the Dakatia River.

Unit 7 - Meghna Dhonagoda Irrigation Project

This unit has also been defined as the entirety of the Meghna Dhonagoda Irrigation Project (MDIP). The project was completed in 1987 and comprises an irrigation system with flood control and pumped drainage. There have been problems with breached embankments (1987 and 1988); the west side of the project area is under threat of erosion from the River Meghna.

Unit 8 - Dhonagoda

This unit is bounded by the Daudkandi/Comilla road to the north where it borders the Gumti Phase I Project area (Unit 10). The western boundary is the River Dhonagoda, the southern boundary was originally the road embankment going west from Chandpur but has now been extended south to the River Dakatia for drainage considerations. The area drains west and south through khal systems linked to the above mentioned rivers.

Unit 9 - Sonaichari

This small unit contains the only substantial hill in the region. The northern boundary is the Gumti river with the Indian border to the east. The area drains to the south and west through the Dakatia and Little Feni rivers. Most of the unit is taken up by the Sonaichari Irrigation Scheme which receives water from the River Gumti but suffers from drainage congestion in part due to siltation of the River Little Feni (Old Dakatia) and the River New Dakatia.

Unit 10 - Gumti I

This unit is currently being developed as an FCD project. The unit lies to the north of the Daudkandi-Comilla road embankment and otherwise is surrounded by new river embankments.

Unit 11 - Gumti II

This unit lies between the River Gumti and the River Titas to the south and north respectively. The eastern boundary is the Indian border and to the west lies the Meghna river. The unit is dissected by a number of substantial rivers. A feasibility study was completed for this unit in 1991. The area suffers substantial overbank flooding from the Meghna and flash floods from the tributaries flowing in from the Tripura Hills.

During the later part of this study a second study of this unit was completed and the result of the new studies are incorporated in this final regional plan.

Unit 12 - Ashuganj

This unit of relatively higher land lies between the River Titas and the River Meghna where it forms a large island which is only slightly flooded during the monsoon season.

Unit 13 - Titas

This unit borders the northeast region (FAP 6) and geographically is similar to the hoar areas of that region and has a number of small streams entering from the Indian catchments to the east. The unit is liable to deep flooding from overbank spillage from the Meghna and Titas rivers.

1.6 National Objectives

The South East Regional Water Plan has to be formulated in the context of the national objectives for development of agriculture and water resources. These objectives as stated in the current Five Year Plan and the principles for the Flood Action Plan, are summarised in this section. The relationship between the current study and the other components of the Flood Action Plan are also described.

1.6.1 Fourth Five Year Plan (FFYP)

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 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 Plan is a comprehensive document, which outlines objectives and strategies for each economic sector. The objectives defined for agriculture, flood control and water resources development are summarised below.

Agriculture

Objectives for the agricultural sector are as follows:

- 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, in order 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.

To achieve these objectives, a strategy is being implemented which emphasises increased efficiency in resource use in order to achieve higher growth rates with less capital investment. The strategy includes the following elements:

- 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 to generate 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.

Flood Control and Water Resources

Plan (FFYP) objectives for flood control and water resources are:

- Rapid increase of irrigated areas to sustain technological transformation.
- Provision of supplementary irrigation facilities, with complementary flood control and drainage measures and in consonance with other resources, in order 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.

The main elements of the strategy defined in the Plan are to:

- 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.

1.6.2 Objectives of the Flood Action Plan

The Regional Water Plan (RWP) is also required to follow the eleven guiding principles of the Flood Action Plan (FAP) which both extend and reinforce the objectives of the Fourth Five Year Plan. These principles are set out below:

1. Phased implementation of a comprehensive Flood Plan aimed at:

   - protecting rural infrastructure;
   - controlling flooding to meet the needs of agriculture, fisheries, navigation, urban flushing and annual recharge of surface and groundwater resources.

2. Effective land and water management in protected and unprotected areas.

3. Measures to strengthen flood preparedness and disaster management.

4. Improvement of flood forecasting and early warning.

5. Safe conveyance of the large cross border flows to the Bay of Bengal by channelling through the major rivers with the help of embankments on both sides.

6. River training to protect embankments and urban centres.

7. Reduction of flood flows in the major rivers by diversion into major distributaries and flood relief channels.

8. Channel improvements and structures to ensure efficient drainage and to promote conservation and regulation.

9. Flood plain zoning where feasible and appropriate.

10. Coordinated planning and construction of all rural roads, highways and railway embankments with provision for unimpeded drainage.

11. Encourage popular support by involving beneficiaries in the planning, design and operation of flood control and drainage works.

1.7 Relationship between the South-East Regional Study and other FAP Studies

The South-East Regional Study (SERS) is not directly physically affected to any serious degree by most of the other regional studies. (FAP 2, 3, 4 and 6). According to FAP 25 full embanking of all upstream main rivers would only raise peak water levels at Chandpur by 0.06 m which is not significant in terms of embankment design or flood depths.

However FAP 6 could affect the early monsoon levels in the Upper Meghna but no information will be available on this before completion of FAP 5.

FAP studies of direct relevance to the SERS include:

-	FAP 7, Cyclone Protection Project	Units 1,2 and 4
-	FAP 9B, Meghna Left Bank (LB) Protection Project	Units 6,7 and 11
-	FAP 10, Flood forecasting and Early Warning	Units 8,10,11 and 13.

All the other FAP studies 11 through 26 have implications for all SERS units. It is unfortunate that many of the following components reported too late to be of direct benefit to this study:

FAP 11 Disaster Preparedness
FAP 17 Fisheries Study and Pilot Project
FAP 18 Topographic Mapping
FAP 19 Geographic Information System
FAP 20 Compartmentalisation Pilot Project
FAP 21/22 Bank Protection and Active Flood Plain Management Pilot Project
FAP 23 Flood Proofing Pilot Project
FAP 24 River Survey Programme
FAP 26 Institutional Development Programme

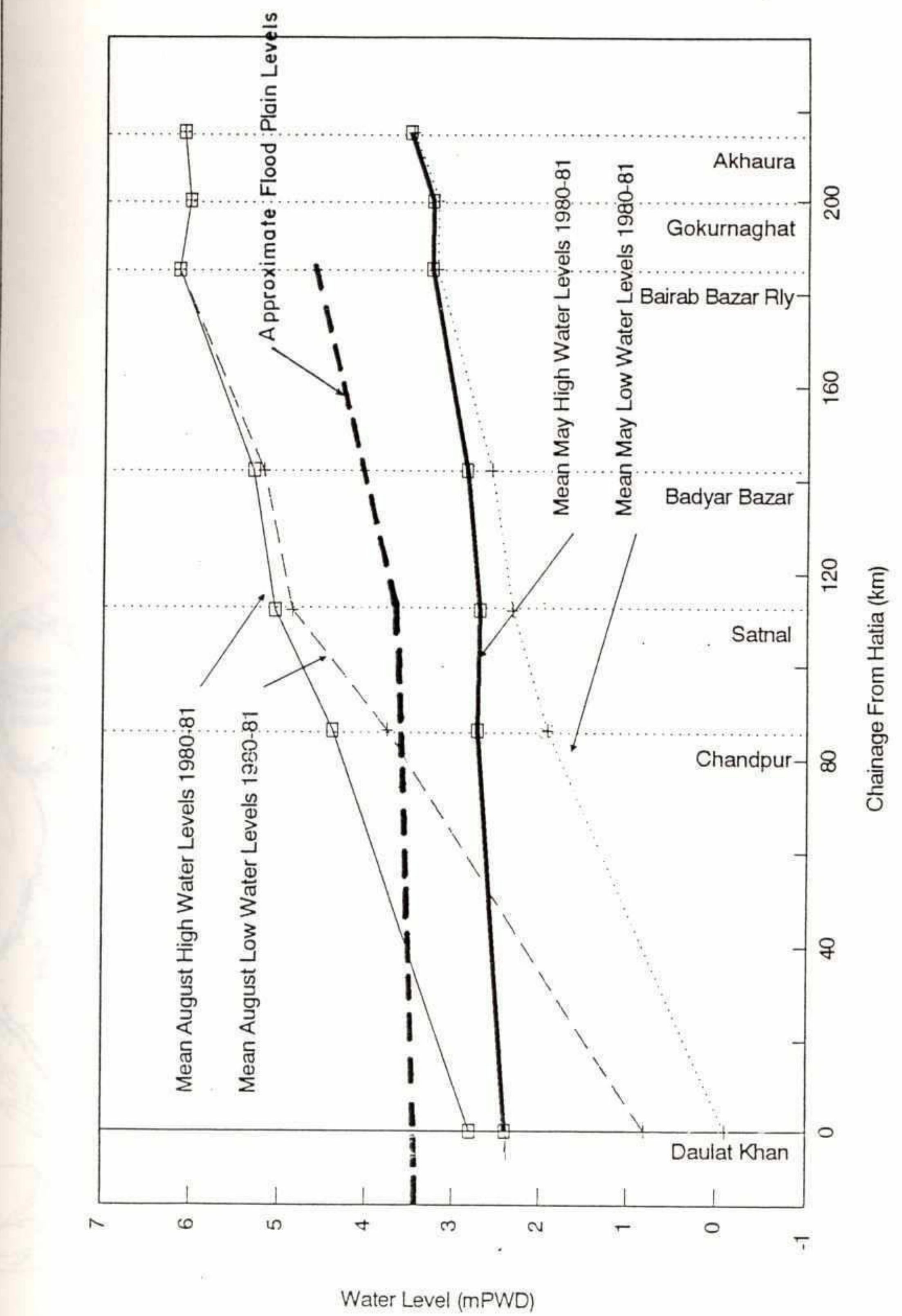
The most critical are FAP 17 (Fisheries Study) and 18 (Topographic Mapping) since they have affected the approach to the feasibility study for the SERS.

Nonetheless, some of the studies have provided considerable useful findings which can be integrated into the study, this particularly relates to

FAP 12 Flood Control Drainage and Irrigation Agricultural Review
and FAP 13 Operation and Maintenance Study.

Other information has been obtained from FAP 14 (Flood Response Study), FAP 16 (Environmental Study), FAP 15 (Land Acquisition and Resettlement Study). The results, even if initial, from these studies will be more relevant to the Feasibility Study when specific development recommendations are being put forward.

Figure 1.2
Meghna Water Surface Profiles



Source: **SERWRDP**

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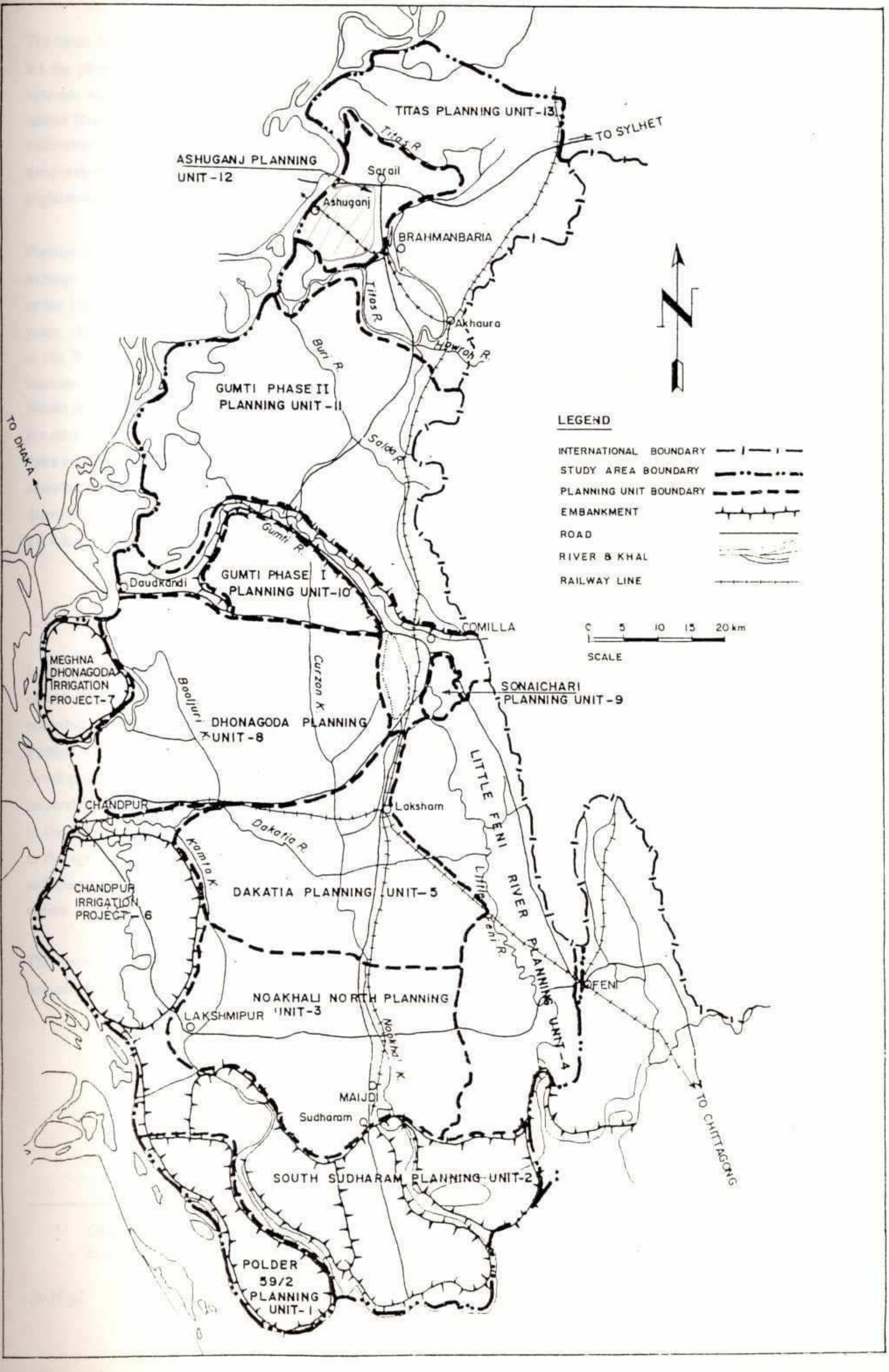
Figure 1.3
Planning Units



1.3 Demography and Socio-Economics

The main socio-economic issues facing the region in the medium - to long-term provide the economic context for the proposed water resources development programme. The most pressing issue is the need to improve incomes and living standards, and simultaneously to create new job opportunities for the rapidly expanding labour force. Present living standards in the region are exceptionally low. Population pressure on the available cultivable land is extreme, and is growing; this has increased the incidence of landlessness and has led to the marginalisation of a growing proportion of the population. Information on cultivated and irrigated areas and population by Planning Unit in 1991 has been summarised in Table **1.1** for ease of reference.

Population density in the region like much of Bangladesh, is already one of the highest in the world, at an average of about 1 500 persons per square kilometre of cultivated land (equivalent to 15 persons per hectare, or six per acre). Although the rate of natural increase of the population is expected to decline over the next 35 years, the population is still forecast to grow by 28% in the 15 years from 1990 to 2005 and by a further 31% in the 20 years from 2005-2025. Population density per unit area of cultivated land is therefore projected to increase by 68%, to nearly 2 600 persons per sq km by the year 2025. The calculation of these estimates is shown in Table **1.2**. No allowance has been made in the projections either for out-migration from the area, or for intra-regional migration. There has been net out-migration from the region over the past two decades, but there are obvious limits to the extent to which excess labour supply in the south-east can continue to be absorbed elsewhere in Bangladesh. Similarly, the scope for significant intra-regional migration is limited: population densities are uniformly high in the region, other than in the southern parts of the area (Planning Units 1 and 2), which suffer from less favourable soils and saline groundwater resources.

1.4 Agriculture

Improvements in agricultural productivity will hold the key, for the foreseeable future, to meeting the twin objectives of income growth and the creation of productive employment opportunities in the region. The present contribution to output and employment of productive economic sectors other than agriculture is very limited. Further, the prospects for significant growth in the non-agricultural sectors are largely contingent on development within agriculture: industrial production in the region is concentrated in agro-processing industries; mineral or other non-agricultural natural resources are minimal [1]; and the large and growing services sector in the region is heavily dependent, directly or indirectly, on the agricultural sector. Without sustained growth in the agricultural sector, in other words, there is very little likelihood of the other economic sectors growing sufficiently either to absorb the increasing labour force, or to improve the level of average incomes in the region.

The basic agricultural characteristics of the area in terms of the areas of cultivated and irrigated land is presented in Table 1.1 and 1.2.

---

1 Other than natural gas, the income from which accrues directly to the national government and which creates few jobs locally.

TABLE 1.1

Cultivated Area, Irrigated Area and Population, by Planning Unit, 1990

	Planning Unit	Net Cultivated Area (hectares)	Net Cultivated Area (Share) (%)	Irrigated Area (hectares)	Irrigated Area (Share) (%)	Population 1991 ('000)	Population 1991 (Share) (%)
1	Polder 59/2	26 469	3.4	0	0.0	252	2.1
2	South Sudharam	89 636	11.5	1 594	0.6	847	7.1
3	Noakhali North	74 526	9.6	25 833	9.0	1 329	11.1
4	Little Feni River	77 901	10.0	18 839	6.6	1 180	9.8
5	Dakatia	68 507	8.8	22 946	8.0	1 069	8.9
6	Chandpur	39 750	5.1	23 132	8.1	806	6.7
7	Meghna Dhonagoda	13 440	1.7	13 440	4.7	257	2.1
8	Dhonagoda	88 065	11.3	31 026	10.8	1 579	13.2
9	Sonaichari	15 944	2.1	9 757	3.4	371	3.1
10	Gumti Phase I	26 139	3.4	8 500	3.0	447	3.7
11	Gumti Phase II	122 172	15.7	60 980	21.3	2 020	16.8
12	Ashuganj	25 919	3.3	14 766	5.2	371	3.1
13	Titas	89 979	11.6	47 988	16.8	1 035	8.6
	Sub-total	758 447	97.6	278 801	97.5	11 563	96.4
	Other misc. Area	18 216	2.4	7 249	2.5	438	3.6
	Total Study Area	776 663	100.0	286 050	100.0	12 001	100.0

Source: Areas from Consultants Estimates
Population derived from 1991 Census Report,

TABLE 1.2

Population Per Sq Km of Gross And Net Cultivated Area, 1990-2025

	Planning Unit	Gross Area (hectares)	Net Cultivated Area (hectares)	Population 1991 ('000)	Population 2005 proj. ('000)	Population 2025 proj. ('000)	Population (000 per sq km) 1991 Gross	1991 Net	2005 Gross	2005 Net	2025 Gross	2025 Net
1	Polder 59/2	30 848	26 469	252	323	424	0.8	1.0	1.0	1.2	1.4	1.6
2	South Sudharam	110 046	89 636	847	1 085	1 426	0.8	0.9	1.0	1.2	1.3	1.6
3	Noakhali North	99 535	74 526	1329	1 703	2 237	1.3	1.8	1.7	2.3	2.2	3.0
4	Little Feni River	97 362	77 901	1180	1 512	1 986	1.2	1.5	1.6	1.9	2.0	2.5
5	Dakatia	86 108	68 507	1069	1 370	1 800	1.2	1.6	1.6	2.0	2.1	2.6
6	Chandpur	52 398	39 750	806	1 033	1 357	1.5	2.0	2.0	2.6	2.6	3.4
7	Meghna Dhonagoda	16 189	13 440	257	329	433	1.6	1.9	2.0	2.5	2.7	3.2
8	Dhonagoda	112 405	88 065	1579	2 023	2 658	1.4	1.8	1.8	2.3	2.4	3.0
9	Sonaichari	19 165	15 944	371	475	625	1.9	2.3	2.5	3.0	3.3	3.9
10	Gumti Phase I	31 486	26 139	447	573	752	1.4	1.7	1.8	2.2	2.4	2.9
11	Gumti Phase II	140 854	122 172	2020	2 588	3 400	1.4	1.7	1.8	2.1	2.4	2.8
12	Ashuganj	28 913	25 919	371	475	625	1.3	1.4	1.6	1.8	2.2	2.4
13	Titas	101 510	89 979	1035	1 326	1 742	1.0	1.2	1.3	1.5	1.7	1.9
	Sub-total	926 819	758 447	11 563	14 817	19 465	1.2	1.5	1.6	2.0	2.1	2.6
	Other misc. Areas	28 094	18 216	438	561	737	1.6	2.4	2.0	3.1	2.6	4.0
	Total Study Area	954 913	776 663	12 001	15 378	20 202	1.3	1.5	1.6	2.0	2.1	2.6

Source: NCA from Consultants Estimates
Population derived from 1991 Census Report, assuming 2.01% linear growth rate (1991 Census Report, page 4).

1.5 Planning Units

The choice of planning units is based on the regional sub-divisions described in the previous section but, in addition, the following three factors were taken into account.

- For a water plan it is logical that the unit boundaries are water related rather than being based on administrative districts, such boundaries include rivers and catchment divides.
- Boundaries are also created where embankments of existing roads and railways form logical divides.
- Existing project boundaries have been used where appropriate.

Figure 1.3 illustrates the division of the region into planning units and an outline description of each of the planning units is given below. More detailed descriptions are given in Chapter 5 of those units where development interventions have been considered.

Unit 1 - Polder 59/2

This unit is for the most part surrounded by embankments and is bounded by the Lower Meghna to the west and south, Baggar Dona to the east and the poorly drained lands of Noakhali to the north. The unit comprises recently deposited silts carried by the Lower Meghna. The area is subject to periodic cyclone damage, saline intrusion through the uncompleted embankments, particularly during the monsoon season, and tidal surges.

Unit 2 - South Sudharam

This area has similar characteristics to Unit 1 but is divided into a number of polders and is not entirely closed to the sea at the present time.

Unit 3 - Noakhali North

This unit is to the north of the poldered units 1 and 2 and in the past excess water drained through the Noakhali Khal to the sea when the area was coastal. This drainage is now impeded and the area around Begumganj suffers severe drainage problems. The remainder of the area drains to the west through the Rahmatkhali regulator into the Lower Meghna. This regulator is subject to pronounced tidal effects but is upstream of saline influence throughout the year. The drainage of this unit is interlinked, by khals, with unit 4 to the east and unit 5 to the north. The northern boundary was taken as a road embankment. However during the study a large part of Unit 5 was found to be under the influence of proposals for Unit 3. The unit does not appear to suffer from overbank spillage from the Lower Meghna at its upstream limit and this is due to the restricted access for flood flows between the Chandpur-Laksham road and the northern boundary of the Chandpur Irrigation Scheme.

CHAPTER 2

REGIONAL STRATEGY

2.1 Introduction

The development of the region's water resources unit must be arranged to serve the principal needs of the local population. The present and likely future development of the Southeast region will be dominated by the agricultural sector. There is virtually no water consuming industry in the region and therefore the primary requirements for water use are for domestic supply and for irrigated agriculture. It is considered unlikely that large water consuming industries are likely to be developed in the region during the plan period.

The present situation in the region is similar to that of all regions of Bangladesh with an over abundance of water during the monsoon season and severe shortages in the dry season. There are no opportunities for seasonal storage in any significant quantities except for groundwater. Thus all potential future development must involve improved water management through flood control, drainage and irrigation. Also all future water utilisation will require pumping of surface or groundwater resources since gravity supplies during the dry season are generally impossible due to the low river levels. Adequate domestic water supplies are the first priority requirement and all calculations for water availability for agriculture must allow for such supplies.

Development of the region's agricultural sector faces a number of specific constraints. Critical constraints at present include:

- the extreme scarcity of undeveloped cultivable land
- flooding
- limited irrigation water availability, and
- scarcity of public and private sector financial resources either for investment or for operation and maintenance of flood control facilities.

Deficiencies in the physical infrastructure and weaknesses in the systems of agricultural credit provision and other support services are further, but less intractable, problems affecting the sector.

Productivity improvements in agriculture will depend essentially on:

- land enhancement through appropriate flood control and drainage schemes, and increases in irrigated areas; the latter generally yielding the best returns to investment.
- increases in crop yields as a result of improved crop varieties and cultivation practices, and higher levels of inputs.

Together, appropriate land enhancement schemes and increases in irrigated areas should lead to further increases in cropping intensities, and the concomitant substitution of high yielding crop varieties for the lower-yielding, traditional varieties. This should increase aggregate agricultural output and output per unit input of land, water and capital. Aggregate farm incomes and employment will therefore increase, with multiplier effects in agro-processing, marketing and other related activities.

For reasons discussed later in this chapter there is virtually no scope for further surface irrigation development in the region without public sector involvement. However, there is scope to increase the irrigated areas on the basis of private sector investment in groundwater resources. At present, nearly 8% of the region's cultivated area is irrigated. In the absence of any additions to the utilisable surface water resources, the irrigated area has been forecast to increase by about one fifth in the period 1992 to 2012 to over 44% of the cultivated area. The remaining scope for increased groundwater development is limited owing to possible difficulties in achieving the full potential to force mode wells (see section 2.3.4). The estimates are shown in Table 2.1 and are based on the consultants estimates of groundwater potential (net of water supply requirements). The increase in the area developed represents an annual rate of increase of just over 3% in the present total of groundwater development. This is less than has been achieved recently but is based on the assumption that force mode wells which form most of the potential in this region will prove more difficult to develop for social and financial reasons. (See section 2.3.1 and 2.3.4b).

TABLE 2.1

Growth of Irrigated Areas, Without Planned Public Sector Interventions, 1990-2012

Planning Unit	Net Cultivated Area (ha)	Irrigated Area 1991 est. (ha)	Irrigated Area 1991 est. per cent of NCA	Irrigated Area 2012 proj. (ha)	Irrigated Area 2012 proj. per cent of NCA
1. Polder 59/2	26 469	0	0	0	0
2. South Sudharam	89 636	1 594	1.8	1 594	1.8
3. Noakhali North	74 526	25 833	34.7	30 000	40.3
4. Little Feni River	77 701	18 839	24.2	31 000	39.8
5. Dakatia	68 507	22 946	33.5	25 000	36.5
6. Chandpur	39 750	23 132	58.2	23 132	58.2
7. Meghna Dhonagoda	13 440	13 440	100.0	13 440	100.0
8. Dhonagoda	88 065	31 026	35.2	35 000	39.7
9. Sonaichari	15 944	9 757	61.2	10 000	62.7
10. Gumti Phase I	26 139	8 500	32.5	12 500	47.8
11. Gumti Phase II	122 172	60 980	49.9	83 000	67.9
12. Ashuganj	25 919	14 766	57.0	14 767	57.0
13. Titas	89 979	47 988	53.3	57 500	63.9
Sub-Total	758 447	278 801	37.7	336 933	44.4
Other misc areas	18 216	7 249	39.8	7 249	39.8
Total Study Area	**776 663**	**286 050**	**37.8**	**344 362**	**44.3**

Source: Consultants' estimates (1991 irrigation areas estimated from 1989 Spot imagery and 1991 AST data with adjustments.

Note: Irrigation in other misc. areas assumed constant at 1991 level

The first component of the proposed strategy for development of the region's water resources comprises improvements to land productivity, through the implementation of cost-effective flood control and drainage schemes. This will improve the productivity and profitability of both irrigated and rained agriculture. The second, related component, is the optimal development of irrigated areas through the provision of surface water-where economically viable - to supplement available non-saline groundwater resources.

Any public sector investment programme for flood control and irrigation must take into account the realities of Bangladesh's financial and organisational situation. The resources available for public sector investment are limited in relation to the scale of the country's overall requirements. It is therefore essential that investments be limited to those programmes which merit the highest priority in terms of economic returns per unit of capital invested. The scale of any proposed public sector investment programme must take into account the limited implementation and management capacity of the concerned authorities, and the recurring problems of inadequate funding for the operation and maintenance of public sector facilities.

The success of the proposed development strategy will, of course, depend crucially on the maintenance of a national agricultural policy framework which is conducive to productive investment in agriculture. In particular, continuation of the recently instituted process of deregulation and privatisation of the distribution and marketing of agricultural inputs (notably, irrigation equipment and fertiliser) will be essential to optimise growth in the agricultural sector. Maximisation of agricultural productivity will also require continued efforts to improve the effectiveness of the agricultural extension services, and an overhaul of the rural credit system; these are essentially national issues which fall outside the scope of the present study.

The strategy must also take into account the impacts of water resources development for the agricultural sector on other economic sectors, and the social and environmental implications of potential development options. In the case of FCD/FCDI schemes, the most critical impact outside agriculture is likely to be on the fisheries sector. Capture fisheries will be, usually negatively, affected by the implementation of any new flood control measures, whereas the development of aquaculture could yield substantial benefits.

The following sections of this chapter describe the constraints in greater detail and set out the principal water development options on a regional and sub-regional basis.

2.2 Constraints to Development

2.2.1 Information Deficiencies

As described in the Interim Report there are substantial gaps in data in several disciplines. The most notable of these include:

- capture fisheries
- the environment (including ecology)
- income distribution
- non-agricultural flood damage

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In addition to the absence of data in these critical areas, there is room for considerable scepticism concerning the accuracy of some data. This has led to the consultants ignoring data where it appears inconsistent and unreliable. This has affected almost all areas of study including such basic data as ground levels and water levels. However the data selected for use has been checked, as far as possible at this stage of planning and before feasibility studies. This final report has also taken into account information obtained during the Gumti II and Noakhali North Feasibility studies (1993) including primary data.

Although data availability is not a direct constraint to development it is certainly a constraint to development planning and may severely delay implementation of projects. Such projects cannot proceed until adequate data is available on which to make sensible development decisions through properly researched feasibility studies and designs. Bearing in mind the additional requirements now being demanded by donors and by FPCO especially in terms of people's participation fisheries and environmental concerns such studies will require correspondingly increased resources.

2.2.2 Availability of Public Sector Finance for Water Resources Investment.

Public sector expenditure on water resources programmes in Bangladesh during 1990/91 was estimated at approximately Tk 5 000 million. A recent World Bank review ('Bangladesh Managing Public Resources for Higher Growth', April 1991) indicated that by the end of the current Five Year Plan, public sector expenditure on water resources programmes could be running at the level of Tk 6 000-7 000 million per year, in terms of 1990/91 prices, or 20-40 per cent higher (in real terms) than during 1990/91. Of the total forecast expenditure by the end of the Plan period, some Tk 1500 million might be required for maintenance, and the balance (Tk 4 500-5 500 million) could be available to finance new investment projects: primarily, those projects identified as priorities in the Flood Action Plan studies.

The actual 1991/92 budget for investment projects in the water resources sector has been set at Tk 6500 million, of which the local currency component accounts for Tk 5 500 million and foreign exchange components for Tk 1 000 million. Allowing for price inflation and for possible underspending on the allocation, this level of expenditure is more or less in line with that indicated in the World Bank study.

These figures indicate that public sector investments in the water resources sector by the mid-1990s may be running at a level of about Tk 5000-6000 million per year (in 1991 prices). Based on external financing agencies' past and current attitudes towards Bangladesh's requirements, it is reasonable to assume that external resources would be made available in an amount adequate to meet this overall level of expenditure.

One of the objectives of the overall Flood Action Plan programme is to enable choices to be made between competing water resources development projects and programmes for different parts of Bangladesh, in accordance with their relative technical and economic viability. Until such time as the project pre-feasibility studies for other regions are complete, it is impossible to judge the priority which should be attached to projects in the south-east region, relative to competing projects elsewhere. Nor is it possible to judge the adequacy of the overall financial budget for water resources development which has been previously estimated (see above).

However, for the purposes of this study it is necessary to make an estimate of the likely scale of finance which might be available for projects in the south-east region, for comparison with the possible requirements for particular projects, or groups of projects. Other things being equal, it would be reasonable to suppose that the region's share of the total national budget for water resources development might be roughly equivalent to its share of either the total national cultivated area or national population, i.e, about 11-12 per cent. This would indicate a level of expenditure of about Tk 550-600 million (US$ 15-16 million) per year (1991 prices) from about 1994 onwards. As has been pointed out, this estimate is necessarily arbitrary.

2.2.3 Environmental Factors

As described in Annex IV and in Chapter 3 of this report there are many critical aspects where the data available is inadequate to enable a full Environmental Impact Assessment (EIA). However the Initial Environmental Evaluation (IEE) and the Environmental Annex have identified a large number of aspects which could be critical for any proposed scheme. The single most important message of the evaluation to date is that any proposals for future development must be approached with the utmost caution and that at the feasibility stage every effort must be made to ensure that a realistic programme of data collection and analysis is undertaken to allow future project designs to include effective mitigation and enhancement measures in a cost effective manner.

The IEE and Annex IV have deliberately adopted an approach which seeks to identify potentially negative impacts both for the natural resource environment and for the socio-economic environment. This is entirely reasonable given both the inadequacy of data available and the multiple undesirable effects which have occurred in many existing schemes, whilst acknowledging their substantial benefits.

The later chapters of this report attempt to identify for each suggested development in each planning unit the principal environmental concerns which need to be considered at the feasibility stage. However there are a number of identified potentially negative environmental impacts which can be universally connected with all the identified projects in the region.

These aspects include:

- Habitat and biodiversity
- Aquatic and terrestrial ecology
- Energy and chemical flows
- Fisheries
- Agricultural systems
- Survival strategies
- Public health
- Local participation.

Many of these aspects are interdependent and there are no projects of any kind, structural or non-structural which do not involve trade offs amongst these aspects.

The original Terms of Reference for this study did not require a full EIA either at the regional plan stage or the feasibility study stage and the environment related inputs were not intended to provide such. It is also to be noted that the environmental guidelines issued by the FPCO were not available in time for any adjustment to be made to the scope of the regional planning study. In the draft regional plan report suggestions were made as to how some of the aims of the guidelines might be achieved by provision of additional inputs some of which were later agreed to. However, as indicated in Annex IV there was insufficient data and insufficient time available to allow the undertaking of an EIA meeting the recommended standards for the feasibility studies. It is essential that the FPCO and the donors agree on a way forward which allows consultant's a chance of meeting mutually acceptable targets for each project.

Of those impacts mentioned above the most critical effects are likely to be felt in terms of the fisheries (capture) and the survival strategies of disadvantaged groups. The potential damage to capture fisheries has been identified as having the largest single directly negative impact in economic terms and could be brought about directly as a result of physical changes to water systems or indirectly through consequential actions by farmers through increased application of agrochemicals.

2.2.4 Physical Factors

There are physical constraints particular to each of the 13 planning units and these are described in later chapters. However in general terms they can be described as follows:

- Climate
- Water Resources
- Topography
- Drainage
- Flooding

(a) Climate

This is discussed in more detail in Chapter 2 of Part 1 of this report and in Annex VI. All planning units receive heavy rainfall in the monsoon period from May to September. The coastal parts of the region (units 1,2 and the Southern Part of unit 4) are subject to the effects of cyclones principally in the months of April, May and September / October.

Rainfalls in the months from October through to April are much lighter and more unpredictable and from November to March the one in five dry year effective rainfall is nil when considered on a decad basis.

Temperatures during the monsoon period are hot with relatively low diurnal variation however during the dry season temperatures are much more variable and low night time temperatures in the months of December to February places a constraint on the planting and/ or the development of the Boro rice crop. This is the principal reason why the highest irrigation demand occurs in March.

(b) Water Resources

The principal physical constraint to water resources development in the south east region is the limited amount of surface water available to the region for future development of irrigation. Indeed almost the whole of the internal surface water resource is fully developed and any increase in surface irrigation will have to come from the Meghna. Any further development in usage of existing pockets of stored water is likely to be at the expense of other existing users. There is evidence from the surveys undertaken for the Gumti II and Nokahlali Feasibility Studies that this is already a problem for some LLP users. This shortage of water is limited to the dry season particularly the later part (February to April) when the potential requirement for irrigation is at its maximum and available supply of surface water is at its minimum. The critical month for planning purposes is March and the National Water Plan Phase II allocated 204 m^3/s of Meghna water for the region. For planning purposes it is necessary to consider the maximum long term potential for irrigation development in the region and then to compare this requirement with the resources available and the existing requirements. The estimated total requirements assume no increase in existing cultivated areas and also assume that at full development a maximum of 75% of this area might be irrigated. This figure allows for areas continuing to grow non-irrigated crops and for increases in areas of homesteads, orchards and other infrastructure. The figures also assume net irrigation demand of 1.25 l/s/ha in the critical month of March. Table 2.2 shows the areas and potential water requirements for each planning unit. It is worth noting that 95 750 ha are irrigated from groundwater which is 33% of the total irrigated area and 16% of the potential irrigated area; the groundwater potential is also 36% of the total irrigation potential.

Although the potential water requirement estimates are the maximum gross potentials it will become clear that, even when only the realistically estimated projects which might be developed within the plan period are considered there will still be a deficit when the net future surface water requirements are compared with the presently allocated water requirements under the National Water Plan Phase II. (See Chapter 6).

For the above reasons the consultants have assumed that in most areas where exploitable groundwater exists its development should be encouraged and for planning the surface water requirement full groundwater development has been assumed to take place during the planning period unless there are other constraints to groundwater development.

(c) Topography

Almost the entire region is very low lying and flat. The very slight slopes which do exist are generally from east to west and from north to south. The overall situation can be described as follows:

Latitude	Level in West (Meghna) (masl)	Level in East (Indian Border) (masl)
24° 00' N	4	12
23° 45' N	3	6
23° 30' N	3	7
23° 15' N	3	6
23° 00' N	3	5
22° 45' N	3	4

TABLE 2.2

Potential Water Resources Demands for Irrigation Development (March)

Ref No	Unit (4)	Present Irrigation area			Maximum Potential Irrigated Area	Potential Area Irrigable by Ground water (ha)	Balance needing surface water Irrigation (ha)	Present Surface water Requirement $m_3/6$	Maximu Potenti Surfa Wate Requir ment $m^3/6$
		Total (ha)	Ground water (ha)	Surface (ha)	Total 75% of NCA (ha)				
1	Polder 59/2	0	0	0	19 852	0	19 852	0	25
2	South Sudharam	1 594	36	1 558	67 227	36	67 161	2 *	84
3	Noakhali North	25 833	1 727	24 106	55 894	5 500	50 394	30 +	63
4	Little Feni River	18 839	9 410	9 429	58 426	25 883	32 543	12 *	41
5	Dakatia	22 946	7 903	15 043	51 380	13 750	37 630	19 +	47
6	Chandpur	23 132	219	22 913	29 812	219	29 593	29	37
7	Meghna Dhonagoda (1)	13 440	0	13 440	13 440	0	13 440	17	17
8	Dhonagoda	31 026	14 635	16 391	66 049	25 873	40 176	20 *	50
9	Sonaichari	9 757	8 022	1 735	11 958	9 000	2 958	2 *	4
10	Gumti Phase I	8 500	4 666	3 834	19 604	8 483	11 121	5 +	14
11	Gumti Phase II	60 980	26 317	34 663	91 629	83 000	8 629	43 +	43
12	Ashuganj	14 767	5 108	9 659	19 349	11 354	7 995	12	10
13	Titas	47 987	16 611	31 376	67 484	32 883	34 651	39	48
	Other areas (2)	7 249	1 097	6 152	13 662	1 097	13 116	8	16
	Muhuri transfer (3)				14 950		14 950	0	13
		286 050	95 751	190 299	600 716	217 028	383 688	238 +	513

Notes: (1) Potential area not based on 7% of NCA

(2) Areas near Meghna river

(3) Outside South-east Region and includes part of Muhuri Irrigation and Chittagong North Projects

* Denotes water from local resources

\+ Denotes water partially from local resources

Sources: Consultants estimates, based upon 1989 SPOT imagery, interpretation, AST 1991 data adjusted and ground water potential studies.

Natural ground levels adjacent to the Meghna river vary hardly at all over a total river length of more than 150 Km. This produces the generalised flood regime outlined in Chapter 1 and discussed in the later sections of this chapter.

The northern part of the region is dissected by a number of rivers which carry waters form the hills above the Indian border to the Meghna. These rivers flow in well defined channels but are very flashy and carry substantial quantities of sediment.

These conditions are a severe constraint to both irrigation and drainage development. Gravity irrigation over substantial areas is impossible because of the combination of dry local rivers, low levels in the Meghna during the dry season and very flat gradients .

(d) Drainage

The main drainage pattern in the northern part of the area is from east to west but river migration of the Meghna and the Titas has caused difficulties for the planning of drainage schemes in this part of the region.

Further south the drainage was to the south in the Little Feni river and the Noakhali Khal. However over the last 50 years accretion of land in the estuary has lengthened drainage routes causing congestion and prolonged flooding in some localities. Some efforts have already been made to alleviate this situation by the construction of the Rahmatkhali regulator some 20 years ago. In the south, drainage is generally a more severe constraint to development than river flooding.

(e) Flooding

As already described in Chapter 1 a large proportion of the south east region is subject to seasonal flooding but the timing and duration of floods have different origins in the various parts of the region. These are discussed in section 2.3.2 in relation to the planning units. However the flooding of agricultural land from whatever cause imposes severe constraints to both rained and irrigated cropping patterns depending on its depth, duration, frequency and timing. The flood planning criteria developed for the master plan have been used as the basis for planning purposes at the regional level. However, at the feasibility stage, with the development and refinement of the regional model (SERM) and the ability to define more accurately the limits at which farmers make decisions to change from one rice variety to another, allow a more sophisticated approach to evaluation of the cropping patterns to be expected under various flood conditions at the critical periods of the cropping calender should be possible.

For the Boro crops this period is likely to be in May or early June but for the aman season crops it is more likely to be in July and August.

However even at this stage it has been identified that the upper limit of flooding for the F1 phase could be adjusted to 0.60 m to define land on which the HYV aman crop can be grown. There is also the possibility of setting another limit at 0.90m to identify the limit at which local transplanted aman (LT aman) can be grown. However, the use of three flood phases between 0m and 0.9m flood depth may be considered unrealistic at the present state of the art of modelling the present land level database and the consequent prediction of flood depth. It is for these reasons that this report has not changed the MPO flood phase depth characteristics for the present analysis at the regional/prefeasibility level of planning.

2.3 Components of a Water Development Plan

This study is concerned with water resources development in its widest sense and with the advent of the Flood Action Plan such development must include water resources management as well as the more conventional aspects. The following sections describe the various possible components, indicate their application to the various planning units and indicate the consultants' approach to planning for each component.

2.3.1 Water Supply

Existing per capita water demands are assumed to be:

District Towns	120 l/c/day
Thana Centre	100 l/c/day
Rural	50 l/c/day
Undeserved	17 l/c/day

These demands provide a guideline as to the current consumption levels and will increase with time.

The current targets are the provision of one hand tubewell (HTW) per 75 of the rural population and the full servicing by piped distributions systems of urban populations, through house connections or standpipes.

Water qualities of groundwater resources are generally acceptable for both drinking and irrigation purposes, but in some areas, including Gumti and Noakhali planning units salinity problems exist. The extent of the problem should be further addressed at the feasibility stage and the likely future scenarios evaluated.

The problem of the quality of water supplies in the coastal area is important. Fresh water recharge to the aquifer during the monsoon period provides a two tier water quality situation in coastal aquifers. Additionally, the changing coastline and deltaic development will also tend to push the saline influence further south. This latter element is however of minor importance.

The other aspect of the rural water supply situation which needs consideration is that of the need, in the short term at least, to avoid creating large regions where suction lift standard hand tubewells (HTW) cannot operate. Hand tubewells currently provide about 85% of the rural population with potable water supplies. The suction lift of the standard hand tubewell is about 7m hence their functioning could place a development constraint on the extent of use of force mode tubewells and also deepset shallow tubewells. Normally the situation is only critical in the period February to April, the end of the dry season being the most critical (i.e. April). However this is the driest period of the year when alternative water sources are virtually non-existent. Some unevenness in the piezometric level in the aquifer of a region can be a natural situation, hence HTW and STW can live in a degree of harmony with force mode pump units (deep tubewells), but the spacing between units is an important factor. Currently there are no zoning regulations and it is left to the natural development mechanism to sort itself out. This often affects the HTW user who becomes the 'loser'.

In areas where water tables are below/beyond the suction capacity of a standard HTW a deep set suction unit has been developed and named the Tara Pump. The unit can operate with the watertable up to 15m below ground level (or about 13m below normal field level). The Tara Pumps are significantly more expensive than the standard HTW and more difficult to install, whilst the current manufacturing capacity is limited.

Adapted well technology is required in the urban areas in Noakhali where only thin layers of fresh water are contained in the upper fine sandy zone of the aquifer. Gauze wrapped wide diameter tubewells of limited depths are used successfully in Maijdi Court, Noakhali.

For long term planning purposes the total requirements for water supply have been assumed as follows:

District Towns 120 l/c/d - 15% of population
All other areas 100 l/c/d - 85% of population.

Based on a total 2025 population of 20.2 million (see Table 1.2) the total water required approximates to a total continuous water requirement of 24 m^3/s. However, for water supply there are two further considerations.

As stated above where HTW and DTW co-exist the HTW can suffer, (this also applies but to a lesser extent where DSSTW occur). This could be controlled by the introduction of licensing arrangements whereby force mode or STW operators are made liable to replace 'lost' water supplies. In most circumstances this can be easily achieved in resource terms but it does require a systematic and well regulated approach to force mode tubewell development. This could prove difficult now that tubewell development is in the private sector. Local participation at the planning stage of force mode well design is therefore, important. A Responsible approach by groundwater development projects, eg National Minor irrigation Development Project,(NMIDP) will be required and the benefits from village water usually outweigh the costs of adding simple supply systems to force mode tubewell installations. It may be noted that many of the farmers benefitting from force mode units are likely to be included amongst those needing replacement domestic supplies. Where groundwater is developed for irrigation, the area available for irrigation development has been calculated from a permitted annual extraction volume. In the consultants view the total water supply volume required for the area to be developed by tubewells should be subtracted from the total permitted abstraction volume before calculating the area which can be served for irrigation development. This will make little difference to overall irrigation development but could make a minor impact on certain areas where large scale groundwater development for irrigation is proposed in densely populated areas. This approach was adopted in the National Water Plan for the assessment of residual groundwater potential for irrigation development.

Where groundwater resources are potable the implications of additional groundwater development on the groundwater table in the dry season (Feb-April) should be assessed. Areas should be targeted for Tara Pump development ahead of predicted problems. For larger villages the option of providing a force mode unit for drinking water supplies could be considered. It should be noted that a 2 cusec (57 l/s) well with header tank could provide ample water supplies to a large village as well as providing irrigation water for homestead garden irrigation. Reticulation systems could be considered together with standpipes etc. Smaller force mode units would be more economic.

In areas where saline groundwaters exist different groundwater abstraction technologies need to be developed focusing on the soil/aquifer profile which receives the monsoon rainfall recharge. In areas with restrictive topsoil conditions the merits of recharge trenches in low areas might solve localised village problems.

2.3.2 Flood Control

The FAP has proposed several possible methods of flood control which may be applied in the various regions of Bangladesh. These methods include:

- Major Flood Embankments
- Submersible Flood Embankments
- Development of Compartments
- Polders

The application of these methods must be carefully assessed depending on the circumstances within each local area bearing in mind the overall objectives of the FAP and also considering alternative forms of flood protection such as flood proofing. All viable interventions must be viewed in the context of overall regional development.

As explained in Chapter 1 the south-east region can effectively be subdivided into three sub-regions,

- Units 13 to 10 or the Titas Gumti Region
- Units 9 to 3 or the Dhonagoda - Dakatia Region
- Units 1 and 2 or the Newly Accreted Marine Char Land

The subregions are convenient for general discussion of the flood control options.

(a) **Units 13 to 10**

In this subregion the river Meghna regularly overtops its banks deeply flooding large areas and covering the remainder of the area with less severe flooding, road access to the thana headquarters of Nasirnagar and Bancharampur is cut, this mainly occurs in August and September. There are also problems of flash floods from rivers which rise in India but the Gumti river is the only one which affects more than a local area, these rivers often rise in May and can prevent the harvest of the boro crop and transplanting with aman. The existing infrastructure includes major river embankments along the Gumti river, submersible embankments in the west of Unit 11 and a number of roads on existing embankments which could be adopted and supplemented to provide drainage compartment boundaries. The Gumti river embankments have breached frequently due partially to poor compaction and poor design, (they are too close to the river in some locations).

However there are a number of constraints to further flood control works in this sub-region and these include the severe economic disadvantage to embankment projects caused by reductions in capture fisheries. In addition the high quantities of rainfall in the region would also result in water being retained behind the embankments unless pumped drainage facilities were also provided. Submersible embankments are worth considering in the deeply flooded areas although the effects of these on capture fisheries can be severe. (See Gumti II feasibility study 1993).

The area is extremely flat and can be classified in many parts as wetlands. Historically, the area has experienced a significant number of river morphology changes particularly with regard to the changed courses of the River Titas. These changes have left their depression scars on the region and a complex pattern of meandering khals and abandoned channels. These features will play an important part in the configuration of any physical intervention in the area.

Suggestions for compartmentalisation have been made for the area, however, the topography probably precludes the from of compartmentalisation being considered in the North Central Area and in FAP 20.

The consultants also believe it wise to await the results of FAP 3.1. The Jamalpur Priority project and FAP 20 the Compartmentalisation Pilot Project before proceeding with compartmentalisation in this sub-region. In the consultants view the social, institutional and environmental considerations involved in compartmentalisation are complex and require an established methodology before recommending such solutions in a regional water plan.

However, the recommendations of the recently completed Gumti II feasibility study do include some recommendations in this respect. The previously suggested proposals for Gumti II have been shown to have poor economic rates of return which confirm the consultants' caution in recommending full protection.

(b) Units 3-9

Two units (6 and 7) comprise existing FCDI schemes where the primary requirements are better maintenance, and in some places improvement or embankment retirement. These are both polder projects aiming to give full flood protection and incorporate pumped drainage. Both projects now work well but were comparatively expensive and have not yielded good economic returns. Units 9 and 4 do not require flood protection being quite remote from the river and relatively unaffected by major flooding from the River Meghna. However they do suffer from local flash floods but contain mainly F_0 and F_1 lands; the main requirement is improved drainage. Unit 8 is at present unprotected from the river and proposals have been considered for providing such protection by main embankments. As described in a later chapter these proposals suffer from two drawbacks as follows:

- possible significant reductions in capture fisheries
- inability to drain local rainfall by gravity in the monsoon season

Units 5 and 3 are already largely protected from flooding from the Lower Meghna. The western part of unit 5 is similar to Unit 8 but this is a comparatively small part of the Unit. Most flooding in these areas is caused by local rainfall and proposals to improve the situation are presented later, (also see section 2.3.4 below).

(c) Units 1 and 2

These two units principally comprise existing polders. The landform, drainage patterns and ecosystems of these units are evolving and their peripheral embankments are still incomplete due mainly to lack of regulating structures. Part of the main embankment to the west of Polder 59/2 is currently being realigned much closer to the Lower Meghna for additional land accretion but other sections are being retired. Polder 59/3A is still open to the sea permitting continued accretion. FAP 7 (now the Coastal Embankment Rehabilitation Project CERP) is directly concerned with these units since they are subject to cyclone damage, whilst part of Unit 2 has been under development by the Land Reclamation Project. Since many structures in the coastal embankment have not been completed some areas are still subject to tidal flooding occasionally.

The only option for flood control in these units is completion of properly designed and constructed embankments together with the necessary drainage regulators. These units are currently in an unstable condition. The estuary study FAP 5B - Meghna Estuary Study, due to start shortly, is expected to make recommendations which could radically affect the drainage of the existing polder areas. It is unfortunate that the Regional Plan has had to be completed before these studies.

2.3.3 Drainage

The extremely flat nature of the region, the very high rainfall and high river levels during the monsoon season produce a combination of circumstances which make improved drainage a major objective of the regional plan. However these same conditions make the development of cost effective solutions difficult. The principal methods used to improve drainage include:

- Enlargement of existing natural drainage channels.
- Loop cutting in natural drainage channels.
- Construction of new Khals.
- Construction of tidal regulators.
- Provision of pumped drainage.

These methods can be used individually or collectively and also in combination with other flood control and irrigation interventions. It is considered that the economic viability of pumped drainage is not likely to prove possible unless it is as part of an FCD/I project where the pumping plant can be used for both purposes. However even in these circumstances the storm drainage requirement is likely to prove too high to provide cost effective drainage benefits.

Tidal regulators using combinations of flap gates and lifting gates or flap gates only can provide effective drainage where conditions are appropriate, which in the case of the south east region is downstream of Chandpur. All these elements have been considered for one or more of the planning units.

The aim of drainage interventions is not necessarily to eliminate flooding due to rainfall and/or over bank river flows but rather to reduce the depth and duration of floods such that improvements can be made to cropping patterns, thus producing increased agricultural benefits. The reduction rather than the elimination of flooding should also help to maintain capture fisheries whilst at the same time providing better conditions for culture fisheries.

(a) Units 10-13

Generally drainage from large parts of these units during the monsoon can only be achieved by pumping from behind major embankments. Unit 10 already has major embankments but no pumped drainage of Gumti I has been developed. Similar interventions have been proposed for Unit 11 (Gumti II) including pumped drainage but are now shown to have poor economic returns. However alternative approaches for some of the less deeply flooded areas in the east of these units have been investigated by the recently completed Gumti II feasibility study and are now included in the Regional Plan. Unit 12 Ashuganj is less affected by floods than other units in this sub-region and gravity drainage through existing channels is generally adequate.

(b) Units 3-9

Unit 3 presently suffers severely congested drainage despite the construction of the tidal regulator at Rahmatkhali some 20 years ago. The consultants have proposed comprehensive drainage improvement and deepening of the khal system coupled with enlargement of the existing regulator. These same measures will also allow increased irrigation in the dry season through reversal of flow in the deepened khal system. This will be particularly important in the Begumganj depression area where, at present, farmers use their neighbours' flooded land as a source of irrigation water in the dry season.

As already stated units 4 and 9 suffer less from river flood but there are some areas suffering congested drainage and specific priority proposals for further studies of this problem have been included in the Plan.

The southern part of Unit 5 will benefit to a substantial extent from the proposals for Unit 3 otherwise drainage could only be improved by combination with a full FCD/I scheme which could have negative effects on capture fisheries. However various proposals for both drainage and irrigation have been made for this unit and these are discussed later.

Units 6 and 7 are already provided with full drainage facilities and no further action is required other than some emergency repairs and maintenance work.

Unit 8 is difficult to improve without causing substantial capture fisheries loss and the proposals investigated have not proved sufficiently economically viable to include in the present regional plan.

(c) Units 1 and 2

The comments made in section 2.3.2 c) apply equally for the drainage aspect since until the studies for FAP 5B and their recommendations are known it is not possible to prepare proposals which can be recommended in an unqualified manner. Properly completed embankments and drainage regulators should result from CERP proposals. There is presently substantial annual movement of char lands and river channel causing both erosion and accretion outside the embankments and the viability of maintaining drainage channels downstream of tidal regulators is difficult. It is in this area that the proposals to be expected from FAP 5B will be of critical importance.

2.3.4 Irrigation

Irrigation is now rapidly expanding in Bangladesh as social pressures increase the need for dry season cropping and as the technologies become more widely available. However irrigation benefits are largely confined to improvement in yields of the Boro crop and this limitation means that only efficiently designed systems provide adequate economic returns. The following paragraphs outline the issues confronting the irrigation sector in the south east region.

(a) Surface Water Systems

There are a number of different methods of irrigation currently employed in Bangladesh and the south-east region as described in Part 1 Chapter 6 section 6.10. However there could be four main types considered for surface water supply to minor level irrigation as follows:

- (a) All gravity
- (b) Gravity with LLP
- (c) Single lift with gravity distribution
- (d) Double lift.

Opportunities for gravity supply are usually limited to direct abstraction from natural rivers and khal by LLP as in (b) above but occasionally as in Ashuganj (unit 12) there is a source available which allows the entire distribution system to be fed by gravity. Most FCDI schemes involve either single lift with gravity distribution, as in the Meghna Dhonagoda Scheme (Unit 7) or double lift, as is generally the case in the Chandpur Irrigation Project (Unit 6).

Double lift schemes are expensive in both capital and O & M terms unless the primary distribution systems can use existing natural channels or khal systems.

Irrigation interventions considered for the regional plan have demonstrated that reasonable rates of return may be achieved only when the areas to be irrigated do not require full FCD protection so that design of the system can be arranged to minimise potential capture fishery losses. This is the case both for the proposals for Noakhali North (Unit 3) and for the Dakatia/Little Feni Transfer (Unit 4 and 5).

Elsewhere surface irrigation is likely to be confined to the LLP mode using existing sources of supply from khals which may be deepened if appropriate.

(b) Groundwater Systems

Groundwater irrigation has substantial potential in the south east region but it is important that future groundwater development optimises the use of the available resources since it has already been demonstrated that in the medium to long term there will be an overall shortage of water resources available for irrigation in the region.

The hydrological studies have indicated that in many areas the optimum development in resource terms can only be achieved if force mode tubewell (FMTW) are used.

Now that minor irrigation, including STW, DSSTW and FMTW development are to be implemented in the private sector it may be difficult to ensure that the most appropriate technology is used in each location. This is particularly the case for FMTW and a number of actions will be needed if this type of development is to play its appropriate part in optimum exploitation of groundwater.

The consultants consider that one cusec or even 0.5 cusecs (30 or 15 l/s) are more appropriate generally for the following reasons:

- The organisation of cooperatives or other water user associations is easier to manage for this smaller scale of development.

- The 2 cusec wells are generally inefficiently used (smaller areas served than is possible).

- Smaller wells should have lower operating costs per unit of water.

- The smaller wells can be developed using less expensive drilling methods and less expensive components.

Generally FMTWs should be designed to run for up to 22 hours per day for peak periods and if necessary small night storage ponds could be developed which might also be used for fish culture for the long periods (9-10 months) when the storage is not required. Such methods could assist in reducing the capital cost per ha to a level which is much more competitive with STW technology (See annex IX). However it will probably still be necessary to ensure that a reasonable number of wells are constructed within one locality in one season so that drilling contractors can offer competitive prices. This will need the assistance and support of the proposed NMIDP technical assistance so that a viable organisational effort allows such development. A combination of improved organisational methods, efficient design to achieve maximum area per unit, the use of appropriate casing and screen materials and the lower prices for the mechanical units expected in the private sector should enable the technology to survive in competition with STWs but there may be a period of years when FMTWs are less popular and this could result in inefficient development of groundwater potential. It could also result in conflicts later as resources become more fully developed.

2.3.5 Navigation

Outside Dhaka, Chandpur is the largest port in the country and has good shipping connections with Chittagong, Mongla and Dhaka. It is a major focus for inland water transport in the Meghna estuary. The study area is not well served by inland navigable waterways compared to other areas of the country. In the BIWTA Mater Plan it is proposed to make the 31 km of the Titas river Mahisherchar to Salimganj a Class III waterway and part of the Dakatia a Class IV waterway. The country boat routes surveyed by BIWTA also include 40 km of the Gumti River. There are many unclassified routes used by country boats, these should be investigated at the feasibility stage.

The consultants' approach has been to ensure that the existing navigation facilities are maintained for all development options by provision of locks where required. The effectiveness of some of the existing locks should be reviewed at the feasibility stage both by site visits and discussion with BIWTA. Where only small boats require access alternative arrangements such as roller ramps or shallow stepped ramps across embankments may be considered. At the feasibility stage additional measures to promote transport facilities may be considered where these prove to have positive economic benefits.

Navigation in the country is a very seasonal form of transport; boats are mostly used during the monsoon when river levels are high and the navigable channel network is quite extensive. In the dry season transport is predominantly by the road network and rural tracks. Flood control and drainage systems have most impact on navigation since they address the water network/ regime during the monsoon. Dry season impacts are mainly caused by the reduction in LAD (least available depth) through the abstraction of surface water by LLPs; this will be particularly so in the Titas-Gumti area where LLP usage is quite extensive. Khal re-excavation can help to address this problem, however the economics of khal re-excavation needs to be carefully assessed particularly in terms of the likely period of effectiveness of the re-excavation measures.

Each intervention should assess the likely impact on the natural channel network in terms of:

- changes in bed level (particularly in the dry season)
- changes in water level (particularly in the dry season)
- closures

Modifications in channel width are generally not so critical.

2.3.6 Fisheries

The available data on fisheries is limited and of doubtful reliability. However it has already been established (FAP 12) that FCDI projects can result in substantial losses of yield from capture fisheries but can also provide opportunities for greatly extended benefits from culture fisheries. All development proposals for FCDI schemes should examine and propose measures to limit losses to capture fisheries and ensure gains to culture fisheries. Project designs will need to include such mitigation measures if most schemes are to prove economically and environmentally viable.

The fisheries, particularly, capture fisheries, bring benefits to the most disadvantaged groups in society. There are a number of both physical and institutional measures which could be implemented to improve future projects. Such measures could include fish locks, licensing of publicly owned and flooded borrow pits, khals and other water bodies to co-operatives of disadvantaged groups. There is also scope for intensive development of culture fisheries particularly in the north of the region since there is already noticeable development in the southern part.

The proposals included in the Regional Water Plan include a number projects which have been developed so as to minimise fisheries losses and at the same time offer opportunities for increased development of culture fisheries.

The Noakhali drainage and irrigation proposals would not interfere with fish migration patterns since the area, depth and duration of flooding is affected only partially. There would remain large areas of land in the F1 and F2 categories is in the south of the area but effective drainage does reduce floodplain areas. Also the provision for irrigation by deeping khals will ensure extended opportunities for resident capture fishery species to thrive through the provision of additional areas and depths of fresh (better quality) water supplies. The proposals for the Dakatia/Little Feni pumped irrigation transfer scheme are now designed such that the effects on fisheries are reduced since no flood control measures are included. Thus the movement of fish is unaffected from about mid April until the end of the year. Only when pumping is required at the Dakatia station (Meghna mean river level < +2.2) would the regulator gates be closed. This will need further study at the feasibility stage but certainly capture fisheries losses should be greatly reduced compared with flood control options.

In Chapter 7 of part I of the report mention is made of several possibilities for enhancing fisheries benefits or reducing capture fisheries losses. Such measures include:

- Construction/ rehabilitation of fish ponds
- Licensing of publicly owned water bodies
- Development of culture hatcheries and nurseries
- Fish Farming
- Managed capture fishery (culture based)

Opportunities for all the above interventions can be enhanced by flood control drainage and irrigation systems. FAP 17 will be investigating such initiatives.

The consultants believe that combinations of licensing and the other measures could ensure that the landless communities are given increased opportunities in these areas. Development of fishery cooperatives to manage licensed areas with the licence conditions set to encourage restocking of nearby capture fisheries in local khal systems could be one way of improving prospects for the fishing communities. The development of new fish ponds through their inclusion in LLP and groundwater units could both improve these systems economics by reducing required pumping capacities through night storage and provide fishery benefits, since the ponds would only be required for storage for a relatively short period each dry season.

These proposals must remain tentative at this stage but could merit further study at later planning stages.

2.3.7 Cyclone Protection

The Cyclone Protection Project (FAP 7) started in 1990. As a result of the exceptional cyclone of April 1991 the content of the project has changed and enlarged to include an Emergency Cyclone Protection Project to be completed in 1993 and a mid term programme, Phase II, for which construction was scheduled to start in 1993 and be completed by mid 1995. In addition FAP 11 (Disaster Preparedness) and FAP 10 (Flood Forecasting and Early Warning Project) also have a direct bearing on the development and coordination of efforts to mitigate the effects of cyclones. There have been a number of charges in the programme and its scope and the current project is now called the coastal Embankment Rehabilitation Project. The CERP will directly affect two of the planning units in the South East region (Units 1 and 2). These units which are already largely poldered will require embankment improvements, including some retirement and new structures. At present these works are scheduled for the Mid Term Programme Phase II. Some additional works are proposed in the regional plan. The timing of additional water development proposals must await the outcome of the above programme so that such development can be considered against the background of a stable and secure environment. The consultants are particularly concerned about the stability of the west side of polder 59/2 which it is hoped will be studied within the FAP 5B Estuary Study if a complete system is not established under CERP.

2.3.8 Flood Proofing

The main alternative to flood protection and control, which can be classified as a water management option is flood proofing. To adopt flood proofing is to accept that an area is better left open to flooding but to take a series of measures to reduce or eliminate non-agricultural damage by both structural and non-structural methods. Such methods include:

Structural

- Raising homesteads on mounds of earth or stilts
- raising all publicly owned buildings above flood level
- protection of infrastructure (roads, markets etc.)
- provision of adequate cross drainage paths for floods
- raising potable water wells above flood levels

Non-Structural

- Mass communication/media programmes
- Forecasting and early warning programmes
- Disaster preparedness and relief programmes

All these programmes are essentially national in character rather than regional and all are included in other FAP studies. The consultants have reviewed the situation for the south east region and have identified those areas where flood control interventions are not appropriate or economic. In these areas the consultants have also identified where major existing infrastructure has not yet been flood proofed. In fact most of the region is served by railways, national and thana roads which are already above design flood levels. However much will remain to be done in some urban areas and in villages in the west of the sub-region to improve flood proofing. In Chapter 10 the areas where floodproofing may be required are identified. It is not possible at this stage, of planning to be specific concerning the other most appropriate measures for each area nor to cost such measures. However the coordination of resources is essential if any of them are to be effective. There will be a need for different approaches to the construction of new public buildings and the measures to flood proof existing ones and perhaps different standards may be appropriate for these. Depending on local circumstances it may be appropriate to select either a school, mosque or health clinic/hospital for up grading depending on its location, size and suitability for the task (e.g. storage or shelter).

The principal agency responsible for coordination for the structural approaches could be the Ministry of Local Government, Rural Development and Cooperatives. The agencies to be responsible for the non-structural elements in addition to the above ministry would include the Ministry of Disaster Relief and Rehabilitation (Disaster Preparedness) the Ministry of Education (Mass Communication), the Ministry of Irrigation Water Development and Flood Control (early warning) and the Ministry of Information and Broadcasting (Media programmes).

CHAPTER 3

METHODOLOGY FOR PROJECT APPRAISAL

3.1 Capital Costs

3.1.1 Basic Methodology

The calculation of engineering costs is given in Annex X. This follows the general approach as given in the Master Plan Organisation (MPO) Technical Report Nr 13 but in certain cases the Study has gone into more detail.

The Consultants broke costs down into materials, labour and plant costs based on their own experience. The need to ensure that embankments are compacted means that traditional methods of construction and the associated cost are not always applicable.

Minor irrigation costs, including the LLP component of double lift irrigation schemes, have been considered as agricultural costs, since minor irrigation development has now been handed over to the private sector. In the case of major pumping stations, both capital and O&M costs of pump stations are regarded as project costs.

3.1.2 Project Start Dates and Period of Analysis

It has been assumed for all projects that the first year of capital expenditure (Project Year 1) will be **1994/95**. This allows a period of three years from mid-1991 for completion of the feasibility studies, detailed designs, tendering and negotiation of finance. This has been estimated as follows:

1. Complete Feasibility Study by mid late **1993**
2. Complete Detailed Designs Commence land acquisition and complete international tender and evaluation by mid **1994**
3. Negotiate finances

The need for timely land acquisition for all project development works cannot be over emphasised. There are numerous examples where this has been a very problematic issue which has seriously hampered project completion.

It should be noted that this scheduling is used only for the purpose of comparing and ranking projects at the pre-feasibility stage, and has been adjusted as appropriate in formulating the Regional Plan.

The economic analyses have been carried out for a 30 year period.

3.1.3 Phasing of Expenditure

Capital expenditure has generally been assumed to be phased over a period of five years (ie, from Project Years 1-5), in equal annual amounts. Operating and maintenance costs have been assumed to be incurred from Project Years 6-30 in equal annual amounts. In the case of retirement of embankments for the Chandpur Irrigation Project, the capital costs have been spread over only two years, since this work is urgent and must be done in that time. Land appropriation processing time will be critical in this case.

3.1.4 Economic Conversion Factors for Capital and O&M Costs

Project capital and operating costs in financial (market) prices have been adjusted to economic prices by applying the Conversion Factors defined in the 'Guidelines for Project Assessment' (FPCO, May 1992) to the local components of costs. Capital and operating costs for the main items (embankments, pump stations, 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. The results were given in Tables 15 to 18 of Annex X. All costs have been calculated in terms of constant 1991 Taka.

3.1.5 Economic Cost of Land Acquisition and Resettlement

The issues of land acquisition and resettlement are being studied as a separate element (FAP 15) of the Flood Action Plan studies. The now to be applied regulations state that 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 with a 50% premium for compulsory purchase. In the case of land acquired for the present proposals this value has been estimated at Tk 400 000 per ha in financial prices. This is based on "recorded" land values plus 50% which possibly approximately to current market values. There is no additional compensation for the cost of resettlement incurred by the individuals whose land has been acquired. Additionally crop loss compensation is not paid and allowances for the impact on cropping of soil disposal (spoil from excavation) is non existent.

The economic value of land acquired for project works has been taken to be the Present Value (at a 12% discount rate) of the net income foregone from future agricultural production on the land. This value has been calculated as the regional average net agricultural income per hectare in economic prices, estimated at about Tk113,000 per hectare, as shown in Table 3.1 and 3.2. (The basis for the calculations of return per ha by land type is described in Section 3.3 of this Report). In these tables the terms F0 to F3 refer to flood phases, (see Section 3.3.2); Ir to irrigated land, and Io to rainfed land.

The economic value is about a quarter of the current market price of land. A substantial divergence between economic values calculated in this way and market prices is to be expected as landowners place considerable value on land apart from the income they expect to get from cropping. This includes the value of land as a hedge against inflation, one's position in society as a landowner, and as a secure livelihood for future generations. As in developed countries, the value of land usually exceeds the level justified by agricultural incomes or rentals.

TABLE 3.1

Summary of Net Returns per Hectare by Land Category

Land Category	Gross Income	Total cost		Net income		Improvement in Net. Inc. (Incl. Family Labour	
		Incl. Family Labour	Excl. Family Labour	Incl. Family Labour	Excl. Family Labour	Drain	Irrigate
F0I0	31741	16203	11268	15537	20473	2478	
F0IR	53949	27629	20251	26320	33698	3671	10783
F1I0	28871	15812	10819	13059	18052	6309	
F1Ir	47569	24920	18069	22649	29500	6920	9590
F2I0	16362	9612	6768	6750	9593	2130	
F2Ir	34497	18768	14114	15729	20383	1531	8979
F3I0	10173	5553	3863	4620	6310		
F3Ir	30121	15923	11911	14198	18210		9578

Source: Based on MPO cropping pattern data

TABLE 3.2

Land Acquisition: Economic Cost Estimates

Land Acquisition: Economic Cost Estimates		Net Income per ha inclucing Family Labour	Weighted Average of Net Income per ha
Land category	Share of Total SER NCA (%)		
F0I0	18	15537	2797
F0Ir	9	26320	2369
F1I0	27	13059	3526
F1Ir	11	22649	2491
F2I0	18	6750	1215
F2Ir	6	15729	944
F3I0	9	4620	416
F3Ir	2	14198	284
Total	100		14041
PV @ 12%, 30 years (Tk/ha)			113104

3.2 Methodology for Estimating Incremental Crop Production Benefits

The analysis of project effects on crop production has been based on the following key parameters:

- areas in each flood phase: Present (P), Future with project (FW) and Future without project (FWO)
- irrigated areas (P, FW, and FWO)
- cropping patterns (P, FW, and FWO)
- crop budgets - input use, yields and prices (P, FW, and FWO).
- reductions in flood damage

Data sources, methodology and the assumptions made for this analysis are discussed in the following sections.

3.2.1 Flood Phases

The evaluation of flood mitigation options in Bangladesh has for some time been based on classifications of flood depth known as flood phases. Flood phases are categorised as follows:

F0	-	flood depths of < 0.3 m	
F1	-	flood depths of 0.3 - 0.9 m	
F2	-	flood depths of 0.9 - 1.8 m	
F3	-	flood depths of >1.8 m	(flooded for less than nine months per year)
F4	-	flood depths of >1.8 m	(flooded for more than nine months per year)

This classification system (with minor modifications) has now been in use for some time in broad level planning, and has served its purpose well. Crop statistics and cropping distributions have been based on the flood phases, and they have become an important planning parameter.

It is understood that these flood phases defined by the Soil Resources Development Institute (SRDI) and the Soil Data Analysis Programme (SODAP) have been based on the preparation of flood level inundation maps based on soil and land use characteristics. The availability of computational hydraulic models and the computerised land level data base prepared under the present study permits a more objective approach to the determination of flood phases, and permits them to be related to duration and frequency of flooding.

A drawback of the present classification, for other than broad level planning, is that it relates neither to the duration of flooding, nor to the frequency with which the inundation occurs. It was thought that the classification in its broadest sense ought to apply to average year conditions. Crop statistics have, however, been related to flood phases, it is not thought generally likely that many farmers would risk crop loss at a frequency in excess of once in five years. It was therefore considered appropriate for the present investigations to relate flood phases to the inundation experienced with a return period of about five years.

The selection of representative years for modelling purposes has been discussed in the Hydrology Annex (Annex VI). For each of the representative years, flood depth area characteristics have been computed using the Mike11 hydro-dynamic model for the south-east region (SERM) and the land level database. A typical processed model output is shown in Table 3.3.

TABLE 3.3

Typical Processed MIKE11 Hydrodynamic Model Output

Base Run, 1983 Conditions

DAKATIA

Flood Depth/Area Characteristics

Depth of water exceeded (metre)	Flood Duration (Area km2)						
	2 Day	5 Day	10 Day	20 Day	40 Day	60 Day	90 Day
40.0	374.9	370.9	366.8	357.7	352.4	349.6	310.8
0.2	356.1	351.5	345.6	335.0	330.6	327.0	277.8
0.4	339.5	334.3	325.7	310.6	303.1	298.1	230.8
0.6	316.6	306.9	295.6	279.2	271.6	265.1	147.9
0.8	283.6	272.0	257.3	231.4	219.4	210.5	77.8
1.0	227.1	211.7	196.3	160.4	143.8	130.3	25.8
1.2	153.8	133.1	112.4	84.9	76.9	68.5	6.1
1.4	83.4	68.8	53.1	26.1	18.9	16.3	3.5
1.6	27.4	17.6	11.7	6.0	5.1	5.0	3.1
1.8	6.9	5.1	4.2	3.4	3.2	3.2	2.8
2.0	3.5	3.3	3.2	3.0	2.9	2.9	2.6
2.2	3.0	2.9	2.8	2.8	2.8	2.7	2.4
2.4	2.8	2.7	2.7	2.7	2.6	2.6	2.2
2.6	2.6	2.6	2.5	2.4	2.3	2.3	2.0
2.8	2.3	2.3	2.3	2.2	2.2	2.1	1.5
3.0	2.2	2.1	2.1	2.0	1.9	1.9	1.2
3.2	1.9	1.7	1.7	1.4	1.3	1.2	1.1
3.4	1.2	1.2	1.2	1.2	1.2	1.2	0.9
3.6	1.2	1.2	1.1	1.1	1.0	1.0	0.6
3.8	1.0	1.0	0.9	0.9	0.8	0.8	0.2

Notional Flood Phase Distribution (Per cent of Area)

Mapped Area = 594.2 km2

Phase	2 Day	5 Day	10 Day	20 Day	40 Day	60 Day	90 Day
F0	41.5	42.3	43.5	45.7	46.7	47.4	57.2
F1	15.6	17.0	18.3	21.4	22.8	23.9	34.1
F2	41.8	39.8	37.5	32.4	30.0	28.1	8.2
F3/4	1.2	0.9	0.7	0.6	0.5	0.5	0.5

Notional flood phases have been computed in order to indicate the sensitivity of the classification to the year on which it is based, and to the duration for which certain water levels are exceeded. On the basis of the approach adopted by SRDI and SODAP, and from consideration of the outputs, a ten day duration was considered most appropriate for classification of the flood phases (Table 3.4). The classifications are summarised in Figure 3.1 and in Table 3.4. Interpolating simply by rank, the data of the following years have been found to be representative:

Planning Unit	Representative Year
Dhonagoda	1984
Sonaichari	1984
Noakhali North	1983
South Sudharam	1983
Little Feni	1988
Dakatia	1984

The data of the above years have been used in the appraisal of pre- and post-project flood phase distribution, and hence land enhancement benefits.

In the separate Album of Drawings the flood phases in the present conditions and the future conditions for the Noakhali North project have been presented for the representative year (1983). These are both based on the flood phases as calculated from the model results and the land level database. Noakhali North being one of the projects selected for feasibility level assessment. The analyses carried out for the feasibility study is of a different order and this is discussed later in this volume.

3.2.2 Irrigated Areas

Estimates of irrigated areas in the south-east region are available from a number of sources:

- Thana crop statistics for 1986/87 from the Bangladesh Bureau of Statistics (BBS).

- Irrigated areas by thana based on MPO Projections for 1989/90 based on BBS information and AST (Bangladesh-Canada Agricultural Sector Team Census) information.

- Data collected by the Bangladesh-Canada Agricultural Sector Team (AST) on numbers of minor irrigation equipment by thana for the years 1986-1989 and data for 1990/91, including a sample survey of command area sizes.

- Irrigated areas have been visually interpreted from the SPOT satellite imagery (Feb/March 1989). Irrigated area estimates derived in this way are not always comparable with the AST data, but have the advantage of showing the spatial distribution of irrigated areas within planning units, thanas and soil associations.

Figure 3.1

Evaluation of Flood Phase Distributions - Base Conditions
10 Day Duration

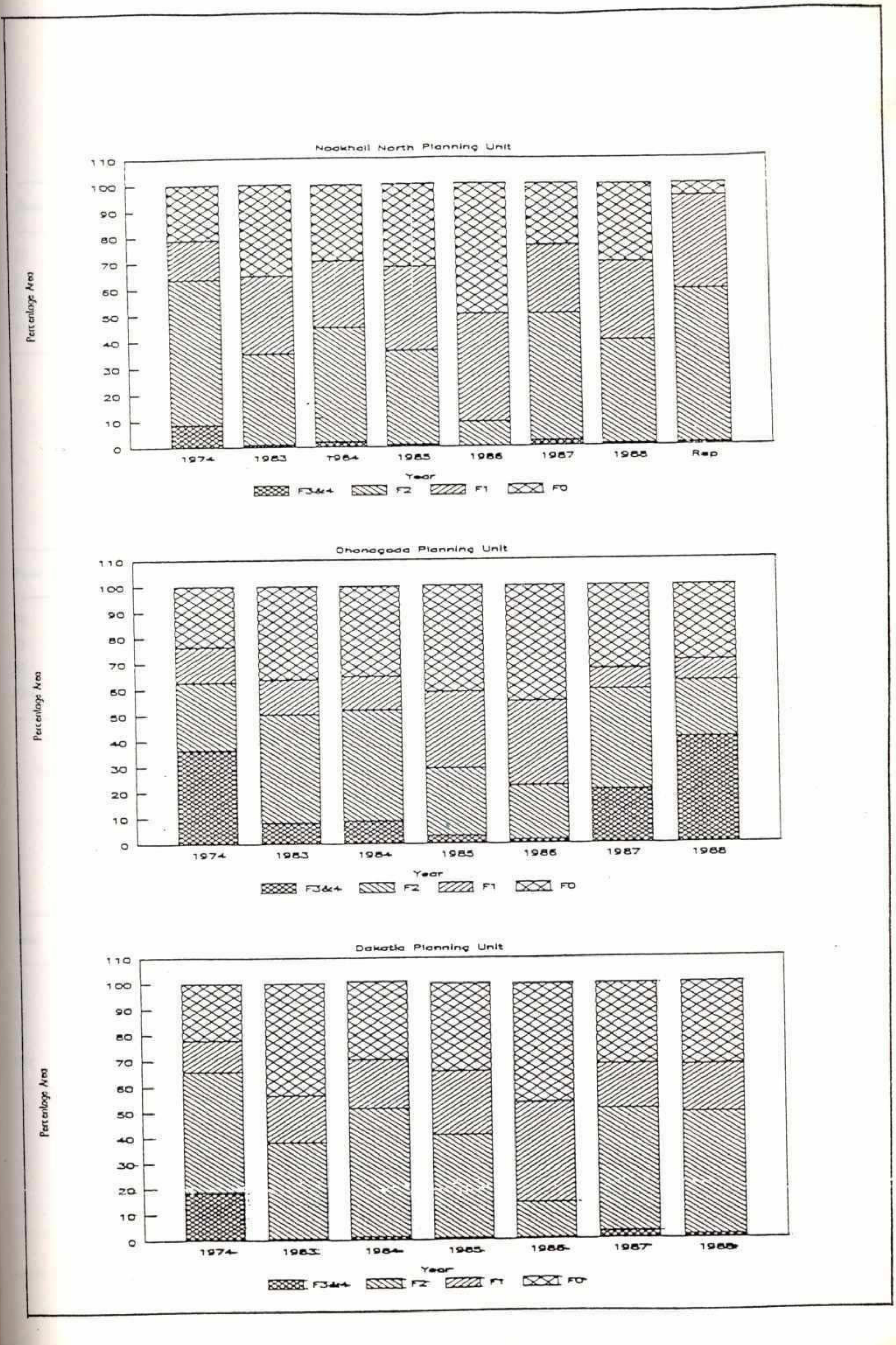

TABLE 3.4

Evaluation of Flood Phase Distributions: (10 Day Duration)

Noakhali North Project Area

------------------------Per cent Area------------------------

Phase	1974	1983	1984	1985	1986	1987	1988
F0	21.1	35.1	29.2	31.7	49.8	23.9	30.2
F1	15.2	29.6	25.6	32.1	40.7	26.2	30.0
F2	55.0	34.1	43.0	35.2	9.2	47.8	39.0
F3/4	8.7	1.2	2.2	1.0	0.3	2.2	0.7

Dhonagoda Project Area

------------------------Per cent Area------------------------

Phase	1974	1983	1984	1985	1986	1987	1988
F0	23.8	36.3	35.2	41.3	45.0	32.6	29.5
F1	13.7	13.5	12.9	29.5	32.7	8.1	8.1
F2	26.0	42.1	43.0	26.0	20.6	38.4	21.5
F3/4	36.6	8.1	8.8	3.2	1.7	20.9	0.9

Dakatia Project Area

------------------------Per cent Area------------------------

Phase	1974	1983	1984	1985	1986	1987	1988
F0	22.1	43.5	30.5	34.2	46.4	31.7	32.1
F1	12.2	18.3	19.0	24.9	39.0	17.5	18.7
F2	47.0	37.5	49.9	40.3	14.0	47.8	47.7
F3/4	18.7	0.7	1.4	0.7	0.5	2.9	1.5

The assumed distribution of present irrigation by mode was estimated for the analysis of crop production benefits from a combination of the AST 1991 data and the 1989 SPOT imagery interpretation as follows:

- irrigated areas were assessed with the help of SPOT satellite imagery (February/March, 1989). At first, the areas were plotted on the SPOT images. These images were then taken to the field to verify in sample locations whether the areas identified were irrigated crops. On confirmation or correction, the plotted areas were measured by electronic planimeter. The areas measured from SPOT imagery interpretation were adjusted on a pro rata basis to resolve discrepancies in the gross measured area of each planning unit

- the AST 1991 data on irrigated area by mode was distributed over the planning units in proportion to the gross area of each thana and multiplied by a suitable factor so that the total irrigated area corresponded with that assessed from the SPOT imagery. However the results of the farmer surveys have shown that the AST data may be regarded as a minimum irrigated area and therefore where the AST data exceeds the area estimated from the SPOT imagery the AST total has been used.

It had originally been hoped to determine the irrigated area according to flood phase by superimposing the SRDI land classification on the irrigated areas as interpreted from SPOT imagery. However, since the flood phases derived from the SRDI land classifications did not correspond well with results of the SERM, this approach was not useable. Irrigated areas were therefore distributed over the flood phases pro-rata to net cultivable area.

In analysing the development options, each planning unit has generally been divided into one or more areas having more or less uniform characteristics. The planning unit totals of irrigation by mode have been distributed over these areas from considerations of topography, and irrigation as identified on the SPOT imagery.

The above approach essentially provides estimates of the area irrigated during the dry season (almost wholly for boro). Supplementary irrigation of aus and aman is much less common and for the region as a whole has a negligible effect on aus and aman yields. According to MPO estimates for south-east region only 12% of HYV aus (3% of all aus) and 2% of transplanted aman (1.6% of all aman) receives supplementary irrigation. Bangladesh Bureau of Statistics (BBS) data for 1988/89 indicate irrigation of 6% of aus and 2% of aman in Comilla (greater district) with no irrigation of aus and aman in Noakhali (greater district). The reason for this appears to be that if the farmer has irrigation facilities he generally plants HYV boro. The equipment is then dismantled during the monsoon season and often used for other purposes.

3.2.3 Cropping Patterns

Flood Control Drainage and Irrigation (FCDI) projects generally increase crop production by bringing about changes in cropping patterns. In order to predict the effect of FCDI projects it is necessary to derive typical cropping patterns by flood phase and by irrigation availability.

Eight different Land Categories have been considered in this study: four flood phases (F0-F3), each either irrigated or rainfed. Flood phase F4 (section 3.2.2) has been incorporated with F3 to create one flood phase (land generally flooded to a depth of greater than 1.8 metres in accordance with MPO practice/National Water Plan Phase II Studies). Irrigation type (eg, shallow tubewell or low lift pump) is not thought to be a major determinant of cropping pattern. Consequently, all irrigation types have been assumed to have an equal effect on cropping patterns.

MPO has estimated cropping patterns by land category in each MPO Planning Area for 1989/90. These estimates were based on BBS upazila level crop statistics, decision rules for assignment of crops to flood phases, and a minor field checking programme.

The effects of possible FCDI projects on cropping patterns may be assessed according to the areas in each land category before and after project implementation. It has been assumed that land which comes under irrigation as a result of a project will generally be cropped according to the pattern prevailing on the land already irrigated. Exceptions being in the Titas and Gumti II planning units. Similarly, it has been assumed that land on which flooding is reduced will generally acquire the cropping pattern typical of its new flood phase. Cropping intensity generally increases with reduced flood depth.

It has been assumed that a planning unit falling into an MPO Planning Area has the cropping pattern derived by MPO (as broken down by land category). Cropping patterns estimated on this basis provide a consistent basis for evaluation of crop benefits, although they may sometimes be at variance with data from other sources. The MPO Planning Areas applicable to each planning unit are as follows:

Planning Unit		Present Cropping Pattern Data Source MPO Planning Area
1	Polder 59/2	35
2	South Sudharam	35
3	Noakhali North	33
4	Little Feni River	34
5	Dakatia	33
6	Chandpur Irrigation Project	32
7	Meghna-Dhonagoda	32
8	Dhonagoda	32/33 mean
9	Sonaichari	34
10	Gumti I	31
11	Gumti II	31
12	Ashuganj	29
13	Titas	31/29 mean
14	Muhuri	36

The standard cropping patterns for each planning area are given in Table 3.5.

MPO cropping patterns have been slightly modified by the removal of orchards from cropping patterns on F0 land. The inclusion of highly profitable orchards in unirrigated F0 land means that when irrigation is introduced on this land income is reduced as cropping patterns switch out of orchards into relatively less profitable irrigated field crops. In practice this would not happen: farmers would maintain their orchard areas. Therefore the area of orchards has been removed from the cultivable area which is now restricted to annual field crops. This also is probably more truly representative of the field situation since most overhead crops are grown on raised land which forms part of homestead and pond areas.

TABLE 3.5

Cropping patterns used for each Planning Area Crop Intensity (%)

Land Cat.	B aus	HYV aus	B aman	LT aman	HYV aman	L boro	HYV boro	HYV Wheat	Potato	Jute	Sugar cane	Pulse	Oil-seed	Spices	Other	Orchards	Total
Planning Area 29																	
F0-I0	22			10	1			1	0	13	5	5	15	3	7	30	112
F0-Ir		14		36	45		68	13	1	9		5	5	5	5		206
F1-I0	40			21	26			6	1	17	3	10	25	4	16		169
F1-Ir		10		55	31		83	8	2			2			7		198
F2-I0	18		16	19				7	3	22		5	18	1	3		112
F2-Ir			25	10			92	5	1						1		134
F3-I0			44			8		1				6	15				74
F3-Ir			14			25	71										110
Planning Area 31																	
F0-I0	40				60			2		9		5	10		4	19	149
F0-Ir		36		9	86		41	36	10					2	10		230
F1-I0	40		3	17	30			7		25		6	13	6	19		166
F1-Ir		8		55	37		78	18						1	3		200
F2-I0	55		45					25	1	10		17	24	1	3		181
F2-Ir			25	20			79	17	3				20		1		165
F3-I0			63			7		8				6	12				96
F3-Ir			26				100										126
Planning Area 32																	
F0-I0																100	100
F0-Ir		25		17	80		52	40	1		3				2		220
F1-I0	58			28	40					42				12	20		200
F1-Ir		25		50	40		49	40	5					6			215
F2-I0	38		37					13	3	11		5	12	2	2		123
F2-Ir			25	10			82	14	1				10				142
F3-I0			54			3			1			8	7				73
F3-Ir			15			33	67										115
Planning Area 33																	
F0-I0	39	15		11	65			3			1		2	3	4	23	166
F0-Ir		11		26	60		81	11	3						5		197
F1-I0	44	8		39	40			4	1	6			8	2	6		158
F1-Ir		10		50	40		78	10	3						9		200
F2-I0	22		43	16				5	1	2		8	15	1	1		114
F2-Ir			25	10			92	6	1						1		135
F3-I0			91					2				5	10				108
F3-Ir			15			77	23										115
Planning Area 34																	
F0-I0	34	5		25	60				5	1	1	2	2		1	10	146
F0-Ir		20		12	83		75	18	2	1	1	2	2	1	3		220
F1-I0	30	8		55	40				5	1		5	5		3		152
F1-Ir		22		58	40		78	6	2			3	3	1	4		217
F2-I0	10		20	20								10	10		3		73
F2-Ir			25	10		1	96	1	1						1		135
F3-I0			26									4	1				31
F3-Ir			15			39	61										115
Planning Area 35																	
F0-I0																100	100
F0-Ir																	0
F1-I0	37	10	2	64	18			3	5	1	1	15	18	1	3		178
F1-Ir				60	40		100										200
F2-I0	19		11	10		2		2				7	2				53
F2-Ir			25	10			100										135
F3-I0																	0
F3-Ir																	0

Notes: Cropping patterns taken from MPO based on 1989/90 data
I0 - not irrigated,
Ir - Irrigated

3.2.4 Crop Input Use

Estimates of input use have been made for each of the main crop categories as defined by MPO:

- Broadcast (B) aus
- Transplanted (T) aus, High Yielding Varieties (HYV) including Local transplanted (LT) aus
- B aman
- T aman (local and including Local Improved Varieties (LIV))
- HYV aman
- L boro
- HYV boro - almost always irrigated
- Wheat - irrigated
- Wheat - not irrigated
- Potato - irrigated
- Potato - not irrigated
- Jute
- Sugar cane
- Pulses (area weighted averages for masur, mung and mashkalai)
- Oilseeds (mustard)
- Spices (chillies used as typical spice crop)
- Vegetables (brinjal used as typical vegetable crop)

Data from both primary and secondary sources have been reviewed in order to make estimates of agricultural input use. For the revised Region Plan particular use has been made of the field investigations carried out for the Gumti II and Noahkali Project feasibility studies. This information has been checked against the secondary data sources used in the draft regional plan, and more recent secondary data from other studies such as FAP 12.

The Consultants' assumptions on input levels by crop are summarised in Table 3.6.

3.2.5 Crop Yields

a) Present Yields

Sources of information on crop yields are reviewed in the agricultural annex.

Results of the survey of 800 farmers in the Gumti II and Noahkali feasibility study areas (which together cover 31% of the region) are compared in Table 3.7 with the most recent BBS data (average of 1989/90 to 1991/2) and the results of a survey conducted by FAP 12 in and around the Meghna Dhonaghoda Irrigation Project area. Yield assumptions used in crop budgets are also shown in Table 3.7. BBS yield data gives considerably lower estimates for rice yields than the farmer surveys. DAE also collect crop yields statistics and their yield data is generally above that of BBS, but below that of farmer surveys. The higher yield levels assumed in crop budgets generally reflect the results of the farmer surveys. These yield levels are confirmed by other sources of information such as the annual monitoring survey for 1991 for the DTW II project covering some of the northern part of the project area which gave a yield of 5.5 tonnes per ha for boro.

TABLE 3.6

Use of Crop Inputs

Crop	Labour (man) (days)	Draft Anim' (pr dys)	Seed (kgs)	Fertiliser (kg)			Dung	Pest'[illegible]
				Urea	TSP	MP		
B Aus, local	141	45	85	80	40	0	1000	0.2[illegible]
T Aus, HYV	176	47	30	140	50	10	1000	0.5[illegible]
B Aman local dw	109	44	83	40	0	0	0	0.1[illegible]
T Aman, local	168	40	44	100	40	0	0	0.2[illegible]
T Aman, HYV	181	40	30	140	110	35	700	1.1[illegible]
Boro, local	118	25	40	120	0	0	0	0.0[illegible]
Boro, HYV irrig	211	45	30	193	160	45	1000	1.0[illegible]
Wheat irrig.	127	45	130	130	115	80	0	0.3[illegible]
Wheat unirrig.	102	45	130	130	80	50	0	0.3[illegible]
Potato irrig.	194	44	1000	277	290	102	1500	1.1[illegible]
Potato unirrig.	175	44	1000	277	290	102	1500	1.1[illegible]
Jute	215	45	9	89	67	9	2000	0.0[illegible]
Pulses: ave.	51	30	31	0	0	0	0	[illegible]
Mustard	58	37	10	192	144	40	750	0.1[illegible]
Sugarcane	255	65	5000	88	41	7	3000	0.[illegible]
Spices (chilli)	157	30	1	100	180	90	2500	0.0[illegible]
Veg. (brinjal)	270	44	1	100	60	40	2500	0.3[illegible]

TABLE 3.7

Comparison of Yield Data from Different Sources

Tonnes per hectare (rice as paddy)	Farmer survey	FAP 12 (MDIP) project	FAP 12 (MDIP) outside	BBS avg. 1989-91	Used in crop budgets
B Aus, local	1.89	2.08	2.04	1.43	1.90
B Aus, HYV	2.65	3.59			n/a
T Aus, local	2.36	2.99			n/a
T Aus, HYV	3.17	4.22		2.76	3.10
Mixed aus/aman	3.01	1.71	1.14		n/a
B Aman local d.w.	1.73	1.87	2.04	2.21	1.75
T Aman local d.w.	2.5				n/a
T Aman, local	2.3	3.31	1.29	2.07	2.30
T Aman HYV	3.52	4.66	2.8	3.09	3.55
Boro, local	0	3.15		2.22	2.80
Boro, HYV	5.37	5.04	4.47	4.06	5.10
Wheat irrigated	2.25	1.92	1.98	2.09	2.25
Wheat unirrigated	1.99	1.96	1.98	2.09	1.80
Potato irrigated	15.03	9.52	17.38	11.45	15.00
Potato unirrigated	11.49	9.52	17.38	11.45	11.00
Jute	1.83	1.26	1.02	2.12	1.90
Pulses: keshari	0.76		0.9	0.64	0.70
mung	0.62		0.9	0.66	0.60
masur	0.48		0.9	0.79	0.50
mash	0.70		0.9	0.00	0.70
Mustard	0.76	0.74	0.49	0.77	0.75
Sugarcane	38.41	32.8		32.64	36.00
Spices (chilli)	2.05	1.21	0.58	2.31	4.00
Veg. (brinjal)	8.01			7.18	8.00

h) Future Yields

Previous appraisals of FCDI projects have commonly assumed that substantial input supply and agricultural extension programmes would accompany projects, and that farmers would use recommended doses of inputs and receive yield rates appropriate to these levels of inputs. In reality, while FCDI projects and irrigation have generally been found to lead to changes in cropping patterns (due to altered flood phasing), it is not immediately apparent that they have resulted in an increase in input application or yields received for a given crop type grown under the same land and water conditions as before.

In one of the most detailed recent evaluations of a major FCDI project (Thompson 1989), no differences were found in yields for winter crops (mainly boro) and aus between Chandpur Irrigation Project (CIP) and adjacent 'control' areas outside the project boundaries. In summarising the yield impacts of FCDI the following extract from Thompson is particularly relevant:

> "Flood protection appears to be successful in maintaining yields closer to 'normal' in unusual flood years, compared with unprotected areas, but otherwise CIP has not provided an additional benefit over the switch in cropping pattern. That is, yields in a normal year are not higher compared to outside when the same type of paddy is considered. In general this probably reflects levels of input use .. . fertiliser use for a given crop type is not higher inside CIP compared to outside areas.
>
> "Thus CIP does not appear to have provided more effective extension services relative to non-project areas, nor has any supposed increase in wealth due to more productive agriculture been reinvested as working capital in an attempt to further increase yields."

This finding is supported by detailed analysis of farmer survey results which did not identify any improvement in yield or associated change in input use for the same crop grown on higher, and therefore less flood-prone, land. Although evaluations of completed projects by FAP 12 has in some cases identified yield improvements inside FCD project areas (see Table 3.7), it concluded that:

> " in most projects the major impact on weighted mean paddy yields is from farmers switching to more productive types of paddy when hydrological conditions change sufficiently to permit this".

For the purposes of the pre-feasibility economic analysis, it has been assumed that for a given crop type a single yield value (and level of inputs) is applicable in both the without and with project conditions. The yield figures used have been assumed to allow for normal levels of crop damage due to flooding. Differences in yields between the with and without project cases have been assumed only in cases where flood protection would cause a reduction in the average annual level of crop damage (see section 3.2.7).

Similarly no difference is assumed between present and future yields (with and without the project). There is no evidence that there is an upward trend in the yields of individual crops. Analysis of BBS statistics by IFDC[1] indicate that although hyv boro yields rose by 0.3% per year from 1973 to 1979, they then declined by 0.4% per year up to 1989, despite increased use of fertiliser. This is attributed to an increasing proportion of the expanding area being grown under less suitable conditions. Boro yields are best on heavy soils and these areas were the first to be cultivated with the crop. As boro expands it has in turn pushed wheat, pulses and oilseeds on to more marginal land so their yields have also suffered. Analysis of data on hyv aman paddy IFDC[2] shows an annual yield decline from 1972 to 1988 of 0.5%. Analysis of yields reported by BBS for the region shows a pattern of static yields for major crops over the last six years (see Agriculture Annex). Static and declining yields are also attributed to increasing cropping intensity, reduced flooding (which may add silt and organic matter to the soil, reduced production of pulses and use of animal manure (both of which improve soil structure and fertility.

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[1] Farm Level Fertiliser Use Survey, 1990/1 Rabi/Boro Season, I Jahan, K Sanyal, IFDC, 1993

[2] Farm Level Fertiliser Use Survey, 1989 Aman Season, Sidhu and Ahan, IFDC 1991

This approach, both for with and without project, and present and future yields, is consistent with the FPCO Guidelines for Project Appraisal (Agricultural Impact Assessment - Modified February 1993).

3.2.6 Crop Flood Damage

It is extremely difficult to place a value on the cost of flood damage to crops. Farmers assess flood risk in planning their cropping pattern and are able to minimise losses by selecting appropriate crops. Statistics from DAE and BBS vary widely, but BBS appears to be more consistent and has been used for the purposes of this report. Damage frequency curves have been plotted using hydrological data from the SERM model and BBS data for the Comilla and Noahkali regions. Details of these calculations are in Annex II.
The 'expected' annual average crop damage, calculated as the sum of the damage frequency differentials between 1985 and the other years for which data are available (1983, 1984, 1987 and 1988) has been estimated to be as follows:

Annual Average Crop Damage
(per cent of planted area)

	aus and aman	jute
Comilla region	3.26	0.63
Noakhali region	0.22	0.00

For the evaluations of those projects which would provide a significant degree of flood protection, the average crop damage reductions have therefore been taken as being equivalent to 3.26% of areas planted to aus and aman and 0.63% of jute areas for projects in planning units within Comilla region. The expected flood damage levels in Noakhali are negligible (0.2% for aus and aman) and therefore no reductions in crop flood damage have been assumed for projects in Noakhali region.

Damage to boro has been difficult to assess as losses due to flash floods are generally not recorded in flood loss statistics. Analysis of farmer interviews in the Gumti II area suggest that the average annual loss is between 3% and 5% in areas prone to flash flooding. As the higher figure refers to a quite limited sub-project area, the regional plan has assumed an overall loss of 3% in planning units that are vulnerable to flash floods.

The value of these losses has been assumed as the gross crop value less 25% of the total costs (to allow for harvesting and other costs saved). The value of reduced flood losses has been incorporated into project cash flows separately from farm income to enable the magnitude of this benefit to be clearly identified and sensitivity tests to be carried out.

3.2.7 Financial and Economic Prices for Crops and Inputs

A summary of the financial and economic prices used in this report is presented in Table 3.8 and 3.9. The basis for these price estimates is described below.

Financial Prices

Market prices of agricultural commodities were collected from a sample of producer markets for the Gumti II and Noahkali studies. These prices have been used for the revised regional plan. Prices are farmers' selling prices at the harvest period and have been adjusted for farm to market transport. They were collected from AMD market statistics for the period 1989 to 1992. Three year averages were calculated for the periods 1989-1991 and 1990-92. The 1989-91 prices were used as 1991 Financial Prices in financial appraisal, and as a base for calculation of economic prices. The 1990-2 prices were used to calculate 1992 financial prices as a comparison with 1991. No allowance for inflation was incorporated in these calculations as no upward trend could be discerned in price data from individual markets over the period covered.

Data on the cost of labour, draught animals and other inputs were obtained from farmer case studies in Gumti and Noahkali. Although the use of power tillers is becoming widespread, the cost of cultivations amount to much the same as those using hired draught animals. The price of draught animals in the Table 3.9 is for a bullock pair less the cost of the attendant that is invariably hired with the animals. This is to avoid double counting of labour cost as crop labour requirements also include an allowance for cultivations with draught anmials.

Economic Prices

Economic prices have been derived from 1991 financial prices using conversion factors provided by FPCO. for tradable commodities these conversion factors are calculated from the 1995 World Bank Commodity Price forecast converted to 1991 prices, using an exchange rate of Tk38 = $1. Export parity prices have been used for urea and jute, import parity for wheat, sugar, TSP, MP and oilseeds. For rice a mid-point price between import and export parities has been used to reflect the fact that Bangladesh is more or less self sufficient in this commodity. Other crops have been revalued using the standard conversion factor of 0.87.

The consultants have a number of reservations about this approach. These include the use of 1991 prices for projects evaluated in 1993, and the use of conversion factors for tradable commodities rather than actual economic prices (which would remove variations caused by local market conditions within Bangladesh). However FPCO is keen to maintain consistency with other FAP projects, so their guidelines have been adopted in full, apart from a correction of an error in the conversion factor for wheat which has been increased from 1.29 to 1.44 to remove a processing adjustment from wheat to flour as farmers actually sell wheat as grain.

TABLE 3.8

Financial and Economic Prices for Agricultural Products

Main Products		unit	Financial Prices (Taka)		Conversion Factor	Economic Prices
			(1991)	(1992)		(1991)
B Aus		kg	6.17	6.17	0.88	5.43
T Aus		kg	6.17	6.17	0.88	5.43
B Aman		kg	6.96	7.47	0.88	6.12
LT Aman		kg	6.96	7.47	0.88	6.12
HYV Aman		kg	6.96	7.47	0.88	6.12
L Boro		kg	5.89	6.19	0.88	5.18
HYV Boro		kg	5.89	6.19	0.88	5.18
Wheat		kg	6.53	7.18	1.44	9.40
Potato		kg	4.09	4.16	0.87	3.56
Jute		kg	7.94	7.67	1.06	8.42
Pulses: keshari		kg	12.63	12.31	0.87	10.99
mung		kg	17.62	17.05	0.87	15.33
masur		kg	20.48	21.89	0.87	17.82
mash		kg	12.11	14.57	0.87	10.54
Groundnuts		kg	13.93	13.27	0.88	12.26
Mustard		kg	13.93	13.27	0.88	12.26
Sugarcane		kg	0.70	0.70	0.95	0.67
Spices (chilli)		kg	7.64	8.40	0.87	6.65
Veg. (brinjal)		kg	3.73	3.79	0.87	3.25
By Products						
Rice straw	HYV	kg	0.50	0.50	0.87	0.44
	local	kg	0.50	0.50	0.87	0.44
Wheat straw		kg	0.50	0.50	0.87	0.44
Jute sticks		kg	1.11	1.11	0.87	0.97
Pulse straw		kg	1.50	1.50	0.87	1.31
Oilseed straw		kg	0.23	0.23	0.87	0.20

TABLE 3.9

Financial and Economic Prices for Agricultural Inputs

Inputs	Unit	Financial Prices (Taka) (1991)	Financial Prices (Taka) (1992)	Conversion Factor	Economic Prices (1991)
Human Labour	day	40.00	43.00	0.75	30.00
Bullock pair*	day	40.00	57.00	0.87	34.80
Seeds					
B Aus	kg	9.26	9.26	0.88	8.15
T Aus	kg	9.26	9.26	0.88	8.15
B Aman	kg	10.44	11.21	0.88	9.19
LT Aman	kg	10.44	11.21	0.88	9.19
HYV Aman	kg	10.44	11.21	0.88	9.19
L Boro	kg	8.84	9.28	0.88	7.78
HYV Boro	kg	8.84	9.28	0.88	7.78
Wheat	kg	9.80	10.80	1.44	14.11
Potato	kg	9.50	10.00	0.87	8.27
Jute	kg	22.00	22.00	1.06	23.32
Pulses	kg	24.00	24.00	0.87	20.88
Groundnuts	kg	19.00	19.00	0.88	16.72
Mustard	kg	19.00	19.00	0.88	16.72
Spices (chilli)	kg	600.00	600.00	0.87	522.00
Veg. (brinjal)	kg	400.00	350.00	0.87	348.00
Fertiliser					
Urea	kg	4.72	5.26	1.45	5.90
TSP	kg	5.78	7.60	1.88	10.76
MP	kg	4.54	7.24	2.02	8.27
Animal manure	kg	0.10	0.10	0.87	0.09
Pesticide	kg	500.00	500.00	0.87	435.00
Deisel fuel	litre	14.00	14.00	0.63	8.82
Irrigation (diesel pumps)					
LLP	ha	2462	2462	0.63	1545
STW/DSSTW	ha	5089	5089	0.63	3211
DTW/FMTW	ha	5928	5928	0.62	3686
(typical irrigation fees, not above financial cost used in financial farm budgets)					

Notes: Financial prices are based on an average of a number of local producer markets.
Conversion Factors are from FPCO Guidelines on Economic Analysis
* price of draught animal pair excludes attendant

3.2.8 Costs of Minor Irrigation

Capital and annual operating costs for different types of minor irrigation equipment have been estimated on the basis of surveys of pump operators, farmers and secondary data. Details of cost calculations are in Annex IX. Costs have been calculated for a range of different modes including:

a. LLP 1 - 0.7/1.0 cu.sec pump irrigating 10 ha, using the same 8hp engine as a STW.

b. LLP 2 - 2 cusec pump irrigating 20 ha.

c. STW - a conventional STW using a Japanese engine. Although many STWs have cheaper Chinese engines, these are slightly less fuel efficient and have a shorter life (crankshafts usually break after 2 or 3 years, so their overall cost has been calculated to be slightly higher than the Japanese engine.

d. DSSTW - as for the STW but in an unlined pit 1.5 m deep.

e. DFMTW 1 - a 1 cusec version of a DTW for deeper aquifers. Now that BADC is no longer installing DTWs it is likely that future private investment in this mode will be in this type of smaller well. Although most existing DTWs are the larger and more costly 2 cusec wells, the cost of a smaller cheaper well has been used as the replacement cost of existing DTWs.

Capital costs include the cost of water channel construction (unlined earth). Costs of additional LLP required for surface water irrigation schemes has not been included in the cash flow as a capital item, with replacement costs being incorporated at the end of their life. Rather capital costs for both existing and additional equipment has been annualized over the life of the well/pump at an interest rate of 12% per year (16% at financial prices). Not only is this approach more straightforward, and treats project related and non-project investments in the same way, but it is more than likely that many of the LLPs purchased by farmers would be second-hand and so have a different cost and replacement profile. This approach can distort IRR calculations if returns are very different from the 12% discount rate, however the cost of LLPs is small relative to overall project costs and benefits.

Operating costs are based on an irrigation water pumping requirement of 740mm per year. Although this is about 25% less than the calculated crop water requirements for boro in Gumti, it is thought to reflect the actual amount that farmers apply. If the full crop water requirement is provided, then irrigation costs at financial prices for STW and DTW exceed the actual fees charged, leaving the pump operator to make a loss. In addition it would require tubewells to operate for unrealistically long hours to supply known command areas. What farmers are doing is making a realistic compromise between irrigation costs and crop water requirements.

The cost of the different modes is calculated as follows:

Financial prices

	Operating cost	Capital Cost	Total Cost (Taka/ha)
LLP 1	1302	1132	2434
LLP 2	1171	1319	2491
STW	2411	2537	4948
DSSTW	3050	2605	5655
DTW 1	3310	2619	5928

Economic prices

	Operating cost	Capital Cost	Total Cost (Taka/ha)
LLP 1	866	675	1541
LLP 2	769	779	1548
STW	1607	1503	3109
DSSTW	2063	1556	3619
DTW 1	2137	1549	3686

Economic prices have been calculated using conversion factors laid down by FPCO. These substantially reduce both capital cost (by removal of import duties) and fuel and other operating costs.

Average costs by mode have been calculated as, for LLP, the average between LLP 1 and LLP 2, and for STW/DDSTW, an average weighted 80% STW and 20% DSSTW. The cost of traditional irrigation has been calculated as a labour cost Tk7,200 per ha in financial prices or Tk5,400 at economic prices. This is substantially more than alternative sources such as LLP and STW. In fact what the farmer is paying for with his own labour is a saving on hiring a mechanical pump. Therefore the labour cost has been reduced by 50% which puts it between an LLP and STW. In practice actual labour use may be less than 180 days per ha as farmers apply less than optimal amounts of water. There is evidence from Gumti (but not Noahkali) that traditionally irrigated boro does yields less (and also gets lower levels of fertiliser).

Crop budgets at financial prices include irrigation costs based on fees charged in pumps surveyed in the Gumti II irrigation pump survey. For boro this was:

LLP	Tk	4090 per ha
STW		5348 per ha
DTW		5019 per ha

An overall fee for irrigating boro has been calculated using the average for different modes weighted by the proportion of modes found in the region. The cost for other crops has been calculated according to the proportion that their fees are to the boro fee. These costs are:

Boro	Tk	4377 per ha
T Aus		1425
Wheat		2257
Potatoes		3068

Only 25% of the aus fee is applied as it is assumed that most crops get no irrigation. For wheat and potatoes the full amount is applied to the irrigated crop budget. It is assumed that local boro only needs half the irrigation of hyv boro as it is grown in naturally wet places. In both Noahkali and Gumti a flat rate irrigation fee is the normal method of charging for water, rather than a share of the crop.

For the purposes of comparing technologies and assessing the potential for groundwater use under difficult conditions a number of other technologies have been evaluated in Annex IX. These indicate that both DSSTW and SFMTW can provide an economic alternative to STW in situations where the water table has fallen sufficiently to reduce the efficiency of STW operation.

3.3 Crop Budgets

3.3.1 Economic Returns

Net economic returns to each of the major crops, based on the above data sets for input use, yields and prices, are presented as Table 3.10. These basic crop models have been used in the evaluations of crop production in each pre-feasibility study, using the methodology described in Section 3.4 below. These budgets show that, apart from high value crops such as vegetables, spices and potatoes, the returns to HYV aman and boro, together with irrigated wheat, are better than for most other field crops. This suggests that FCDI development which enables more of these crops to be grown, will result in good increases in farm incomes in terms of economic prices. However net income at financial prices is significantly lower (see section 3.3.2).

3.3.2 Financial Returns

Net financial returns per hectare have also been calculated for individual crops and for each major land category (F0 - F3, with and without irrigation). Tables showing these calculations are in Annex VIII. The results of these calculations are summarised in Tables 3.11 and 3.12. Unlike the net economic returns in Table 3.10, financial net returns include irrigation costs. Neither financial nor economic crop budgets include a specific allowance for the cost of seasonal credit as farmer surveys have determined that few farmers borrow money from informal or formal sources for this purpose. In addition the 10% allowance included for miscellaneous costs according to the FPCO Guidelines is sufficient to cover the small amount of credit that farmers do require.

The financial crop budgets also show a general increase in income for crops grown on irrigated and/or less flooded land, however the returns to irrigated wheat are relatively poor, which is reflected in the declining popularity of this crop.

TABLE 3.10

Gross Income, Costs and Net Income per Hectare (Taka) Economic prices

Crop	Gross Income			Production Costs				Total	Net
	Main Crop	By-Product	Total	Labour	Draught	Seed	Fert.& Pest.	Costs	Income
B Aus. local	10316	1653	11969	4227	1566	693	1098	8342	3627
T Aus. HYV	16832	1349	18180	5280	1636	244	1751	9802	8378
B Aman	10718	761	11480	3278	1531	763	293	6450	5029
T Aman. local	14087	2001	16088	5040	1392	404	1129	8762	7326
T Aman HYV	21743	1544	23287	5415	1392	276	2864	10941	12346
Boro. local	14513	2436	16949	3540	870	311	708	5972	10977
Boro. HYV irrig	26434	2219	28653	6330	1566	233	3754	13072	15581
Wheat irrig.	21157	979	22136	3810	1566	1835	2796	11007	11129
Wheat unirrig.	16926	783	17709	3048	1566	1835	2172	9482	8227
Potato irrig.	53375	0	53375	5820	1531	8265	6206	24005	29370
Potato unirrig.	39141	0	39141	5250	1531	8265	6206	23378	15764
Jute	15991	3670	19661	6435	1566	210	1494	10676	8985
Pulses: ave.	8808	914	9721	1521	1044	647	0	3534	6188
Mustard	9194	150	9344	1725	1288	167	3121	6931	2413
Sugarcane	23275	0	23275	7650	2262	3325	1497	16207	7068
Spices (chilli)	26587	0	26587	4710	1044	522	3488	10740	15847
Veg. (brinjal)	25961	0	25961	8100	1531	174	1914	12891	13069

Note: Total costs include an additional 10% for miscellaneous costs

TABLE 3.11

Gross Income, Costs and Net Income per Hectare (Taka) Financial prices

Crop	Gross Income			Labour	Production Costs		Irrig.	Fert.& Pest	Total Costs	Net Income
	Main Crop	By-Product	Total		Draught	Seed				
B Aus. local	11723	1900	13623	5636	1800	787		834	9963	3660
T Aus. HYV	19127	1550	20677	7040	1880	278	356	1345	11989	8688
B Aman local dw	12180	875	13055	4370	1760	867		254	7975	5080
T Aman. local	16008	2300	18308	6720	1600	459		828	10568	7740
T Aman. HYV	24708	1775	26483	7220	1600	313		2106	12363	14120
Boro. local	16492	2800	19292	4720	1000	354	2189	566	9712	9580
Boro. HYV irrig	30039	2550	32589	8440	1800	265	4377	2640	19275	13314
Wheat irrig.	14693	1125	15818	5080	1800	1274	2257	1792	13423	2395
Wheat unirrig.	11754	900	12654	4064	1800	1274		1453	9450	3204
Potato irrig.	61350	0	61350	7760	1760	9500	3088	4147	28880	32470
Potato unirrig.	44990	0	44990	7000	1760	9500		4147	24647	20343
Jute	15086	4218	19304	8580	1800	198		1048	12789	6515
Pulses: ave.	10124	1050	11174	2028	1200	744		0	4369	6805
Mustard	10448	173	10620	2300	1480	190		2045	6617	4003
Sugarcane	24500	0	24500	10200	2600	3500		1234	19288	5212
Spices (chilli)	30560	0	30560	6280	1200	600		2171	11276	19284
Veg. (brinjal)	29840	0	29840	6280	1200	400		2171	11056	18784

Results of the analyses of net financial returns per ha by land category are summarised in Table 3.12. Financial returns including or excluding family labour, increase with higher better drained land. Returns are highest on F0 land, and lowest on F3 land. In each land class net returns increase substantially if irrigated crops are grown.

TABLE 3.12

Summary of Net Returns per Hectare by Land Category

1991 Financial Prices

Land Category	Gross income	Total cost incl. family labour	Total cost excl. family labour	Net income incl. family labour	Net income excl. family labour	Improvement in Net inc. (incl. family labour) drain.	Improvement in Net inc. (incl. family labour) Irrigate
F0I0	35944	17877	11603	18067	24341	3551	
F0Ir	60378	33004	23166	27373	37211	4358	9306
F1I0	32545	18028	11573	14516	20972	7814	
F1Ir	52829	29813	20804	23016	32025	7533	8499
F2I0	17637	10935	7237	6702	10400	2010	
F2Ir	38410	22927	16752	15483	21658	1360	8781
F3I0	11278	6587	4334	4692	6944		
F3Ir	34260	20137	14787	14122	19472		9431

Returns with and without family labour assume a standard contribution family labour which varies from crop to crop, but is the same for all sizes of farm. In practice the smaller farmers hire much less labour, so returns per man day have been calculated using the farm models in Annex VIII.

These calculations show that the assumed cropping patterns are financially viable and that farmers will benefit from improved drainage, flood control and irrigation.

3.4 Models for Analysis of Incremental Crop Production

Cropping patterns for each planning unit have been calculated by multiplying the relevant MPO area cropping pattern for different land categories (see Section 3.2.4 above) by the area (hectares) of each land category within the particular planning unit. Net crop income (excluding on-farm irrigation costs) has then been calculated for each planning unit by multiplying the net economic returns for each crop by the area of each crop within each planning unit.

As already noted in the previous section, orchards have been excluded from these calculations. In all cases the area of orchard has been maintained at its present levels and excluded from the effective NCA for annual crops. This avoids the possible replacement of orchards in the with project scenario with less profitable irrigated crops. In practice the area of orchards might expand with an increased area of F0 land. In this case project benefits would increase.

The analysis has been carried out for the following cases:

- Present (1991)
- Project Year 1 (1994/95 - see Section 3.1.)
- Future without (1): without project conditions, in the year in which full benefits would have been achieved in the with project case, taken to be Project Year 10 (see Section 3.5 below)
- Future without (2): without project conditions in Project Year 30 (the final year of the analysis period)
- Future with (1): with project conditions in Project Year 10
- Future with (2): with project conditions in Project Year 30.

For projects in which there is no further unexploited potential for groundwater irrigation development, the Present and Future without cases (1) and (2) have been assumed to be identical.

Where there is further scope to develop groundwater irrigation, it has generally been assumed that development of the resource will continue either with or without the project. The area irrigated with groundwater has been assumed to increase at 10% per year for each mode (shallow and deep tubewells), up to the time at which the limit of physical availability of groundwater is reached, or at which the practicable limit for irrigation (generally taken to be 75% of the land area in a particular flood category) has been reached. The growth rate of 10% is approximately equivalent to the average annual growth of minor irrigation achieved over the past decade in Bangladesh as a whole. The 75% limit on the area to be irrigated within each land category is an assumption based on the likely practical constraints to further development which are imposed by land tenure, organizational factors and local topography. In these cases, Future without (1) corresponds to Project Year 10 and Future without (2) to Project Year 30: the differences in net crop incomes between these two dates will arise from increases of groundwater irrigation in the area.

On-farm irrigation costs were computed in the next stage of the analysis, using the cost per hectare data given in Section 3.2.9 above.

3.5 Phasing of Incremental Benefits

Incremental crop benefits comprise the difference between crop incomes (net of production costs) in the 'with' and 'without' project cases, over the 30 year appraisal period. Changes in net crop income in the without project case have been phased in accordance with the forecast growth of the irrigated area, as described above. Net crop income in the with project case has been assumed to be the same as in the without project case during the project construction period (assumed to be from Project Years 1-5, as discussed in Section 3.1). Project incremental benefits have then been assumed to be built up over a five year period from Project Years 6-10. In the first year of project operation (Project Year 6) incremental benefits will be 20% of the full level, increasing to 40% in the second year of operation, 60% in the third year, 80% in the fourth year and 100% in the fifth year (Project Year 10). This phasing of incremental benefits corresponds to that recommended in the FPCO 'Guidelines'. For Chandpur Project, where it is proposed to retire embankments, the evaluations have been based on a rapid construction period since it is assumed that these works will be treated as urgent and the benefits, which take the form of reduction in losses, will accrue immediately.

The final output of the agricultural model was the stream of incremental net crop benefits for the period from Project Year 1 to Year 30. This net benefit stream was then carried forward for the analysis of overall project costs and benefits.

3.6 Methodology for Estimating Impacts on Fisheries

3.6.1 Introduction

The main potential impacts of FCD and FCDI projects on fisheries can be summarised as follows:

a) **Negative impacts**

(i) Construction of flood control embankments and/or drainage works reduces the area of floodplain available for fish spawning, nursery and feeding grounds, reducing overall fish production potential both within and outside the FCD area. Within the area, this affects not only the capture fishery but also pond culture fishery, which depends partly on the collection of fish fry from the wild.

(ii) Construction of regulators or cross dams on rivers prevents migration of fish to and from breeding grounds, resulting in reduced stocks of affected species both within and outside specific project areas; within FCD areas, the result will be a change in the species composition, with the migratory species (principally higher value carp and prawns) being displaced by resident (generally lower value) fish species.

(iii) Access to the reduced areas of open waters within FCD schemes for the purpose of 'subsistence' fishing may be restricted, with detrimental consequences for nutrition, particularly of the poorest sections of the community who obtain a significant part of their animal protein and vitamin intake from fish caught in 'common property' waters.

(iv) Increased use of chemical fertilisers and pesticides, resulting mainly from the extension of the area of irrigated high yielding crop varieties within flood controlled areas, accelerates the contamination of natural water bodies and may lead to higher fish mortality rates.

(v) Reductions in fish stocks endangers the livelihood of professional full time fishermen, who may be obliged either to emigrate from the area or to seek employment as unskilled labourers.

b) **Positive impacts**

(vi) Improved water control reduces the risk of loss of stocks in fish ponds due to flooding, and may thereby encourage a more rapid development of fish farming, subject to availability of fish and/or shrimp fry -see (i) above. Benefits will, however, accrue mainly to land owners with adequate areas for fish ponds rather than to displaced capture fishermen or other poorer groups.

(vii) Improved control similarly improves the prospective returns from stocking and management of fish production in other water bodies such as canals and borrow pits.

Quantification of any of these impacts is subject to a high degree of uncertainty, due to:

- an absence of reliable data on current fish resources (species composition, standing stocks, etc.)
- inadequate information on present fish catches (quantities by species from different water bodies) and past trends in catches
- limited data on catch rates achieved by different categories of fishermen (full-time, part-time or subsistence)
- inadequate information on the numbers, locations, status (cultivated or uncultivated) and yields of ponds
- limited experience of the actual impacts of FCD schemes on the fisheries resource.

Despite these data deficiencies, an attempt has been made in this Report to quantify the potential scale of the reduction of fish catches from open water within specified project areas as a result of project interventions. These are to a very large degree based on the fisheries and environmental assessments carried out for the Gumti II and Noahkali studies, and from data that is beginning to emerge from FAP 17.

The basic assumptions on which the quantified estimates of fisheries impacts have been made are described in section 3.6.2 below. Results for each proposed project are given in the individual project evaluations.

3.6.2 Impact on Capture Fisheries Production

Losses of output of capture fisheries are assumed to be caused primarily through:
- obstruction of fish migration and spawn from embankments, regulators etc.
- reduction in the area of flood plains and the duration of flooding.

Production in rivers and khals has been ignored as data from FAP 17 and the feasibility studies indicate that they produce only a small proportion of fish from within potentially impacted areas, and are also relatively less affected by FCDI.

The average productivity of flood plain fisheries is based on the newly available data from FAP 17 of 152 kg per ha. This is much higher than previous estimates of 50-70kg per ha. Obviously if a flood plain is completely drained this production will be lost in total. It is assumed that there is no production from land flooding to less than 30 cm (F0). On other flood land it can be assumed that production is, to some extent, proportional to the length of the flood period. If it is assumed that, everything else being equal, that land that floods deeper also floods for longer, then this land will have a higher fish yield, and land converted from, say, F3 to F1, will suffer some loss. The overall average yield by flood plains has been weighted for individual flood phases via some assumed factors. This enables flood phase yield to be calculated as:

	F1	F2	F3	Average
Fish production factor	3.0	3.5	4.0	
Fish production kg/ha	138	161	184	
Share of F1-F3 land in SER	52%	33%	15%	100%
= average production	72	55	28	152

In addition losses are caused by obstructions to migrations. A factor for this has been assessed subjectively together with an overall assessment of the flood plain productivity which varies according to proximity to major rivers. This factor is assumed to be 100% in an average flood plain fishery, to 150% in an exceptionally productive fishery, to 50% in a totally empoldered area.

These factors interact: obstruction reduces fish access to floodplain while drainage reduces the area / duration of where the potential production can take place.

To assess the economic impact of FCD it is necessary to:

- value the catch in terms of potential sales by fishermen
- calculate the cost of catching in terms of gear cost and fishermen' time

Both of these are themselves affected by FCD.

Surveys by FAP 17 show that fishermen get about 69% of the published market prices for fish. A survey for the Gumti II study collected the following data on fish catch and market prices, which has been converted to fishermen' prices by deducting 31%:

	tonnage	market price		fishermen's price
High value fish	5039	Tk58/kg		Tk40.02
Medium value fish	5835	39		26.91
Low value fish	15727	27		18.63
			Weighted average	24.50

For the regional plan this has been simplified, for an average flood plain, as:

High value fish	25% of catch @ Tk40.03/kg ex-boat	
Low value fish	75% of catch @	18.63
Overall average		23.98

Obstruction to migration affects the value of the catch as few high value carp are caught in obstructed areas. The proportion of high value fish is assumed to be up around 40% on an unobstructed flood plain, but declines to nothing with total obstruction and loss of potential.

The cost of catching has been calculated as Tk30 for one day of labour, plus Tk10 per day for gear with a daily catch of 3kg. In fact most fishermen are self-employed and the Tk30 represents a low season agricultural wage rate (being lower than the Tk40 used in crop budgets). It could be argued that a lower figure should be used as fishermen have few alternative sources of income. but it could also be said that the catch rate of 3kg per day is on the high side, and a "wage" of Tk20 per day with a 2kg catch represents the same cost per kg of fish. As the yield potential of the flood plain falls the unit effort needed to catch the remaining fish will increase, so daily catches will fall and costs per kg of fish will rise.

The net value of fisheries has been calculated as the ex-boat production value less the cost of catching. This has been converted into economic prices using the SCF of 0.87 for fish and gear, and labour conversion factor of 0.75. The net value of the fishery can fall below zero if average daily catches are worth less than the Tk30 nominal wage plus Tk10 gear cost - in this case fishermen' income falls below Tk30. Losses of net benefits from the more productive fisheries will be split between fishermen and lessors of jalmahals, (controlled fishing grounds) who will be able to extract less rent from fishermen to the point where it is no longer worthwhile to enforce their fishing rights.

Mitigation measures, such as incorporation of fish passes in river regulation structures, operation of regulators to allow the migration of fish out of and into FCD areas at critical periods of their life cycle, or the allocation of areas of land within FCD schemes for controlled flooding, have been considered in the analysis of fisheries for the Regional Plan. However, the effectiveness of these and similar measures has yet to be demonstrated under Bangladesh conditions. Consequently any quantification of the benefits or mitigation impact of such measures would be necessarily arbitrary and has therefore not been attempted in this study. Although it would be possible to restock empoldered areas with fingerlings, and on papaer this appears to be an economic proposition, it may not in practice be feasible in many of the project areas because of the limited duration of flooding (about 5 months is needed for restocking). In addition issues of cost recovery and sustainability, as well as division of benefits amongst fishermen and others, have yet to be resolved by the two projects currently involved in restocking.

3.6.3 Impact on Culture Fisheries Production

Fish pond production is also assumed to be unaffected by FCD apart from a significant reduction in flood damage which has been incorporated into non-agricultural flood loss assessment.

Improved control over flooding is expected to improve the productivity of culture fisheries and to encourage a more rapid development of the industry. Data presented in the MPO Technical Report Nr 17 indicate that for the Chandpur Irrigation (and Flood Protection) Project, the proportion of ponds cultivated increased from 16 per cent to 51 per cent in the first two years after project completion (1978 and 1979) and had reached the very high level of 95 per cent by 1984.

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To what extent these increases in fish cultivation can be attributed to flood control on its own is not clear. Fish cultivation in adjacent areas outside the Chandpur scheme also increased markedly during the 1980's. Some 56 per cent of households which owned a large pond in control areas outside the Chandpur scheme were engaging in fish cultivation by 1987, compared to around 12 per cent of households in 1977 according to recent surveys (Paul M. Thompson, 'The Impact of Flood Control on Agricultural Development in Bangladesh', 1989). Within the Chandpur Project area, Thompson's surveys showed that the proportion of households owning a large pond who cultivated fish had increased more than in the control areas, reaching 72 per cent in 1987. Chandpur has traditionally been an area of intensive fish cultivation, with a much higher concentration of fish ponds than in other parts of the South East Region. The applicability of the percentage increases in fish culture realised in Chandpur to other parts of the region is therefore questionable. A part of the growth in fish cultivation between 1977 and 1987 could also be attributed to the construction of the Raipur fish hatchery, which should have encouraged fish culture both within the Chandpur scheme area and in adjacent areas. A further part of the growth would have been due to a general increase in farmers' appreciation of the profitability of fish culture and better knowledge of the techniques.

3.6.4 Phasing of Fisheries Losses

It has been assumed that these losses will not be incurred until project completion (Project Year 6). In reality, there could be losses in earlier years once construction of embankments or regulators has started, but there is no clear basis on which to estimate such losses at this pre-feasibility stage of study.

As discussed above, no benefits from potential increases in culture fisheries production have been attributed to any of the projects at this pre-feasibility stage of analysis. Nor have any costs or benefits been included for the possible artificial stocking and management of open water bodies within different schemes.

3.7 Estimation of Non-agricultural Flood Damage

3.7.1 Direct Damage

Information on the extent of non-agricultural flood damage in the south-east region has not been collected on a systematic basis by the authorities other than in years of exceptional flooding. It is not therefore possible to compute an accurate damage-frequency curve for the region from which to estimate the average expectancy (in value terms) of non-agricultural flood damage, with or without additional flood protection works. Data are, however, available in some detail for the exceptional (1 in 50 year) floods which occurred in 1988. Data for 1985, when a 'normal', or 1 in 2 year flood occurred, indicate that non-agricultural flood damage in the south-east region was negligible. For estimating purposes, it has been assumed that the damage-frequency curve will be a straight line between these two years (1985 and 1988): this over-simplification is necessary in the absence of a more complete data set. This basis of estimation will tend to over-state the likely extent of direct flood damage, but does implicitly allow some margin for the indirect costs of flooding incurred as a result of the disruption of communications and transport, for example (see below).

Total non-agricultural damage in the south-east region in 1988 has been estimated at Tk 3 539.9 million. A summary of the loss estimates, compiled by the Consultants from data provided by the various authorities concerned, is given in Table 3.13. Further detail on sources and methods of estimation are provided in Annex VIII. Losses in Comilla region amounted to Tk 3 078.5 million and in Noakhali to Tk 461.4 million. Average damage per square km amounted to Tk 458 600 in Comilla region as a whole; damage was highest in Brahmanbaria District, and lowest in Comilla District. In Noakhali region, losses averaged only Tk 87 600 per square km.

TABLE 3.13

Summary of Non-agricultural Damage by District

District	1988 (Tk million)	Non-agricultural Damage Area (sq km)	Average damage (Tk'000)	
			per sq km	per ha
Brahmanbaria	1 331.1	1 916	694.7	6.9
Chandpur	588.8	1 704	345.5	3.5
Comilla	881.4	3 093	285.0	2.8
Sub-Total	2 801.3	6 713	417.3	4.2
Unallocated/Comilla Region	277.2	6 713	41.3	0.4
Total Comilla Region	3 078.5	6 713	458.6	4.6
Feni	36.9	922	40.0	0.4
Lakshmipur	167.5	1 652	101.4	1.0
Noakhali	98.7	2 691	36.7	0.4
Sub-Total	303.1	5 265	57.6	0.6
Unallocated/Noakhali Region	158.3	5 265	30.1	0.3
Total Noakhali Region	461.4	5 265	87.6	0.9
Total SE Region	3 539.9	11 978	295.5	3.0

Source : Consultants' estimates - see Annex VIII.

Average annual non-agricultural flood losses have been calculated as the area under the damage-frequency curve, on the assumption that losses in a one in ten year flood (with a probability of 0.10) will be zero and losses in a one in 50 year flood (with a probability of 0.02) will be as computed for 1988. An allowance of 20% has been deducted for the concave shape of the curve. In the pre-feasibility studies, average non-agricultural flood losses have been valued on this basis at Tk153 per hectare (Tk15,300 per sq km) in Comilla region, and Tk34 per ha (Tk3,400 per sq km) in Noakhali region all in economic prices. It has been assumed that these losses will be avoided over the gross area that benefits from flood protection.

Benefits in terms of reduced damage to fish ponds has been calculated separately. Although official statistics suggest many ponds are not cultured. In fact surveys in the Gumti area show that the area of cultured ponds exceed the total pond area reported in statistics, so for the purposes of this calculation it is assumed that all ponds are cultured and produce 1760kg/ha (also from the Gumti survey). The area of ponds in all planning units are reported at around 2% of the gross area, so it is assumed that the potential damage is the loss of one year's production valued at Tk35/per kg (the price of carp less the cost of catching - about 20% of the gross value). This amounts to Tk61,600 per ha. Although less than one year's production may be lost, physical damage may also be done to the pond. The probability of damage is assumed to be 0.02 on the basis that no damage occurs in a one in ten year flood. This is Tk1232 per ha pond, or Tk25/ha of the area of the planning unit protected from damage. The value of flood damage has been increased annually by 3% to allow for population and economic growth. This is at the lower end of the range of increases suggested in the FPCO Guidelines, but the 1991 census indicates a reduced rate of populaiton growth.

3.7.2 Indirect Damage

Flooding can be expected to cause indirect financial and economic losses in addition to the direct losses which have been computed above. Indirect losses may include, for example, additional interest payments on working capital by industries, due to delays in deliveries of finished goods as a result of disruptions to transport. More general types of indirect economic cost may also be incurred: for example, levels of investment within a region may be generally lower because of the perceived risks of recurring flooding which could inhibit potential investors.

However, any assumptions concerning the likely scale of these types of indirect economic damage would be wholly speculative, since there is a complete absence of data on which to make any reliable estimates. As noted, the method of calculating direct damages does implicitly make some allowance for indirect damages.

3.7.3 Limitations of the Estimation Method

A note of warning may be given here. Many national and international experts have opined that the published flood damage estimates are significantly on the high side, due mainly to:

(i) the official habit of calculated or conscious overestimation for budgetary provisions,

(ii) the hope of undertaking most accumulated or foreseeable maintenance work in the name of flood damage,

(iii) the marginal push of the 1988 flood triggering off latent damage arising from a history of inadequate repair and maintenance work to buildings, equipments, roads and other infrastructure, and

(iv) the lack of a systematic methodology, since unlike crop damage estimation non-agricultural damages estimated only occasionally, following catastrophic or cyclones.

It may be mentioned that some direct damages such as urban housing losses or losses to rural hats and bazars or municipal water supplies etc. are not included in the above estimates due to the lack of data. As already noted, secondary effects of floods in terms of reduced economic activity, consumer demand, reduced employment, etc. are also not included.

It may also be noted that the 1988 Flood did not significantly affect the Noakhali and Feni districts of the south-east region and as such, the region's share of the national damage is considerably less than that of other areas. It may be noted here that the feasibility study for Noakhali North Suggests that the 1988 flood approximated to a 1 in 10 years event in that area (much less than in other parts of the country). The southern polder areas in particular are far more prone to flooding caused by cyclone events which has not been addressed by the above approach. Such damage analysis is covered in the Cyclone Protection Project, (now CERP) an allied FAP study which is formulating coastal embankment works and coastal development needs.

3.8 Methodology for Environmental Evaluation

3.8.1 Aims and Objectives

The aims and objectives of the Initial Environmental Evaluation (IEE) study have been:

a. To identify the status and condition of the existing environment which will be subjected to interventions under the proposed regional water plan projects.

b. To identify and evaluate the likely future environmental impacts and changes associated with the proposed plan activities.

c. To highlight important impacts and key policy issues early in the processes of identifying problems and planning of solutions, and to recommend ameliorative measures to ensure sound environmental management and monitoring.

The national environmental policy requires special consideration to be given to the protection of the natural and human ecological systems, to avoid degradation, pollution and loss of bio-diversity. Most natural wetland and forest habitats in Bangladesh have already disappeared or have been thoroughly influenced by human intervention. Thus, the loss of natural habitats is already of less significance than the socio-economic impacts on the local communities and the maintenance, through good management, of the habitats on which communities now depend. The aims of the regional water plan concentrate on the quality of the human environment, sustaining food production systems and minimising pollution from human waste, industrial pollutants and agro-chemicals. The maintenance of a diversity of species and habitats is vital to these aims. The ecology of the floodplain, estuarine and coastal systems is still diverse, but is believed to be changing significantly under the influence of FCDI and modern agricultural and industrial programmes. The regional water plan aims to ensure that continued development is fostered in a way that can sustain the development potential of the natural and human resources.

The National Environmental Management Action Plan (NEMAP), being organised under the Ministry of Environment and Forestry (MOEF), has specifically allocated the survey and planning for the nation's major floodplain wetlands to the FAP. Although this aspect is not specifically mentioned in the Terms of Reference for any of the FAP studies, this need has been taken into account and areas for conservation identified. Case studies are being done by FAP 16 on the following topics: fishery, resources of the char lands, nutrition, and soil fertility. The resource survey of the char lands is mainly created towards the major rivers; the nutrition survey will be done in MIDP, and the soil fertility study will investigate Chandpur Irrigation Project. Unfortunately the resources being allocated to these studies will not permit a comprehensive survey and future studies may be required.

Institutional strengthening activities for environmental management and monitoring are considered under this study. The TOR focuses attention for this on the needs within the BWDB which is responsible for the overall implementation of FCDI projects. However, the main environmental monitoring work required falls outside of its responsibility. What responsibilities it does have need to be far more closely integrated with the other national institutions concerned with environmental issues and management.

3.8.2 Scope of study

The scope of study is summarised below:

Natural Resource Environment	Socio-Economic Environment
Geology	Agricultural Systems
Soils	Fisheries
Groundwater Hydrology	Sociology
Surface Water Hydrology	Local Participation
Floodplain, Coastal & River Morphology	Survival Strategies
Climate & Seasonality	Demography
Water Quality	Archaeology
Habitat & Bio-diversity	Aesthetics
Aquatic/Terrestrial Ecology	
Energy & Chemical Flows	

3.8.3 Benefits of the study

The study aims to aid the search for development strategies which can sustain the natural resource base for future generations, enable people to survive better with the changing resource implications of new project plans and policies and, where possible, improve the quality of the living and non-living environment.

The conclusions reached through the environmental assessments should provide policy and decision-makers with the best available overview of potentially important implications. Modern environmental assessment is focused on appraising issues which typically have been excluded from development planning in the past. With hindsight these areas are now seen as those which have often contributed to unacceptable political, social, economic and ecological costs in developed and developing countries alike.

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3.8.4 Limitations and Implications for Planning

The study suffers from a number of basic limitations which should be considered during the assessment of its results and in considering how to proceed with project selection and the terms of reference for the feasibility studies. These limitations are discussed below.

a) Access to Guidelines and Methodology

The IEE study took place in advance of the issuing of the FAP Draft Environmental Guidelines and the Draft Guidelines for Environmental Impact Assessment. After reviewing the draft FAP guidelines and the direct requests received from the MOEF, every effort has been made to align the methodology closely (in terms of the content and presentation) in the expected direction. The approach hopes to ensure coherence and consistency of approach with the other environmental FAP studies. The approach adopted should satisfy any donor requirements and those of the MOEF.

The standard approaches to environmental impact assessment have been worked out for single projects which have reached either the feasibility or detailed design phase. There is little history or experience of developing the assessment methodology to the scale and level of detail appropriate to pre-feasibility or regional planning, for which broad conceptual and strategic planning options are more important than specific project details. However, in the case of the present study, the planning has included a large number of projects with many potential alternative modes of development for each geographical planning area. To run detailed assessments on each project and each alternative would have not been possible with the resources available. Similarly, because of the phasing, scaling and other problems discussed below, such an approach would probably have produced an indigestible quantity of material and meaningless results. This could easily obscure the key issues with which pre-feasibility and regional planning ought to be concerned.

b) Lack of Data

Reviews of the available regional database in a number of subject areas have raised concern over the quality of data on which good regional planning can proceed. Data on some natural resources (climate, geology, geo-physics and soils) appear adequate, but the length of time series data on dynamic responses in the seasonal and annual system to natural change and to those induced by human interventions is limited. Official data on basic agricultural, irrigation and yield statistics, while available down to detailed local level statistics, have often proved inconsistent and unreliable on closer examination. Data on the species diversity of the natural flora and fauna and the homestead, field and livestock is less readily available. In the field of ecology and water quality, primary data collection and analysis for sound environmental impact analysis is virtually non-existent. Proposals for basic field surveys and analysis have been drafted in FAPs 2, 5 and 16 to attempt to overcome these deficiencies for FAP planning. However, the time frame available is unlikely to allow any data collection over the minimum period of one year to cover the main seasonal variation in the dynamic biological and chemical phenomena involved. Whether this research can be mobilised and completed in time to assist even the feasibility planning is open to question.

c) Lack of Reliable Predictive Models

The theory of, and tools with which to appraise many of the complex physical, climatic, chemical and biological inter-actions with changing technology and human activity in the environment are still evolving. Thus, the capacity for rapid insight, modelling and reliable prediction of the response of the environment to proposed interventions itself is limited and some important levels of environmental analysis are impossible or difficult to complete.

d) Phasing and Scaling Problems

No realistic assumptions could be made at this pre-feasibility stage of study as to which series of projects will actually be implemented and when. At the regional level, the responses of the social, economic and ecological environment will be quite specific to a particular scale and phasing of development. Thus, the assessment of cumulative effects and the point where the scale and geographical density of interventions breach thresholds, (eg, the potential scale and spread of major disease vectors), are very difficult to appraise except in the most general of ways.

3.8.5 Study Organisation

The environmental assessment should ideally involve three phases, as outlined below:

Stage 1: Pre-Feasibility and regional planning

During the Pre-Feasibility and preliminary regional planning stage an initial environmental evaluation (IEE) is conducted of the conditions in the region and how these affect, or will be affected by, planning options for water resource development. This assessment starts with a generic analysis by mode of development, rather than a project specific approach. This analysis screens and scopes all issues and impacts to identify those key areas of policy and strategic importance. In the main regional planning report only key issues for specific projects are identified to assist in the project ranking exercise to help select projects to go through for feasibility study.

Stage 2: Feasibility planning

Once projects have been selected for feasibility study the first stages of a more thorough environmental impact assessment (EIA) will be carried out on each project to appraise the impacts of the alternative options and to look more closely at some of the issues related to construction and implementation.

Stage 3: Detailed Design, Contract Preparation and Tendering

This EIA process should continue into the detailed design phase, as more data from primary data collection and planning details become available, and as the downstream implications of other FAP projects become clearer. In practical terms, this is the most vital stage for these inputs. It is only then that the specific details of actual structure location, resettlement needs, impact areas, construction and contractor operations, and operating criteria become known. Many environmental aspects should be dealt with and specified in detail in the contract documents, and specifically planned for the tendering, the remaining pre-construction and construction activities and support facilities. Typical specific areas that are usually priority inputs for this stage include among others:

- detailed land acquisition, compensation and resettlement surveys and programmes

- detailed planning of construction operations and facilities to avoid environmental impacts and contractor short-cuts (including public health needs and planning for construction camps)

- detailed planning and specifications for site works and restoration

- undertaking final baseline surveys and setting up of environmental monitoring programmes.

These 'Stage 3' inputs are now standard requirements in many other developing countries and are likely to become so in Bangladesh. However, Stage 3 inputs have not been envisaged so far for this study.

3.8.6 Environmental Assessment Methodology

The IEE methodology which has been developed in this study follows a conceptual approach similar to that of an EIA. First, the impact of the status and condition of the existing environment on the planning approach is considered. Then, the impacts which the various FCDI interventions may have on the state and condition of the future environment during the pre-construction, construction and post-construction periods is assessed; the latter also giving consideration to what may happen in the short, medium and long-term planning horizons. Mitigatory measures to overcome inevitable adverse impacts and planning options to avoid any irretrievable or unacceptable losses are identified. The approach also highlights the complementary measures in other sectors that may be required to ensure that the water resource proposals can achieve their objectives. Environmental monitoring and training needs for improved environmental management associated with the proposed water development plan for the region are also identified.

The first objective is to screen and scope the planning strategy and project options for any potentially beneficial or adverse effects. This evaluation is holistic and identifies linkages across disciplines and sectors. Any potential implications are immediately fed back to the planning team from the start of the planning process, rather than simply identifying them at the end. These linkages can occur between any of the physical, chemical, technical, social, economic and ecological systems affected by FCDI interventions. Ranking the scale and importance of processes has proved difficult with the limited data base, the complex environmental linkages and the problems discussed in Section 3.8.4. Environmental issues in general are described in Annex IV which includes a comprehensive checklist covering every issue which has been foreseen. This checklist has had to rely on the professional judgement of the environmentalists following discussions with the other team members and other specialists. Most of the impact assessments have been completed by other study team specialists.

The impact assessment methodology has tried to ensure:

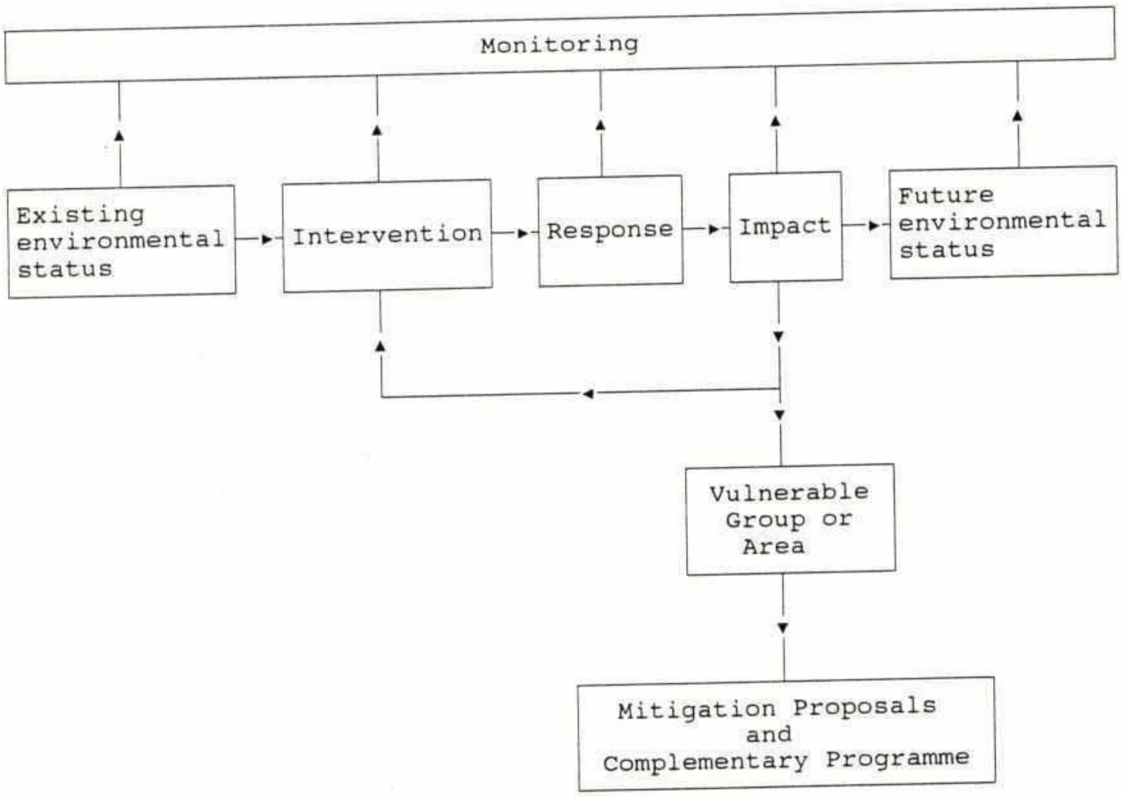
- A rigorous presentation and ranking of all identifiable positive and negative impacts, but with an emphasis on key issues which would potentially downgrade or eliminate projects from the selection process or require special consideration during any feasibility study

- An assessment of the benefiting and vulnerable areas affected by interventions, whether human or other species, their habitats, or the different geo-physical or economic/social/ecological processes on which sustained productivity depends

- An assessment of whether the hidden costs, externalities and multiplier effects which are not normally taken into account in individual project analysis can in practice be dealt with at this stage in the planning cycle in a meaningful way.

The detailed approach required the planning team to identify a comprehensive checklist of potential areas of impact. These included both positive and negative impacts relevant to the each subject area. These were compiled through ***a priori*** reasoning, examination of existing studies and ex-post evaluations, discussions with local people and officials in the study area, and by reference to other specialist institutions and government bodies. Cross-subject and inter-sectoral linkages are then looked for by running through a series of systems and network analyses. By this on-going process the checklist continued to be refined as the planning study progressed. The checklist can employ a variety of classification systems. Each has its usefulness, as long as it encompasses all potential areas of social, economic and ecological concern. The breakdown used here is based on four main inter-related systems reflecting various components of the living and non-living environment, these being: socio-economic, biological, physical, and quality of life. The final checklist, systems and network analysis formed the basis for the evaluation matrix and narrative discussion of the main impact areas.

The overall assessment using network and systems analysis looks for the following chain of potential events:



The initial physical responses and their resultant social, economic or ecological impacts might have a number of levels which are often referred to as primary, secondary and tertiary, or as direct and indirect. This type of terminology can be misleading as the end result from a chain of response and impacts could be of major importance and even outweigh the significance of a primary impact found at the beginning of the chain. In practical terms it is sometimes difficult to make a clear distinction between responses and impacts as this depends on the type of process involved.

The environmental assessment should assess a number of features concerning potential impacts, such as their magnitude, duration, intensity, frequency, scale and cumulative nature, and chain or multiplier effects and whether the impacts are reversible or not. It should also consider the resilience and stability of the environment affected and whether the interventions or mitigatory measures are sustainable. At the pre-feasibility stage and given the limited data, these assessments are necessarily limited, based on professional judgement and not always possible to complete. The large number of process-orientated and qualitative factors involved in the assessment make it more of an art than a science and the assessments provided are meant to form a basis for critical discussion and raising awareness of certain key and critical issues.

3.8.7 Coordination with the Economic Analysis

Although the IEE approach identifies the direct mitigation and compensation programmes, as well as the complementary programmes required (outside of water resources development), project economic analysis does not normally attribute the costs of complementary programmes to individual projects. Usually the achievement of a project's primary objectives are not considered as being dependent upon these additional development strategies. Investments in other sectoral development programmes are assumed to be taking place simultaneously with investments in water resource development, and as part of a wider and integrated development approach. The environmental assessment highlights where other sectoral investments need to be sustained if the full benefits of the regional water plan are to be achieved.

The primary impacts of the regional water plan relate to changes in flood risk and the productivity of land measures only in terms of increased crop biomass. It is known that other potentially quantifiable impacts will occur as a result of irrigation or flood protection; eg, changes in land use, species balance and population levels will affect pest and disease levels and the responses in both the productivity of humans and economic flora. It has proved difficult, and often impossible, to derive any reliable measure of the magnitude of these type of potentially quantifiable impacts because of the paucity of data or knowledge. It was concluded that to attempt to include such items in the economic analysis would have been a matter of insupportable guesswork and could have clouded the results. Thus, only qualitative assessments and ranking have been attempted.

There are other areas were quantification is difficult and has not been attempted. In some cases the adverse effects may only become apparent in the long-term, such as future costs associated with long-term accumulation of project affected pollution systems (i.e. increased pesticide use), the health costs induced by changed lifestyles, or the greater costs of flood damage if future earthquakes liquify embankments. There are cases were future development options might be foregone as a result of the selection of a particular strategy today, such as the lack of integrated planning for navigation and fisheries which would reduce these or considerably change their systems status (i.e loss of diversity).

Other impacts are, in any case, qualitative and could not be quantified, even with an improved data base. They, too, are potentially important for the long-term sustaining of the productive resource base on which the regional water plan will depend. These are highlighted so that they can be taken account of in strategic decision-making, in conjunction with the criteria of economic efficiency.

For the types of issues discussed above the results of the economic analysis alone may not give the best guidance on important strategic decisions concerning the national interests overall. It is for these reasons that the environmental assessment and economic analysis are complementary. Together they provide policy makers with an assessment which explicitly indicate the differing tactical implications and strategic trade-offs for the national interest of economic efficiency, social objectives and sustained long-term management of resources.

Economic and environmental criteria for project evaluation, and their inter-relationship, are discussed in the next 'Section of this Report.

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CHAPTER 4

CRITERIA FOR PROJECT EVALUATIONS

4.1 Introduction

Evaluations of each project have been carried out using the approach and methodology outlined in preceding Chapters of this Report. The objectives against which the relative viability of different projects have been assessed were based on those proposed in the FPCO 'Guidelines' (July, 1991 and revised in May 1992), namely:

- Contribution to national income
- Impact of project on agriculture
- Impact of project on fisheries
- Employment impact of project
- Impact of project on income distribution and poverty
- Main social impacts
- Main environmental impacts
- Quality of life impacts.

The criteria used to measure the contribution of each project to these different objectives are discussed below.

4.2 Economic Criteria

4.2.1 Contribution to National Income

The following indicators of economic viability have been estimated for all projects:

- Net Present Value (NPV)
- Economic Internal Rate of Return (EIRR)

Net Present Values have been calculated at a discount (interest) rate of 12% corresponding to the opportunity cost of capital in Bangladesh, as defined in the FPCO 'Guidelines for Project Assessment'. Sensitivity analyses have been carried out for each project to assess the impact on the project's EIRR of changes in certain of the key variables. The effects on project EIRR have been assessed for changes in the following variables of + or - 10%, 25% and 50%, with other variables remaining as in the base case analysis:

- Capital costs
- Operating and Maintenance costs
- Capture Fisheries losses
- Total Benefits
- Net Incremental Crop Income

Switching values (the proportionate change in a given variable required to achieve a given Internal Rate of Return, other variables remaining as in the base case) have also been estimated for each of these variables for the target minimum EIRR of 12%. Effects on project EIRR of a two or four year delay in the start of project benefits, and of a two or four years delay in project implementation have also been assessed.

The NPV Ratios which were included in the draft regional plan have been removed from the analyses since they are now not required by the FPCO guidelines.

4.2.2 Impacts on Agriculture and Fisheries

Project impacts on agriculture and on capture fisheries (where possible) have been quantified in the economic analyses. The impacts on the social groups involved in these activities are dealt with in the social impact analysis and the biodiversity issues are dealt with in the environmental analysis.

4.3 Main Social Impacts

4.3.1 Impacts on Employment, Poverty Alleviation and Income Distribution

The effects of proposed projects on agricultural labour requirements have been estimated. Unemployment and under-employment are major problems in the region and, other things being equal, a project with a greater employment impact would be preferred to one with a lower impact.

Alleviation of poverty is the second of the three major objectives of the Government of Bangladesh's Fourth Five Year Plan. The criterion proposed in the FPCO 'Guidelines' for measurement of project performance in terms of income distribution and poverty alleviation is 'Share of Incremental Benefits going to the poor'. The poor were defined as households owning less than 0.2 hectares of land, which in the south-east region covers around 50% of all rural households.

Flood control without complementary additional irrigation should benefit all land-owning groups in proportion to their holding size in terms of enhanced farm production capacity (due to shifting land from lower to higher flood phase categories). Landless labourers should also benefit from the additional employment opportunities which such schemes should create. However the landless would tend to suffer disproportionately from fisheries losses.

The provision of additional surface water irrigation resources can be expected to benefit all sizes of both farms, and the landless through greater employment opportunities. Data from Chandpur and other FCDI schemes show that the proportion of a land holding which is irrigated is no less on smaller than on larger farms; indeed, the proportions irrigated on the largest land holdings tend to be lower than on the smallest holdings. FAP 12 has indicated that in general the average incomes of poorer people rose by about 6% in the schemes studied this is less than the increment to larger landholders so that, whilst income distribution still widened, poor people still benefitted. It is interesting to note that in the public participation meetings held as part of the study none of the disadvantaged groups perceived any problems arising from FCD/I projects apart from the obvious disbenefits to navigation and capture fisheries. In Muradnagar there were complaints about blocking of natural drainage channels by Gumti Phase I embankments but such problems should be anticipated and avoided by careful design and local consultation. On the other hand the disadvantaged groups considered that the increased agricultural productivity would bring greater wealth to the area and they would benefit by increased employment in agriculture. Women particularly mentioned additional work in houses for the landowners who would benefit most from the changes. The general impression was that everyone would benefit from the growth in economic activity.

Although there is an element of double counting with fisheries and employment criteria the income distribution and poverty alleviation criteria have been included in the qualitative section of the analysis. It may be mentioned here that FCD/I developments may not be the best route for directly increasing the incomes of the very poor. However, if the fisheries mitigation/improvement components are added to the proposed project interventions then these projects could become more widely beneficial and this should be further examined at the feasibility stage.

4.3.2 Impacts of FCD/I Schemes on Women

The most recent study on the impacts of FCDI projects on women was carried out for FAP 12 which reported in December 1991. Amongst their conclusions are the following:

- in no case is there an unambiguous increase or decrease of any activity either in the impacted or the control area, which probably reflects the socio-economic differentiation that exists among women;

- in seed preservation comparatively more women have experienced an increased work load in both impacted and control areas, but more so in the former;

- in the case of parboiling and storage, both in the impacted and control areas the proportion of women claiming an increased work load is lower than those claiming a reduction, but the proportion claiming an increase is again higher in the impacted areas compared to the control areas;

- in the case of husking, the majority of women have indicated a lower work burden in both impacted and control areas but the proportion of women claiming a decrease is somewhat lower in the impacted areas;

- although women are generally not involved in pre-harvest operations it is interesting to note that, among those who have reported a change, most have indicated an increase in the women's work.

In none of the above cases, except for storage, is there a statistical difference in the response of women between impacted and control areas.

> "The overall conclusion that one may draw here is that in the impacted areas, because of higher production compared to the control area, the work load of women has increased, particularly in activities where women play the major role. However, none of these differences are yet pronounced as the changes are not uni-directional across all households". (FAP 12 Draft Final Report Volume 1, December 1991).

Women probably suffer more than men in severe floods, since they are responsible for cooking and other household activities, this particularly affects women with young children; thus they may tend to benefit more from effective FCD schemes.

Again later in the FAP 12 Report:

> "Chowdhuri et al (1989) undertook the only previous study which focused on the impacts of a FCDI Project (CIP) according to gender. They found that women's workloads had increased because of the increase in paddy production. Although mechanical husking had expanded, richer households employed considerably more poor women in post-harvest processing:results which agree with those found in the PIE projects".

In the consultants view more work is needed both to assess degrees of current underemployment for both men and women and therefore to what extent increased workloads represent utilisation of spare capacity. There are currently insufficient data to know if either increased or decreased workloads are beneficial or not. However the indication of an increase in the hire of poor women by better off households must be a positive indicator and also may suggest that for less rich households there is some spare labour capacity within the family.

Generally women seem to benefit from flood protection and marginally increased labour opportunity. However since there seems to be little overall or differential impact this aspect has not been included in the rankings.

4.4 Main Environmental and other non-quantified Impacts

The environmental annex mentions all possible environmental impacts but the project assessments only consider those which are of direct concern, for example none of the projects considered is liable to introduce malaria into the region, similarly none of the projects would have any effect whatsoever on archaeological sites, since they would be avoided; such topics are not therefore reported.

The environmental topics of major concern are surface water quality as modified by agro chemicals, domestic sewage disposal and industrial pollution, and the effects projects may have on flushing of waterways. Loss of biodiversity has also been identified as a major potential negative consideration. This is important from four main considerations; first, the wider adoption of HYV varieties will lead to a reduction of local varieties which have flourished in the area and probably developed resistance to local pests and diseases, this will particularly affect rice; second, the use of HYV varieties usually involves increased use of fertilisers and pesticides which will eventually leak into the drainage system and are likely to affect the food chain of fish; third the reduction in flooding and the use of agro-chemicals may destroy the natural predators on crop pests. Finally blue-green algae are thought to contribute significantly to formation of natural fertilisers and in some cases these could be significantly affected by flood control and particularly greater use of agro-chemicals.

River morphology can also be significant for some planning units and this also applies to navigation. Similarly good road access is regarded very highly by most inhabitants.

Fisheries are important and are also dealt with in the economic analyses but the potential loss of wetlands due to flood control works is considered. Parts of the area are on migration routes for several species of birds particularly those breeding in Siberia.

It is not possible to quantify the cost or benefit of all these effects and they are therefore, included in the qualitative tables. The FPCO guidelines as revised in May 1993 now recommend that all qualitative criteria are judged using a rating of -5 to +5.

In many cases conversion of paddy fields to shrimp ponds is good commercially but has serious social effects since less labour is required and many farmers lose their jobs. This is not a serious problem at present in the south-east region. Capture fisheries benefit the poor and landless and, whereas culture fisheries may make up some of the lost production when flood levels are controlled, the main benefits go to the pond owners, thus the free resource is not replaced.

Permutations of flood control, drainage and irrigation with capture fisheries and culture fisheries could have varying intensity of impacts and even within one classification, projects will have different magnitudes of impact. In the case of the RWP for the south-east region the consultants believe that the range of negative impacts are relatively small when compared with what may occur in other regions and therefore the ability to record measurable differences amongst the projects is restricted. Also the perceptions of different experts in qualitative assessment is likely to vary substantially.

There are other risks which may make some projects more vulnerable than others such as a long term rise in sea level or cyclone risk. Earthquake risk is considered negligible, (but designers must consider the possibility of liquefaction of embankments and foundations of structures).

At present, due to lack of data on many topics, project ranking by this qualitative method is subjective must only be used as a guideline, nevertheless it provides a tool which enables the planners and policy makers to view the whole of a complex situation but they must also be aware of the limitations of the qualitative ranking as described above when comparing projects in different regions.

4.5 Quality of Life Impacts

4.5.1 Housing and Public Buildings

FCD projects reduce flooding in normal conditions and this is obviously of benefit to houses and public buildings. The only exception to this is that in extreme years the situation may not be improved, due to intense local rainfall, or due to a major failure of embankments. One of the findings of FAP 12 has been that losses were higher in FCD areas after project implementation but this may be due to two reasons, firstly people may have accumulated more wealth due to the project and consequently suffer greater losses when flood damage occurs, and secondly people may have been over confident in the security of FCD schemes and built houses on lower ground. FCD schemes should be generally beneficial to rural and urban infrastructure and irrigation should have little effect on housing and public buildings.

4.5.2 Nutrition

There are two effects of projects which influence the nutritional status of the population, quantity of food and quality. Under all projects proposed the volume of production should increase otherwise the development would not be justified. (This would not be the case if cash crops were to be developed for sale outside the area but that particular case is not considered significant). It has been stated that in the past FCDI projects have adversely affected fisheries and fish is an important source of protein for much of the poorer sections of the population. The projects envisaged for the plan would generally be neutral or with mitigation and improvement measures be beneficial in this respect.

In general the population should produce more food in every type of project considered.

The type of food to be grown is a different matter. FCD schemes will generally permit HYV aman crops instead of B aman. This should be a benefit; FCD should also enable better rabi season crops which will also tend to raise nutritional standards. This increase will be enhanced if the homestead areas can increase due to improved flood control and drainage.

In the case of irrigation projects however the situation is slightly different. Irrigation is almost invariably used to grow HYV boro, this is generally followed by an aman crop, therefore the tendency will be to reduce the variety of food grown although many of the homestead areas should expand. In the long term crop diversification should overcome this problem since there is sufficient non-irrigated fallow land available to replace lost rabi crops and irrigation could extend into other crops including vegetables but there is a possibility of deterioration in the short term.

4.5.3 Transport System

Railways are not significant for the majority of the people in the study area and in any case, are unlikely to be affected by any of the projects proposed. The main forms of transport are road and navigation. In general road access should improve with flood control and drainage. For navigation two distinct types of project should be considered, FCD and irrigation, (submersible embankments are considered later). FCD schemes will impede navigation because embankments or regulators will limit transit of boats. Major regulators are provided with a lock so that communication with the major navigation routes will not be impeded. It is not considered viable to install locks at every regulator and therefore certain minor routes may be changed but most rivers and khals will have some form of communication by waterway.

FCD schemes would have an impact in general mobility across the floodplain in the monsoon season. Reduction of flooding will reduce the lines of communication and some routes may be cut completely, however where these routes are closed improved access by land should be possible.

Surface irrigation could be beneficial since admission of water into khals which at present dry up should enable them to be used for navigation in the dry season but again regulators could impede this traffic..

Submersible embankments present a more complex problem. In the dry season some waterways may be cut and navigation will no longer be possible, on the other hand the embankments should provide a route for land transport and protect other non-elevated roads. However as soon as the embankments are submerged they will be of no use as roads but may still provide an obstacle to navigation. There are no simple solutions to this. stoplog regulators in submersible embankments could allow limited navigation in the monsoon season (by removal of stoplogs) but these stoplogs have generally been found unsatisfactory and are no longer recommended.

4.5.4 Health, diseases and vectors

The major issues in this section are sanitation, water borne diseases and pollution.

In general FCD schemes should reduce health problems, flushing of all khals should be better, pit latrines should be more effective, and there will be less risk of flooding of wells for potable water supply reducing the risk of pollution. The only possible adverse impact could be the introduction of HYV aman on land which is not so deeply flooded and the consequent increase in use of agro-chemicals which will leach into the khal system, and possibly into potable water supplies. However the increased flushing capability of FCD schemes should reduce the build-up of pollution locally.

Irrigation is slightly more complex, again it may lead to seasonally increased agro-chemical pollution, but in the case of surface irrigation, the existing water supplies are already fully used in most of the area so the introduction of water from the Meghna river should not aggravate the situation. Groundwater irrigation is slightly different since it may encompass more leaching of agrochemicals into the system with no increase in dilution.
However the monsoon rains combined with improved drainage should prevent long term build up of chemicals in water supplies.

4.6 Assessment Criteria

The previous sections of this chapter have outlined the various issues which are considered to be of importance to the proposed projects in the region. This section lists the criteria under which these issues are represented in the multi criteria analysis.

4.6.1 Quantitative Criteria

Economic

Economic Internal Rate of Return	EIRR
Net Present Value	NPV

Agricultural

Percentage change in value of production

Fisheries

Change in capture fisheries production

Employment

Percentage change in farm employment

4.6.2 Qualitative Criteria

Physical Environment

Morphology (accretion and erosion)
Surface Water Quality
Salinity
Cyclones.
Sea Level Rise

Ecological

Wetlands Reduction
Biodiversity - Crop Species
Biodiversity - Aquatic Species (non-fish)
Capture fisheries
Culture fisheries.

Socio-Economic

Displacement
Social Conflicts
Investment opportunities
Income Distribution
Poverty Alleviation

Quality of Life

Housing and public buildings (Schools etc)
Nutrition
Transport systems
Health, Diseases and Vectors

Other issues are estimated to have relatively minor impacts and are similar for all projects.

CHAPTER 5

DEVELOPMENT OPTIONS FOR SOUTHERN SUB-REGION

5.1 Introduction

As described in chapter 2 this sub-region comprises recently accreted lands which have been largely poldered but which are still subject to changing morphological conditions as new areas are accreted and others are eroded in the Meghna estuary. There are many possible permutations for future drainage improvements but in view of the current instability of the coastline definitive final solutions to improved drainage are impossible to define at this time. However the forthcoming Meghna estuary study of (FAP 5B) will be studying these problems in some detail and therefore this study has confined itself to identification of the principal problems of the two planning units and to describing some of the possible development options which the FAP 5B study will need to take into account when considering the effects of any proposals they make for further land accretion.

The principal problems of this sub-region can be listed as

- soil salinity
- cyclone damage
- tidal flooding and erosion from the Meghna
- lack of fresh water resources

These problems can be tackled in a number of ways. Firstly the problems of the cyclones and the damage they cause, which includes a contribution to soil salinity problems, are currently proposed for alleviation through the Coastal Embankment Rehabilitation Project (CERP). These proposals have been revised since the draft Regional Plan Report was presented and the most recent proposals are now identified in this report.

5.2 Planning Unit 1 - Polder 59/2

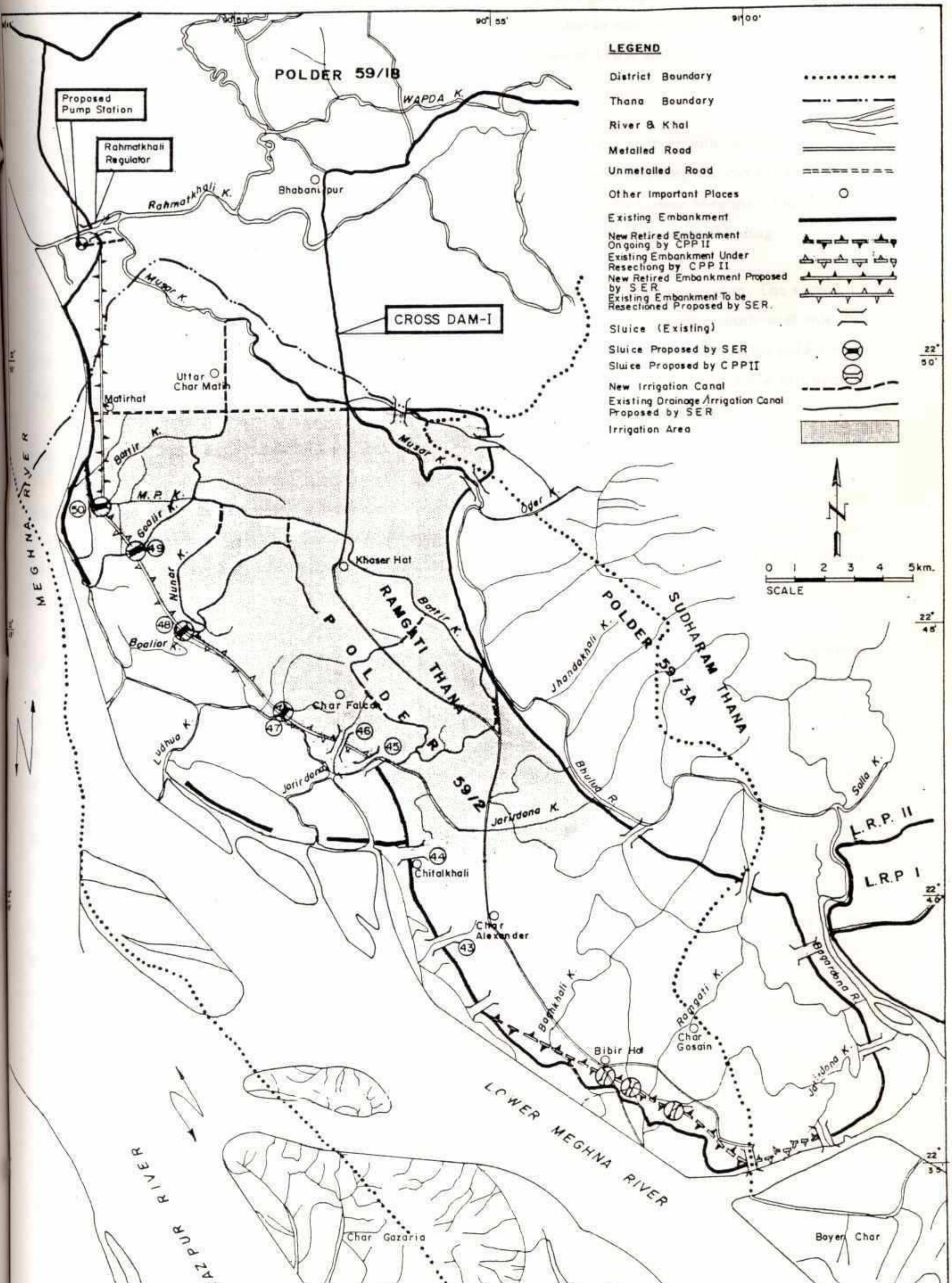
5.2.1 General Description and Constraints

The polder is in the south-west of the study area. Originally the northern part of the planning unit was a branch of the Lower Meghna river and only Ramgati island was permanently above water. The northern boundary of Ramgati island was approximately the line of Jarirdona (See Figure 5.1.). At that time Ramgati island extended further south than it does now. In the 50's accretion of the northern branch of the Lower Meghna river began to occur and this was accelerated by the completion of Cross Dam Nr 1 in 1957; this resulted in the island of Ramgati being connected to the mainland, however erosion still occurs in the south and the thana headquarters has been moved from Ramgati to Char Alexander as a result of this.

The empoldering of Polder 59/2 was completed officially in 1970 although the embankments have never been continuous. Gaps have been left in the embankments and also at the location of proposed drainage regulators in the northwest of the polder because of the continuous cycle of accretion here leading to long drainage paths.

Figure 5.1

Polder 59/2, Planning Unit 1 - Development Proposals



The area is flooded by water from the Lower Meghna river, entering through the gaps from time to time in the monsoon season and drainage is a problem. The groundwater is saline due to marine influences and very little irrigation is practiced due to lack of water. The cropping intensity is about 110% and the crops consist mainly of B aus and LT aman.

On the east side is Polder 59/3A bounded by Bhulua River and not yet closed at its mouth since accretion of Boyer Char blocking the mouth is still continuing. However this accretion is blocking the old drainage path and forcing the drainage to pass westwards across the polder embankment to the Lower Meghna. Flooding in Polder 59/3A leads to public cuts in the east embankment of Polder 59/2 and consequent flooding.

The west bank of Polder 59/2 is subject to a constantly changing pattern of accretion and erosion. The accretion at Chitalkhali has caused abandonment of the BIWTA launch station at Chitalkhali. On the south-west side the embankments have been eroded and retired several times and are threatened again by erosion. This polder was seriously affected in the 1970 cyclone although fortunately the 1991 cyclone was not as serious in this area.

5.2.2 Previous studies and Projects

The polder has been studied under the Systems Rehabilitation Project (SRP) by EPC in March 1988, Mott MacDonald in March 1991 and Land Reclamation Project (LRP) in February 1988. None of the recommendations of the studies have been implemented due to the continuing pattern of accretion at the mouth of Baggardona and erosion on the west side of Ramgati.

LRP recommended that a drain be built from South Sudharam to pick up the flow from Bhulua river, this drain would cross Polder 59/2 and discharge into the Lower Meghna at Chitalkhali. Sir M MacDonald & Partners Ltd supported the proposal. However, it was not taken further at the time due to the problems of finding a suitable location for the outfall which would not be threatened by erosion or accretion. The polder was entered into the mid-term programme of FAP 7 Cyclone Protection Project (now CERP) this programme commenced in 1993 and will last two years. The proposals are basically to retire the embankment from Char Alexander to Ramgati at a safe distance along south western section, resection the embankment along the southern section and the construction of three new Regulators. The implementation of these works is due to commence in 1993.

The CERP considered only the direct seafacing portion of the embankment from Chitalkhali to Baggardona River. But the risk of tidal inundation, saline intrusion, drainage and erosion by Meghna River in the north-western portion have not been covered specifically in the presently programmed works. However discussions with CERP staff revealed that there are substantial items included in the project documents under "minor works" which could be used to address this problem.

5.2.3 Groundwater Development Potential

The ground levels in the planning unit are low and there is significant marine influence. As a result shallow aquifers are saline. Although there are pockets of fresh water they generally comprise their surface lenses and should be reserved for local potable water supplies.

Until recently the potential for groundwater development was considered to be minimal. However the resent development of a significant number of deep wells for irrigation in Lakshmipur thana immediately to the north has identified that there is a significant productive deep aquifer which appears to be confined below a clay layer at depths below 130 m (see Annex V). This aquifer has not been properly investigated to determine is potential recharge nor its spatial extent. It is the consultant's view that such investigations should be undertaken as a matter of some urgency so that this potentially valuable resource can be quantified.

In the event that a limited viable and sustainable resource is identified then serious consideration should be given for zoning areas for development such that the resource is used primarily in areas where no alternative sources are available (such as the southern part of Unit 1 if the aquifer is present in this area.

5.2.4 Project Components

a) Protection works

The meander at the left bank of Meghna River which was near the outfall of Rahmatkhali Khal four to five years ago is shifting downstream to Matirhat. (consequently Rahmatkhali Khal outfall has been stable). The embankment from Rahmatkhali to Matirhat skirts the river bank having an offset distance of 100 m to 150 m only. Also, the construction of the polder embankment from Matirhat to Jarirdona was left incomplete keeping the main Khals i.e. Ludhua Khal, Boalia Khal, Goali Khal, and Battir Khal open to the Meghna River. The object of suspending construction of sluice nos 47,48,49 & 50 in those gaps was to wait and observe till a stable shoreline is found. As a result, tidal flood in monsoon and saline intrusion in dry season through these gaps is worsening the situation in this area. The BWDB, in the mean while started construction of an embankment on newly accreted Meghna bank areas. The work stopped after completion of the portions of embankment shown in Figure 5.1.1 partially due to erosion starting again at the out fall of Boaliar Khal. These works are not in the present CERP works programme.

However as explained above they could possibly be included under the minor works component of the CERP and this is recommended since without these works the polder 59/2 cannot be considered as complete and free from the risks for which the CERP is carrying out the works.

The consultants do not recommend the completion of the embankment enclosing the newly accreted land to the west at this time for two reasons:

i) The downstream progression of the erosion at Matirhat suggests that these recently accreted lands will once again be under threat of erosion from the Meghna.

ii) The FAP 5B Meghna Estuary study will shortly be studying the behaviour of the Meghna in this area and it considered prudent to leave a decision on this area until this study has reported.

The additional protection works required are:

- completion of the river defence works i.e. retirement of embankment from Rahmatkhali Khal to Battir Khal

- complete the new sluices (4 Nos)

- resection the old embankment (between structures 46 and 50)

b) Irrigation works

The draft regional plan report proposals assumed that it would be possible to irrigate the whole of this polder unit from a pump station at Rahmatkhali Khal. However this has been reviewed and it is clear that the levels, discharges and distances involved would require at least double and probably triple lift pumping for part of the area. The scale of the proposals has therefore, been reduced so that the area irrigated can be supplied from a single lift station near Rahmatkhali regulator. The existing khal network would be used, as far as possible, as a primary and secondary system but it is estimated that approximately 9 km of new connecting channels would be required as shown on figure 5.1.1. Otherwise the existing khals should be large enough for the relatively small discharges required.

The new works required are as follows:

- provide irrigation from the inlet to Rahmatkhali Khal to the northern half of polder 59/2 via Musar Khal from a pump station rear the Rahmatkhali regulator

- excavate new khals and re-excavate the existing khals for distribution of irrigation water by LLPs throughout the northern part of Polder 59/2.

The polder has a gross area of 25750 ha and 19956 (NCA) and irrigation is proposed for 8500 ha. The pumpstation has 17.0 m^3/sec capacity (4 units including one standby) down stream of Rahmatkhali regulator with excavation of a canal leading to Musar Khal. There would need to be a regulator on Musar Khal to retain irrigation water but to allow drainage through Rahmatkhali Khal Regulator. There would be 5 new diversion canals to transfer the irrigation water to existing drainage channels for distribution by LLPs. Necessary provision for land acquisition has been made for the works where necessary. (pump station, new retired embankment and new canal reservations).

c) Drainage Works:

The combined drainage works for all the southern polders previously considered under LRP and SRP (1988) have not been taken further. the draft regional plan evaluated this possibility but found it economically non-viable.

This was largely because since the polders are largely of F1 flood phase the benefits of drainage are relatively low. In addition the benefits of the works in progress under the CERP cannot be claimed for the additional drainage works.

In the longer term it is possible that these proposals could be reconsidered if further accretion to the south continues and this is discussed in section 5.3.

The provision of the CERP works and the additional regulators proposed in section 5.2.4(b) above do provide a relatively secure environment for polder 59.2. with improved drainage from the enlarged and extended channel net work.

5.2.5 Costings

The cost of the retirement of embankments (CERP) re-sectioning of existing embankments and three regulators facing the sea which is being done under (CERP) has not been included since this is a sunk cost. Costings for the additional components described above are summarised in Table 5.1.

5.2.6 Economic Evaluation

The standard model for economic analysis has been used with the modifications described here. The cost of the programmed CERP works has been considered as a sunk cost. The O & M costs of CERP works are also regarded as sunk cost and excluded from the FWO and FW situation. In the FWO situation, even after CERP has completed its works, there will still be a risk from cyclones due to the gaps in the northwest of the embankment. This leads to flooding and this is sometimes by saline water, therefore yields have been reduced by 10% for all crops (jute, sugar cane and orchards are insignificant). After all the works have been completed here is still a risk of cyclone damage since the embankments are only designed to withstand a one in five year surge, therefore there is still a risk of saline of flooding though much reduced. To allow for the effects cyclone damage which can destroy the crop and introduce saline water the yields in the FW situation have been decreased by 5% for all crops. It should be noted that the soils in the area are classed entirely as moderately suitable for agriculture whereas soils in the other planning units are generally better, (except for Planning Unit 2). These reductions in yields are therefore quite realistic. Apart from the benefits of irrigation the yields are therefore assumed to increase by 5% in the FW case compared with the FWO case due to the affects of the additional works on retaining and resectioning embankments and constructing new sluices, (as noted above, the FWO case assumes that the southern part of the area has been protected by CERP.

An allowance has been made for loss of capture fisheries based on a reduction in access for migrating species in the north west of the unit. Most fisheries activities are concerned with estuary and marine fishery rather than floodplain fisheries.

The present and proposed cropping patterns are given in Table 5.2. and the summary of benefits in Table 5.3. The results of the sensitivity analysis are shown in Table 5.4.

TABLE 5.1

Capital and O&M Costs in Financial and Economic Prices
Planning Unit 1, Polder 59/2

Item	Capital Cost (Tk'000) Financial Prices	Conversion Factor	Economic Prices	O&M Costs (Tk'000/year) % of Cap. Cost	Financial Prices	Conversion Factor	Economic Prices
1. Resectioning of Embankment (14 Km) (Including turfing)	19626	0.66	12992	6%	1178	0.70	823
2. New Retired Embankment (9 Km) (Including turfing)	21448	0.66	14199	6%	1287	0.70	899
3. Rahmatkhali Pump Station: (Head 3m, Q 17m³/s, 4 Nr units)							
Civil Works:	43734	0.71	30977	2%	875	0.71	623
E & M Works:	73114	0.64	46639	2%	1,462	0.70	1030
Power cost:					2,918	1.54	4494
4. Regulators:							
Location / Size							
Musar Khal 6-1.52mX1.83m	10500	0.70	7392	3%	315	0.72	227
M.P.Khal 6-1.52mX1.83m	10500	0.70	7392	3%	315	0.72	227
Goalir Khal 2-1.52mX1.83m	4500	0.70	3168	3%	135	0.72	97
Boaliar Khal 4-1.52mX1.83m	8000	0.70	5632	3%	240	0.72	173
Ludhua Khal 4-1.52mX1.83m	8000	0.70	5632	3%	240	0.72	173
5. Re-excavation of Drainage channels. (20 km)	2620	0.66	1734	6%	157	0.76	119
6. Excavation of New Irrigation Channels (9.15 Km)	12285	0.66	8133	6%	737	0.76	560
7. Electricity Transmission Line (10 Km)	4500	0.64	2871	2%	90	0.87	78
8. Transformer	9000	0.64	5741	2%	180	0.87	157
9. Vehicles	2000	0.68	1360	4%	220	0.87	191
10. Buildings	500	0.79	395	6%	30	0.72	22
11. Land Acquisition - Homesteads (8 ha)	12000	0.80	9600		0		0
12. Land Acquisition - Agricultural land (60ha)	24000	0.28	6786		0		0
Total Base Cost	266327		170643		10379		9896
Engineering & Administration (15%)	49936		31996		0		0
Physical contingency (25%)	66582		42661		2595		2474
Total Cost	382845		245300		12974		12370

TABLE 5.2

Summary of Cropping Pattern Changes

(% of NCA

Planning Unit 1, Polder 59/2

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus	36	36	36	24	24
T Aus, HYV	9	9	9	6	6
B Aman	3	3	3	2	2
LT Aman	61	61	61	60	60
HYV Aman	17	17	17	24	24
Boro	0	0	0	0	0
HYV Boro	0	0	0	32	32
Wheat irrig.	0	0	0	0	0
Wheat unirrig.	3	3	3	2	2
Potato irrig.	0	0	0	0	0
Potato unirrig.	5	5	5	3	3
Jute	1	1	1	1	1
Sugarcane	1	1	1	1	1
Pulses	15	15	15	10	10
Oilseeds	17	17	17	12	12
Spices	1	1	1	1	1
Veg. irrig.	0	0	0	0	0
Veg. unirrig.	3	3	3	2	2
Total	171	171	171	179	179

TABLE 5.3

Summary of Benefits

Planning Unit 1, Polder 59/2

	Unit	Project Year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	26.5	26.5	26.5	26.5	26.5	0	0
Irrigated Area	'000 hectares	0.1	0.1	0.1	8.6	8.6	12656	12656
Labour Requirement	million man day	7.3	7.3	7.3	8.2	8.2	11	11
Paddy Production	'000 tonnes	74	74	74	114	114	54	54
Cropping Intensity (excluding orchard)	% NCA	171	171	171	179	179	5	5
Irrigated area	% NCA	0%	0%	0%	32%	32%	12656	12656
Net Crop Income	million Taka	235	235	235	312	329	33	40
Crop flood loss reduction	million Taka				10	10		
Non-agric. flood loss reduction	million Taka				0	0		
Fish catch reduction	million Taka				5	5		

Notes:

Project Year 1	:	Assumed 1994/95
Future Without (1)	:	Future Without Project Conditions, 5 years after project would have been completed
Future Without (2)	:	Future Without Project Conditions, Year 30
Future With (1)	:	Future With Project Conditions, 5 years after project completion
Future With (2)	:	Future With Project Conditions, Year 30
% Increment (1)	:	% difference FW (1) over FWO (1)
% Increment (2)	:	% difference FW (2) over FWO (2)

Flood losses refer to average annual losses that will be eliminated by the project.

TABLE 5.4

Summary of Results and Sensitivity Analyses

Planning Unit 1, Polder 59/2

Capital cost	245.3 Tk.m.	Construction period	5 years
Annual O&M cost	12.4 Tk.m. (economic prices)		
Net Present Value @12%	35.96 Taka million (economic prices)		
Economic Internal Rate of Return	13.82 %		

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable						Switching Value (%)
		+10%	+25%	+50%	-10%	-25%	-50%	
Capital Costs	13.8	12.9	11.6	10.0	14.9	16.9	21.7	20.33
O&M Costs	13.8	13.6	13.1	12.4	14.1	14.5	15.1	65.33
Fisheries Losses	13.8	13.7	13.6	13.3	13.9	14.1	14.3	166.50
Reduced flood losses	13.8	14.0	14.4	14.9	13.6	13.2	12.7	77.54
Total Benefits	13.8	15.2	17.0	19.7	12.4	9.9	4.5	12.42
Incremental Net Crop Income	13.8	14.9	16.5	18.8	12.6	10.6	6.4	14.79
Delay in full benefits								
2 years	12.1							
4 years	11.1							
Delays in completion								
2 years	12.3							
4 years	11.0							

The financial capital cost of the proposed works is Tk. 383 million, the O & M costs at completion are Tk. 13.0 million, the EIRR is 13.8% and the NPV at 12% is Tk. 36.0 million. It must be repeated that these costs do not include the CERP works and the project should not be constructed before 1996 when CRP works are expected to be completed, and FAP 5B should have reported on the morphology of the Lower Meghna river. However this suggests that studies for the project could be implemented quite quickly.

5.2.7 Initial Environmental Evaluation

The qualitative assessment of possible environmental impact for this planning unit in respect of the option studied are reviewed here based on the regional IEE with broad identification of important environmental components as described in Annex IV of this report.

The economic evaluation has quantified a number of effects, particularly relating to agricultural production, incremental labour opportunities etc. a relatively small allowance has been made for fisheries losses in the economic analysis.

Although thana statistics suggest over 4000 tons of fish are caught per year in Ramgati thana there is no information concerning how much of this is caught in the Meghna estuary. It is to be expected that this is a high proportion since the polder has a long coastline. In addition after CERP has finished its work there will only remain four small outlets which the proposed works would close and these drain less than one third of the unit.

The closure by structures of these outlets would reduce access for migratory species at high tides.

It will be necessary to study fisheries impact in detail for this project at feasibility study stage. At the present time it is estimated that possible improvements to culture fisheries should partly affect the foreseen loss to capture fisheries and therefore their values in the qualitative assessment are not extreme.

There will be some displacement and potential for social conflict as a result of the recommendation to retire the embankment in the northwest of the area and to exclude the recently accreted lands. This will need careful evaluation and consultation with the people.

The project should enhance the value of the land but landowners will therefore benefit more than the landless. However the poor should also benefit from the project, particularly since there should not be an excess of labour to the same extent as in other areas.

Navigation within the polder is almost insignificant and any decline would be a negligible impact.

A reassessment of the physical factors affecting the polder show a net improvement as a result of the completion of the protection works. The area will continue to be prone to cyclone damage, since the level of protection provided is not absolute, but will be substantially reduced. In very severe cyclones the embankments would be overtopped but should not be breached (according to the CERP design team). Proper drainage provision is thus an important component of the CERP works. The combination of cyclone protection and irrigation water in the dry season should have a positive effect on the soil salinity and on the surface water salinity of the irrigated area.

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Recently obtained data suggests that the completed protection work will provide security against the projected sea level rise during the next thirty years of between 0.1 and 0.15 m (See Noakhali North Study Annex I) which would otherwise make both flooding and drainage slightly worse in the without project situation.

The project can have no effect on Meghna erosion. This will be studied by the FAP 5B, Meghna Estuary study but the proposals for retirement of the northwest embankment along the alignment of an existing road would allow some time for further study and monitoring of the progression of this erosion and will provide protection for the immediate future to most of the unit.

Possibly the most difficult problems concerning the proposals for this unit will be acquisition of land for the proposed retired embankments and the potential for social conflicts between those left outside the embankments and those inside. There will inevitably be pressure to move the embankment nearer to the river. However if the proposed irrigation facilities are to have a reasonably sustained life such pressures must be resisted. This will require a skilled, patient and well thought out programme to inform the people in order to gain acceptance of the proposals before works are commenced.

The summary table of qualitative impact assessment is given in Table 5.5.

Multi-criteria assessment is included in chapter 10.

TABLE 5.5

Qualitative Impacts (Ranked from -5 to +5)

Impact	Rating
Physical	
Sea Level Rise Vulnerability	+ 1
Morphology and Sedimentation (Sustainability)	- 2
Surface Water Quality	+ 1
Cyclone damage vulnerability	+ 1
Soil Salinity	+ 1
Ecological	
Wetlands Reduction	0
Biodiversity - Crop Species	- 1
Biodiversity - Aquatic (Non-Fish)	0
Capture Fisheries	- 2
Culture Fisheries	+ 1
Socio Economic	
Displacement (land acquisition)	- 2
Social Conflicts (embankment retirement)	- 3
Investment Opportunities	+ 1
Income Distribution	- 1
Poverty Alleviation	+ 1
Quality of Life	
Housing and Public Buildings	0
Nutrition	+ 1
Diseases and Vectors	0
Transport Systems	+ 1
Health (sewage etc.)	0

Note : Impacts relate to foreseen differences between future with compared to future without project situations.

5.3 Planning Unit 2 (South Sudharam)

5.3.1 General Description

This area basically consists of Polders 59/3A, 59/3B and 59/3C, see Figure 5.2 and Table 5.6. This is all char land although some of the chars are old. Until the 1950's the Lower Meghna river flowed through part of the area, the river then started to flow west of Ramgati and the accretion of the old channel was accelerated by the construction of crossdam Nr 1 in 1957 and crossdam Nr 2 in 1964.

TABLE 5.6

Polder Areas

Polder	Gross Area (ha)	NCA (ha)
59/3A	29 000	24 000
59/3B	40 000	33 200
59/3C	15 800	12 600
Total	84 800	69 800

Polder 59/3A was not closed due to continuing accretion in the polder even though the closure would only have required a short embankment and a regulator across the mouth of Baggardona. This polder used to be drained by the Bhulua river which was a tributary of the Baggardona but the Bhulua river is now in decline and drainage in the northern part of the polder is through Musa khal and Honrakhali Khal northward to Rahmatkhali khal. (This area is now included in the proposals for planning unit 3 (See Chapter 6).

Polder 59/3B is virtually complete but accretion is continuing on the south and east side. There is at least 5 km of char between the existing Coastal Embankment and the normal high tide mark.

Noakhali khal silts up rapidly and only token attempts are made to clear it. A long sand bar has formed from about 6 km downstream of Sonapur and this prevents drainage south. The catchment to the north of this drains northwards into the Begumganj depression and eventually to Rahmatkhali khal, in Planning Unit 3. However later in the monsoon season, as water levels rise, flow passes over the sand bar to the south though not of significant quantity.

Polder 59/3C was completed apart from gaps left at locations of regulators, partially to allow accretion in the southern part of the polder where ground levels were still low.

Soils in all the area tend to be saline in patches and this may be quite a severe constraint to agriculture, (see section 5.2.3).

5.3.2 Groundwater

The shallow groundwater is of recent marine origin and is saline, there is little potential for improvement since the area is low and the sea is so close. However there are pockets of fresh surface water, some quite deep, but these should be preserved for potable water use.

As described in section 5.1.2 the deep aquifer now being exploited in Lakshimpur and Chatkill should be investigated as a matter of urgency in order to identify if there is potential for exploitation of this resource in planning unit 2.

5.3.3 Previous Studies and Projects

In 1983 the Noakhali Irrigation Project recommended that irrigation water be brought into the area from the Dakatia river either by a pump station at Kamta khal, or by one at Naodona/Gazaria khal, both adjacent to the Dakatia river, water would then be allowed to flow through the existing khals in Planning Unit 3 to Planning Unit 2.

The planning unit has been extensively studied by the Land Reclamation Project (LRP) which has developed two pilot polders and a dam on Daria Nadi, unfortunately the latter was reported to be virtually destroyed in the 1991 cyclone but rebuilt again in 1992. The pilot polders are model developments of their kind. LRP estimate that it may take upto 30 years for the salinity in the soil to be leached out by natural methods, in the meantime crops are growing but with reduced yields.

In 1988 the LRP also studied options of draining the area east to west connecting Noakhali Khal to Baggardona through Daria Nadi and Gaffar Khal with an outfall to channel between south Ramgati and Boyer Char or to Meghna River at Chital Khali through Garirdona Khal of Polder 59/2 after closing Noakhali Khal at Gangchil and Baggardona at southwest corner of LRP Pilot Polder I. This was to replace the former drainage through Bhulua River and Noakhali khal which is becoming increasingly ineffective. In 1990, because of accretion at Chitalkhali LRP reconsidered this, and no longer recommended implementation.

Another proposal of LRP was the provision of a third cross dam to link the island of Sandwip to the mainland, just south of the Noakhali khal outlet. This was to accelerate accretion in the area. The SERS examined the recent situation around Char Pir Baksh using the 1989 imagery and the 1990 photography which shows that large scale accretion is occurring naturally even without the benefit of the proposed crossdam. The government has not rejected the idea of the cross dam finally but it does not appear to be likely to proceed in the foreseeable future and it has not been considered further. Any such development would require a total review of the present natural accretion at both east and west of Char Pir Baksh at the south of Noakhali Khal outlet.

The Meghna Estuary Study Project (FAP 5B) is due to commence shortly. This project will carry out a survey of the estuarine area, prepare a master plan enhancing land reclamation and improvement of coastal lands for drainage, salinity control and water management including potential settlement and development.

5.3.4 Project Options

a) Flood Control and Drainage

Polder 59/3A and 59/3B suffer from water logging and there is soil salinity constraint in all the three polders. In addition a fully closed coastal embankment of adequate design to limit cyclone damage and prevent saline intrusion is also necessary. An internal drainage canal system of adequate intensity will also be necessary not only for removal of water logging but also for leaching out soil salinity to improve agricultural production.

Recently, the CERP has included works on resectioning and retirement of the existing embankment including repairing and constructing new sluices in Polder 59/3B and 59/3C as shown in Figure 5.2.1 under the Mid Term Phase II Programme. The work should be commencing in 1993 to continue for 2 years. The CERP considered only sea facing embankment and drainage sluices but this will not protect the area from saline intrusion through Baggardona, Noakhali Khal and Bamni River which are still open to the sea.

The Noakhali Khal requires a closure just downstream of the outfall of Bamni River along with a regulator to drain out the southern part of Polder 59/3B and western part of Polder 59/3C in addition to drainage from the North (20 m^3/s). The major portion of both the polders would drain directly through the existing sluices and the new sluices under construction by the CERP.

In 1990, LRP recommended a main drainage system combining the whole catchment of Polder 59/3A, 59/3B and 59/3C linking Noakhali Khal, and Bhulua River straight across to Chitalkhali on Lower Meghna river through Polder 59/2 but they did not proceed further with the proposal on the apprehension of siltation of Chitalkhali outfall. In 1991, the Consultants of SRP also supported the outfall at Chitalkhali. The accretion at Chitalkhali still gives cause for concern and this study has evaluated both the SRP proposal and the LRP preferred option with some modifications. They (SRP) proposed a drainage channel across sluice 34A and 35 to take turn to the west inside existing embankment with outfall to the Lower Meghna river. Instead, it is proposed to align the westbound drainage channel from sluice 35 to follow the course of an existing channel outside the existing embankment and out fall to west of Baggardona but to the east of Ramgati as shown in Figure 5.2.2. Baggardona would be closed at its narrowest point at the south-east corner of LRP Pilot Polder I to follow an existing road.

The local people want a Ramgati-Boyer Char crossdam on west Baggardona channel. It could be located at the left blank of this outfall structure. Closing of west Baggardona would expedite the reclamation of Boyer Char.

The above proposals have been costed assuming that the conditions at the mouths of Noakhali Khal and Baggardona river remain stable and do not include the cost of the cross-dam to Boyar Char (which must be considered a long term proposal).

It must be emphasised that these proposals must await the results of studies under FAP 5B since the Meghna Estuary Study could very possibly make proposals which could radically affect drainage of these polders.

Figure 5.2.1

South Sudharam, Planning Unit 2 - Development Proposals

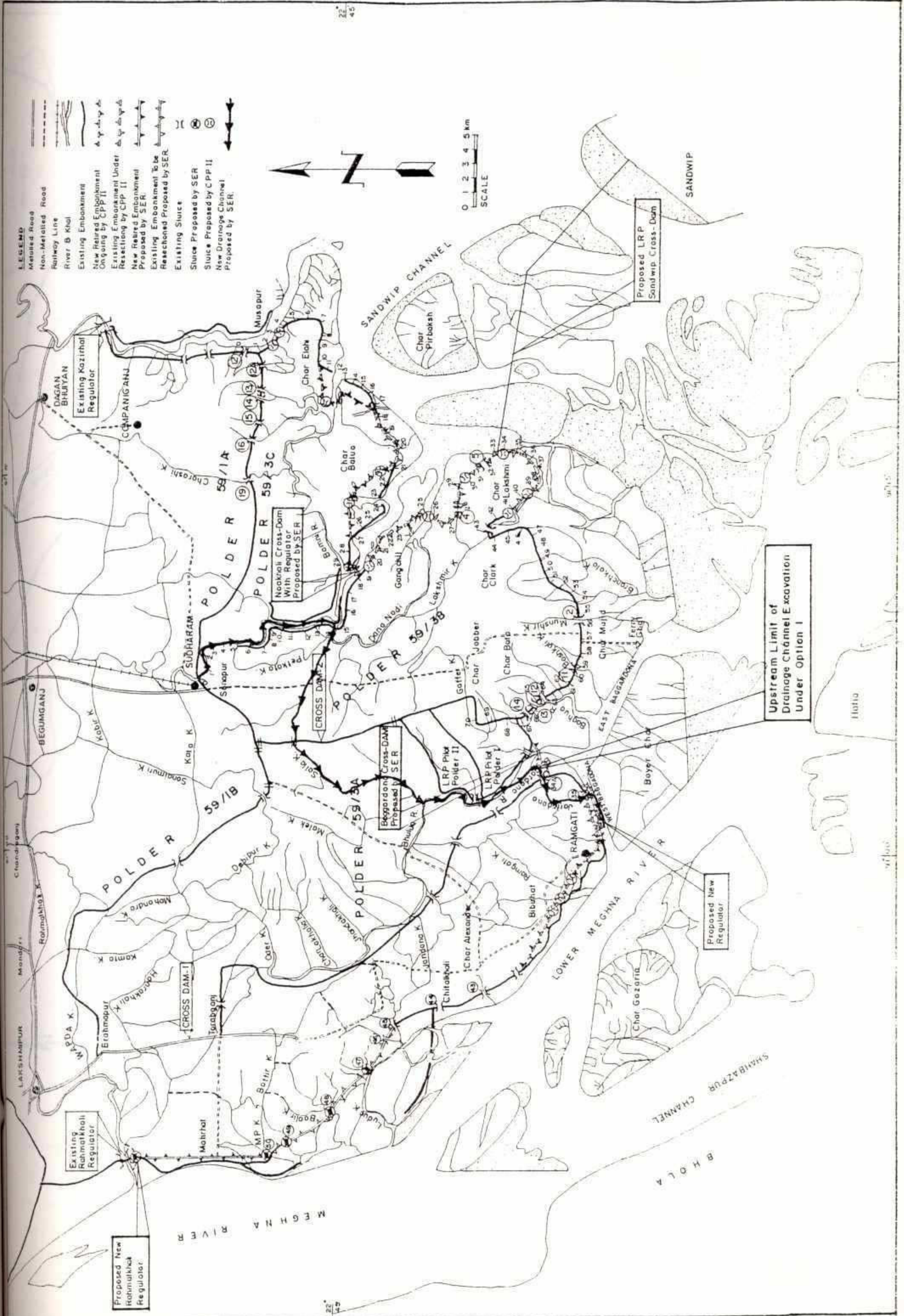
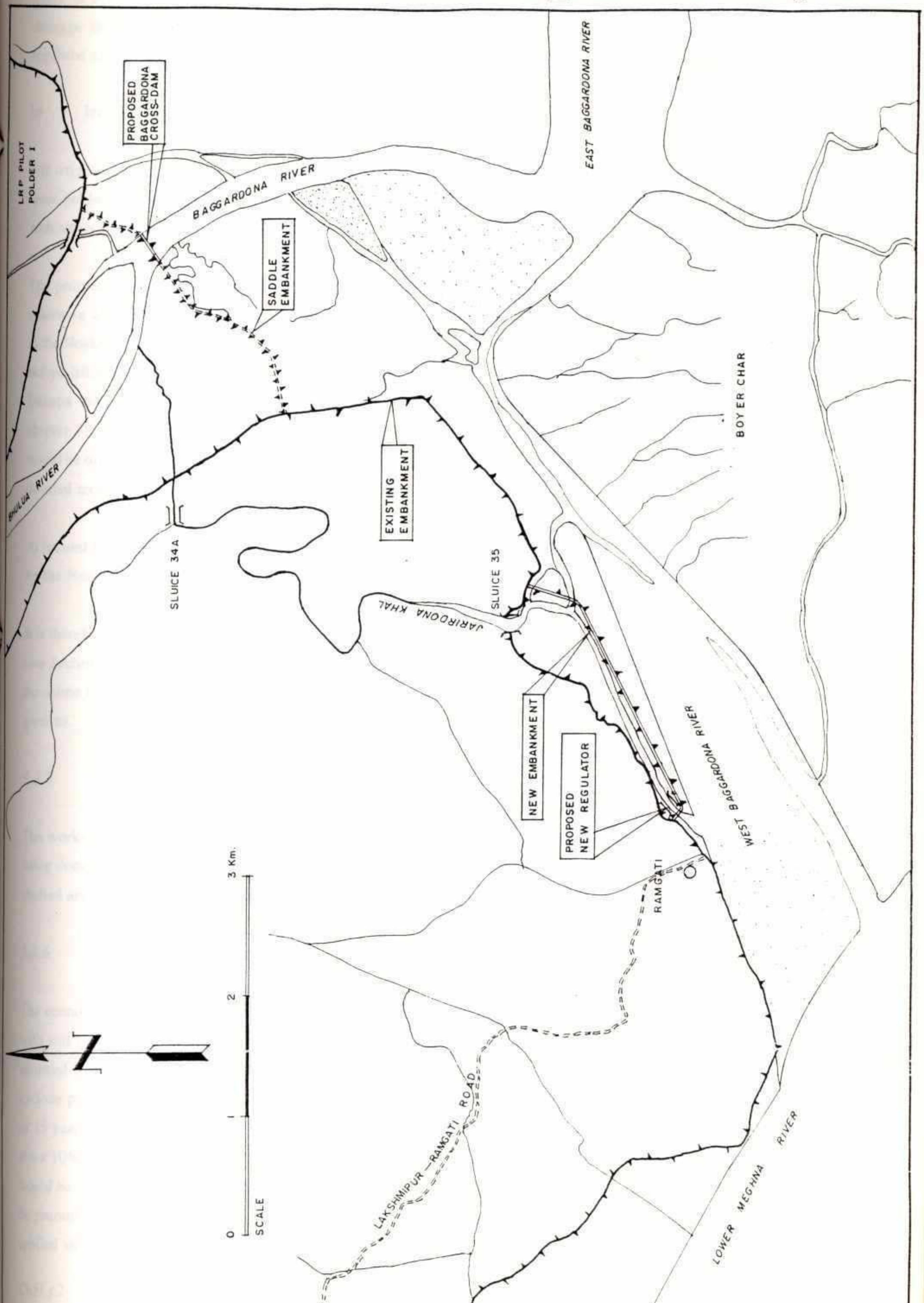


Figure 5.2.2

Proposed Infra Structures of Baggardona Main Drainage Channel



There is evidence of continuing accretion to the south (See Volume chapter 2) with the consequence that drainage through Noakhali Khal could once again become problematic after the closure embankment and regulator are constructed. In this case the option 2 (westwards drainage) would be the more favoured option.

b) Irrigation

For irrigation the only source of surface water would be the Meghna river. Owing to the remote location of these polders relative to the Meghna there are extreme difficulties in diverting surface water to this location without its being used by other areas upstream.

The proposals for planning unit 3 (NNDIP) do, in fact, cover the northwestern portion of polder 59/3A but otherwise all the water which can be brought in though Rahmatkhali Regulator by gravity supply will be used in the Noakhali North unit. Therefore to supply this unit with irrigation water would require double lift pumping before lifting by LLP. This would be the situation whether the water comes from Rahmatkhali or from the Dakatia via Little Feni although in the latter case it is most unlikely that the water could reach unit 2 (See chapter 7). It may be further indicated that if a pumpstation is added at Rahmatkhali then the gravity supply would be diminished to some extent own to higher canal water levels reducing gravity flows. This would require detailed model analysis.

At present there is approximately 1550 ha of surface irrigation in these polders and apart from the area covered by the Noakhali North Drainage and Irrigation Project there is little prospect of further increasing this total.

It is therefore considered to be a high priority to see if there is a prospect for groundwater irrigation in this area (see Section 5.3.2). In the area, at present, Rower Pumps are in extensive use to skim fresh water from above the saline layers but that is for drinking purposes and for the cattle. Some are also used for irrigation of home gardens.

5.3.5 Costing

The works proposed are shown in Figure 5.2.1 and 5.2.2. The cost of embankment and regulators which are being done under CERP has not been included since this is a sunk cost. The costs of the two drainage options studied are presented in Tables 5.7 and 5.8.

5.3.6 Economic Evaluation

The economic evaluation is slightly more complex than elsewhere because of two problems, saline intrusion, with soil salinity and cyclone damage. To cover the problems of saline intrusion and soil salinity it has been assumed that the yields for all crops in the present case are reduced by 15%. Due to the effects of improved cyclone protection with the two closures proposed the yields are assumed to increase to normal over a period of 15 years. It has also been assumed that the yields of aman and aus crops are subject to cyclone damage, for this a 10% reduction in yield has been applied to the without project case where Noakhali Khal and Baggardona would be completely open. In the with project case this reduction is taken as 5% since full protection cannot be guaranteed although the situation will be better than before; for crops other than aman no reduction has been applied since these are grown outside the main cyclone season.

TABLE 5.7

Capital and O&M Costs in Economic Prices
Planning Unit 2, Polder-59/3A and Polder-59/3B.(Drainage 1)

	Item	Capital Cost (Tk '000) Financial prices	Conversion factor	Economic prices	O&M Costs (Tk'000/year) % of capital cost	Financial prices	Conversion factor	Economic prices
1.	Drainage Improvement Works							
	Polder-59/3A							
	- Construction of cross-dam on Baggardona and Bagna Nadi	3291	0.66	2179	6%	197	0.70	138
	- Saddle embankment 2.4 Km.	7224	0.66	4782	6%	433	0.70	303
	Polder-59/3B							
	- Cross-dam on Noakhali khal	5750	0.66	3807	6%	345	0.70	241
	- Saddle embankment 1.0 Km.	3010	0.66	1993	6%	181	0.70	126
	- New drainage sluice in Noakhali Cross Dam (10-1.52mX1.83m)	16000	0.70	11264	3%	480	0.72	346
	Excavation of South Jarirdona Khal (10.8 Km)	40000	0.66	26480	6%	2400	0.70	1677
2.	Construction of Sea Dyke (2.5 Km) at Ramgati	9953	0.66	6589	6%	597	0.70	418
3.	Excavation of Minor Channels Including Structures (DM 38mm/day, 33000ha exLRP Survey)	42900	0.66	28400	6%	2574	0.70	1802
4.	Construction of Ramgati Regulator.(8-3.05mX3.05m)	56000	0.70	39424	3%	1680	0.72	1212
5.	Afforestation (6.00 Km) @ Tk 0.50 lakh/Km.	300	0.87	261	3%	9	0.87	8
6.	Vehicles	2000	0.68	1360	4%	220	0.87	191
7.	Buildings	1000	0.79	790	6%	60	0.72	43
8.	Land Acquisition (47 ha)	18800	0.28	5316		0		0
	Total Base Cost	206228		132644		9177		6506
	Engineering & Administration (15%)	38668		24871		0		0
	Physical contingency (25%)	51557		33161		2294		1627
	Total Cost	296453		190676		11471		8133

TABLE 5.8

Capital and O&M Costs in Economic Prices
Planning Unit 2, Polder-59/3A and Polder-59/3B.(Drainage 2)

Item	Capital Cost (Tk'000)			O&M Costs (Tk'000/year)			
	Financial prices	Conversion factor	Economic prices	% of capital cost	Financial prices	Conversion factor	Economic prices
1. Drainage Improvement Works							
Polder-59/3A							
- Construction of cross-dam on Baggardona and Bagna Nadi	3291	0.66	2179	6%	197	0.70	138
- Saddle embankment 2.4 Km.	7224	0.66	4782	6%	433	0.70	303
Polder-59/3B							
- Cross-dam on Noakhali khal	5750	0.66	3807	6%	345	0.70	241
- Saddle embankment 1.0 Km.	3010	0.66	1993	6%	181	0.70	126
- New drainage sluice in Noakhali Cross Dam (2-1.52mX1.83m)	4500	0.70	3168	3%	135	0.72	97
Excavation of Noakhali Khal (10 km)	10000	0.66	6620	6%	600	0.70	419
Excavation of Salla Khal (23 km)	55000	0.66	36410	6%	3300	0.70	2305
Excavation of Bhulua River (10 km)	10000	0.66	6620	6%	600	0.70	419
Excavation of South Jarirdona Khal (10.8 Km)	80000	0.66	52960	6%	4800	0.70	3353
2. Construction of Sea Dyke (2.5 Km) at Ramgati	9953	0.66	6589	6%	597	0.70	418
3. Excavation of Minor Channels Including Structures (DM 38mm/day, 33000ha exLRP Survey)	42900	0.66	28400	6%	2574	0.70	1802
4. Construction of Ramgati Regulator (12-3.05mX3.05m)	78000	0.70	54912	3%	2340	0.72	1688
5. Afforestation (6.00 Km) @ Tk 0.50 lakh/Km.	300	0.87	261	3%	9	0.87	8
6. Vehicles	2000	0.68	1360	4%	220	0.87	191
7. Buildings	500	0.79	395	6%	30	0.72	22
8. Land Acquisition (77 ha)	30800	0.28	8709		0		0
Total Base Cost	343228		219164		16362		11532
Engineering & Administration (15%)	64355		41093		0		0
Physical contingency (25%)	85807		54791		4090		2883
Total Cost	493390		315048		20452		14415

Capture fisheries losses have been estimated assuming a reduction in access to the polder due to the closure of Noakhali Khal and the Baggardona river but the area of flood plain would not be greatly affected.

For option 1 the capital cost of the works are estimated at Tk. 296.4 million and the annual cost are Tk. 11.5 million. The EIRR is 16.9%. Details of the principal benefits are given in Tables 5.9 and the sensitivity analyses results are shown in Table 5.10.

For option 2 the capital costs are Tk. 493.4, million and the annual costs are Tk. 20.5 million. The EIRR of this option is 10.4%. The summary of benefits is given in Table 5.11 and the sensitivity analysis in Table 5.12.

The cropping patterns for both options are unchanged from the present situation since all flood phases are assumed to remain the same. All benefits are from improvement of yeilds owing to reduced salinity and reduced cyclone damage. The cropping patterns are shown in Table 5.13.

TABLE 5.9

Summary of Benefits

Planning Unit 2, Polder-59/3A & Polder-59/3B (drainage 1)

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	69.8	69.8	69.8	69.8	69.8	0	0
Irrigated Area	'000 hectares	1.7	1.7	1.7	1.7	1.7	0	0
Labour Requirement	million man day	19.4	19.4	19.4	19.4	19.4	0	0
Paddy Production	'000 tonnes	195	195	195	206	206	6	6
Cropping Intensity								
(excluding orchard)	% NCA	170	170	170	170	170	0	0
Irrigated area	% NCA	2%	2%	2%	2%	2%	0	0
Net Crop Income	million Taka	629	629	629	629	662	0	5
Crop flood loss reduction	million Taka				56	56		
Non-agric. flood								
loss reduction	million Taka				0	0		
Fish catch reduction	million Taka				13	13		

Notes:

Project Year 1	: Assumed 1994/95
Future Without (1)	: Future Without Project Conditions, 5 years after project would have been completed
Future Without (2)	: Future Without Project Conditions, Year 30
Future With (1)	: Future With Project Conditions, 5 years after project completion
Future With (2)	: Future With Project Conditions, Year 30
% Increment (1)	: % difference FW (1) over FWO (1)
% Increment (2)	: % difference FW (2) over FWO (2)

Flood losses refer to average annual losses that will be eliminated by the project.

TABLE 5.10

Summary of Results and Sensitivity Analyses

Planning Unit 2, Polder-59/3A & Polder-59/3B (drainage 1)

Capital cost	190.7 Tk.m.	Construction period	5 years
Annual O&M cost	8.1 Tk.m. (economic prices)		
Net Present Value @12%	80.61 Taka million (economic prices)		
Economic Internal Rate of Return	16.86 %		

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	16.9	15.8	14.4	12.5	18.1	20.4	26.1	58.64
O&M Costs	16.9	16.7	16.3	15.8	17.1	17.4	17.9	222.72
Fisheries Losses	16.9	16.5	16.0	15.2	17.2	17.7	18.5	137.38
Reduced flood losses	16.9	18.2	20.2	23.3	15.4	13.1	9.0	32.19
Total Benefits	16.9	18.5	20.7	24.1	15.1	12.2	5.7	25.76
Incremental Net Crop Income	16.9	17.1	17.5	18.1	16.6	16.1	15.3	128.98
Delay in full benefits								
2 years	13.1							
4 years	11.4							
Delays in completion								
2 years	14.9							
4 years	13.3							

TABLE 5.11

Summary of Benefits

Planning Unit 2. Polder-59/3A & Polder-59/3B (Drainage 2)

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	69.8	69.8	69.8	69.8	69.8	0	0
Irrigated Area	'000 hectares	1.7	1.7	1.7	1.7	1.7	0	0
Labour Requirement	million man day	19.4	19.4	19.4	19.4	19.4	0	0
Paddy Production	'000 tonnes	195	195	195	206	206	6	6
Cropping Intensity (excluding orchard)	% NCA	170	170	170	170	170	0	0
Irrigated area	% NCA	2%	2%	2%	2%	2%	0	0
Net Crop Income	million Taka	629	629	629	629	662	0	5
Crop flood loss reduction	million Taka				56	56		
Non-agric. flood loss reduction	million Taka				0	0		
Fish catch reduction	million Taka				13	13		

Notes:

Project Year 1	:	Assumed 1994/95
Future Without (1)	:	Future Without Project Conditions, 5 years after project would have been completed
Future Without (2)	:	Future Without Project Conditions, Year 30
Future With (1)	:	Future With Project Conditions, 5 years after project completion
Future With (2)	:	Future With Project Conditions, Year 30
% Increment (1)	:	% difference FW (1) over FWO (1)
% Increment (2)	:	% difference FW (2) over FWO (2)

Flood losses refer to average annual losses that will be eliminated by the project.

TABLE 5.12

Summary of Results and Sensitivity Analyses

Planning Unit 2, Polder-59/3A & Polder-59/3B (Drainage 2)

Capital cost	315.0 Tk.m.	Construction period	5 years
Annual O&M cost	14.4 Tk.m. (economic prices)		
Net Present Value @12%	-37.02 Taka million (economic prices)		
Economic Internal Rate of Return	10.37 %		

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	10.4	9.5	8.5	7.0	11.3	13.1	17.4	16.30
O&M Costs	10.4	10.1	9.6	8.9	10.7	11.1	11.8	57.70
Fisheries Losses	10.4	10.1	9.7	9.0	10.6	11.0	11.7	63.09
Reduced flood losses	10.4	11.5	13.1	15.5	9.2	7.3	3.8	14.78
Total Benefits	10.4	11.8	13.7	16.5	8.9	6.2	-0.1	11.83
Incremental Net Crop Income	10.4	10.7	11.1	11.8	10.1	9.6	8.6	59.23
Delay in full benefits								
2 years	8.1							
4 years	6.8							
Delays in completion								
2 years	9.2							
4 years	8.2							

TABLE 5.13

Summary of Cropping Pattern Changes

(% of NCA)

Planning Unit 2, Polder-59/3A & Polder-59/3B (drainage 1)

Planning unit only

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus	35	35	35	35	35
T Aus, HYV	9	9	9	9	9
B Aman	3	3	3	3	3
LT Aman	60	60	60	60	60
HYV Aman	17	17	17	17	17
L Boro	0	0	0	0	0
HYV Boro	2	2	2	2	2
Wheat irrig.	0	0	0	0	0
Wheat unirrig.	3	3	3	3	3
Potato irrig.	0	0	0	0	0
Potato unirrig.	5	5	5	5	5
Jute	1	1	1	1	1
Sugarcane	1	1	1	1	1
Pulses	14	14	14	14	14
Oilseeds	17	17	17	17	17
Spices	1	1	1	1	1
Veg. irrig.	0	0	0	0	0
Veg. unirrig.	3	3	3	3	3
Total	170	170	170	170	170

5.3.7 Environmental Evaluation

The qualitative assessment of possible impacts for this planning unit in respect of the options studied have many similarities with those described for planning unit 1. In particular the impacts concerning cyclone impacts, saline intrusion, sea level rise and surface water quality will all be positive only in this case rather more so since this area is more severely affected at present by these phenomena (or is more vulnerable to them).

The economic analysis has included a substantial fisheries loss which is entirely due to the closure of the two main outlets to the sea with the consequential loss of access for migratory species. The main channels, i.e. Noakhali khal and Bhulua river, together with the numerous khals in the area as a whole indicate the potential for capture fishery if properly managed. Together with the development of pen culture technology, the khals and rivers could be fenced with suitable screening materials and may be stocked with suitable species of fish for culture. The Planning Unit is new in formation and as would be expected there are freshwater ponds that are under traditional fish culture. There are homestead ponds but these are mainly used for retaining rainwater for household use.
This aspect will need particular attention if any of these proposals are taken to the feasibility study stage.

Where possible the channel works have used existing bank top widths to minimise the need for land acquisition and consequential displacement. Also the use of spoil spreading would be encouraged but the quality of the spoil may be a problem here.

Again land values would be enhanced probably increasing inequality in incomes and wealth. Since cropping intensity would not increase there would be initially no increase in non family agricultural labour and with the fisheries losses the project would seem to be particularly socially regressive. If the project is to be pursued it would be necessary to design a carefully targeted mitigation programme. Indeed a by pass structure at Noakhali Khal would probably be essential but its design could be quite difficult if it is not to defeat the purpose of preventing saline intrusion.

Given the very active morphological processes along the coastline of this planning unit there must be severe questions relating to the sustainability of any system which relies on southward drainage. In this respect the westward drainage option 2 is preferable but is obviously less effective economically, at present. There is an urgent need for the FAB 5B study to investigate this question and it is considered prudent to delay a decision on any further studies until the Meghna Estuary Study has made its recommendation which could radically alter the possible options and could either improve or make worse the present drainage congestion.

Additionally it may be noted that option 2 (the western drainage route) would be technically more sustainable in the event of continued accretion when also it is probable that the value of the Noakhali Khal fisheries would decline as the sea receded.

The foreseen qualitative impacts are given in Table 5.14.

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TABLE 5.14

Qualitative Impacts of Planning Unit 2 (Ranked from -5 to +5)

Impact	FCD Option 1	FCD Option 2
Physical		
Sea Level Rise Vulnerability	+ 2	+ 2
Morphology erosion and sedimentation (sustainability)	- 3	- 2
Surface Water Quality	+ 1	+ 1
Cyclone damage vulnerability	+ 2	+ 2
Salinity	+ 2	+ 2
Ecological		
Wetlands Reduction	0	0
Biodiversity - Crop Species	0	0
Biodiversity - Aquatic (Non-Fish)	- 1	- 1
Capture Fisheries	- 3	- 3
Culture Fisheries	1	1
Socio Economic		
Displacement	- 1	- 1
Social Conflicts	- 2	- 2
Investment Opportunities	+ 1	+ 1
Income Distribution	- 2	- 2
Poverty Alleviation	0	0
Quality of Life		
Housing and Public Buildings	+ 1	+ 1
Nutrition	+ 1	+ 1
Transport Systems	+ 1	+ 1
Public Health, Diseases and Vectors	0	0

Note: Impacts relate to foreseen differences between future with and future without situations.

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CHAPTER 6

NOAKHALI NORTH DRAINAGE AND IRRIGATION PROJECT

6.1 Introduction

The South East Regional Study was originally identified and prepared in 1987 and was intended to provide two principal outputs as follows:

i) A Regional Water Resources Plan
ii) A feasibility study for a priority project identified during the preparation of the regional plan

The agreement with the consultants led by Sir M MacDonald & Partners Ltd. was signed in October 1990.

The consultants draft regional plan was submitted in April 1992 and accepted subject to revision and updating as agreed between the consultant, GOB and the donors. The consultants identified the priority project now called Noakhali North drainage and irrigation project and requested additional funding to complete the feasibility study in order to accommodate additional requirements.

During the preparation of the Regional Plan, several additional requirements were identified as being necessary to produce a feasibility study nearer to the present requirements of all concerned parties.

After discussions with BWDB, FPCO, the donor and executing agencies the consultants proposed revised TOR to go as far as possible, within the available time and budget resources, to meet the required standards.

The feasibility study draft final report was issued in July 1993 and this chapter summarises the feasibility main report but for greater detail the reader is referred to the nine volumes of the feasibility study.

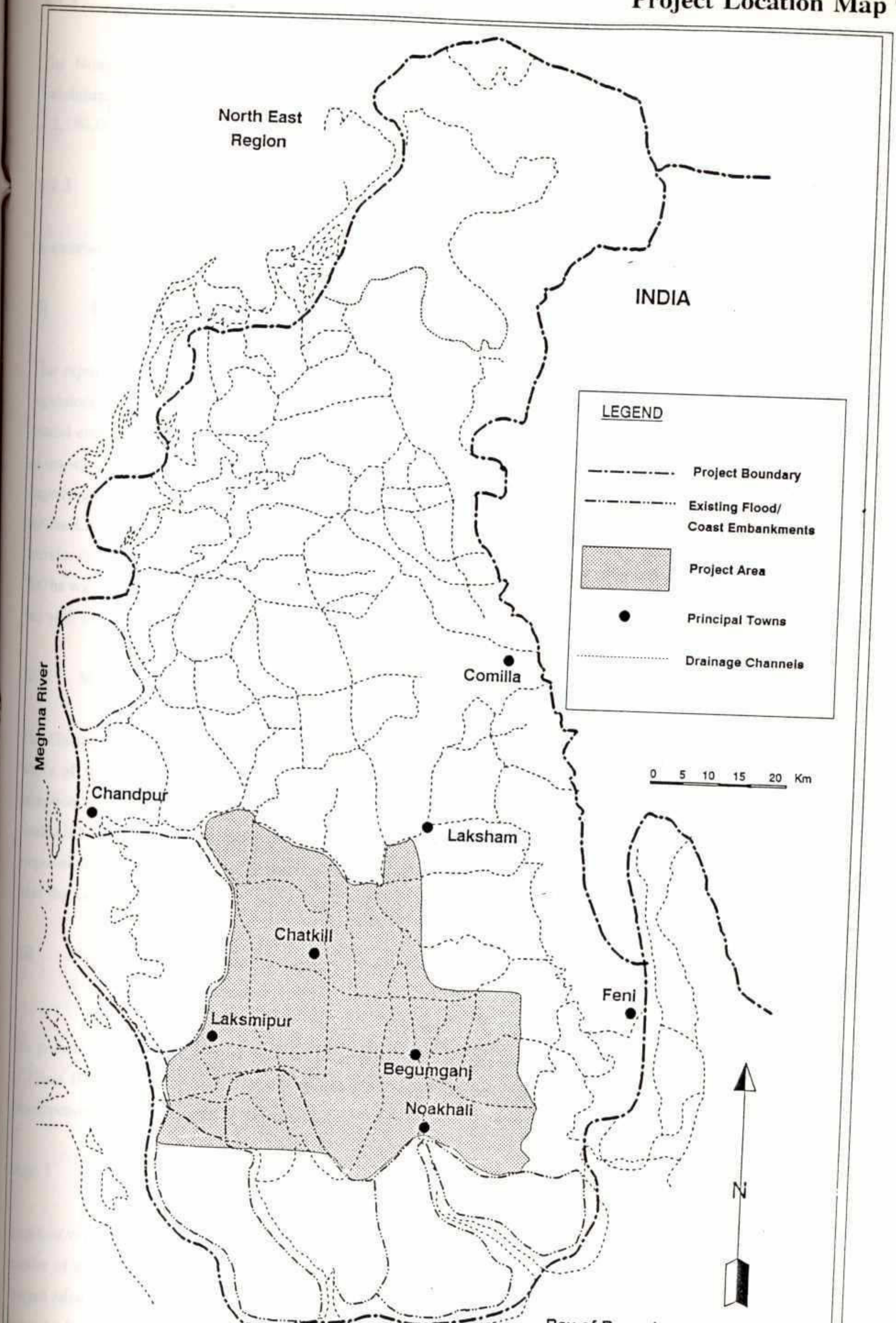
6.1.1 Project Location

The project area lies on the east bank of the Lower Meghna River. It is bounded by the Lower Meghna and the existing Chandpur Irrigation Project on the west, the Dakatia River on the north, the slight ridge bordering the Little Feni River basin on the east and the Noakhali coastal char lands to the south.

The project area is shown in Figure 6.1 in its sub-regional setting. The gross area within the above project boundary is 160 000 ha. The elevation varies between about 3.5 m and 5.0 m above Public Works Datums (PWD).

It is important to state at the outset that the study of this area for drainage purposed must be approached on a sub-regional basis and for this reason the consultants included surrounding areas for study and analysis of drainage effects to identify any substantial inter basin transfers and consequent change outside the defined project boundary. The project area includes all of planning unit 3 and most of planning unit 5.

Figure 6.1
Project Location Map 129



6.1.2 Population

The Noakhali North Project area comprises parts of four districts of the south east region, Chandpur, Lakshmipur, Noakhali and Comilla. The population within the project area from the 1991 census is estimated a 2,186,000.

6.1.3 Previous Studies

A number of previous studies of relevance to the project area are revised below:

(i) Little Feni and Noakhali Regulators (International Engineering Company Inc, October 1961)

This report presents the results of preliminary investigations, detailed designs and cost estimates for proposed regulators on Noakhali Khal and the Little Feni River. The purpose of both regulators, in conjunction with the coastal embankments then under construction under the Coastal Embankment Project, was to prevent the inflow of sea water and resultant salivation, whilst permitting floodwater to be evacuated through flap gates at low tide. Improved internal drainage channels and peripheral embankments were also to be provided. The design selected for the Little Feni (Kazirhat) Regulator consisted of 30 Nr 12 foot (3.66 m) diameter corrugated steel culvert barrels with dished-head flap gates at each end, with three wagon mounted gate hoists provided. An area of 28 700 ha was assumed to benefit, including gravity irrigation for 3 650 ha of boro. The regulator was constructed, but with only 20 Nr barrels. No regulator was constructed on Noakhali Khal.

(ii) Master Plan (International Engineering Co., December 1964)

The Master Plan envisaged a single Comilla-Noakhali Project of 336 000 ha gross covering substantially the whole of the South East Region south of the Gumti River down to the old coastal embankment, with the exception of Chandpur and Meghna Dhonagoda Irrigation Projects and the Little Feni/Old Dakatia basin. The Noakhali North project area more or less corresponds with the South Area designated in the Master Plan. It was proposed to provide full flood protection with pumped drainage initially, flooded by surface water irrigation from the Lower Meghna River.

(iii) Meghna-Muhuri Water Transfer. Draft Planning Report (International Engineering Co/Rahman & Associates, September 1972)

The present project area corresponds with the Noakhali North component and part of the Dakatia component of Phase III of the proposals for the transfer of irrigation water eastward from the Lower meghna River. Development was anticipated in two stages:

Stage I

Irrigation via a primary pump station (an extension of one proposed on the Dakatia River as the first link in the transfer of water to the Muhuri basin) from the Dakatia River into Kamta Khal, and thence via the borrow pit channel adjacent to the Ramganj-Chatkhil-Senbagh road into Noakhali Khal. Delivery to the tertiary channels was to be by low lift pumps (LLP).

Stage II

Flood control by the completion of Chandpur Irrigation Project (now complete), and the embankment of the Dakatia and Little Feni Rivers under, separate components of the transfer proposals. Drainage improvements through channel excavation and construction of an outfall regulator on the lower meghna river more or less corresponding to the now existing Rahmatkhali Regulator.

(iv) Feasibility Report on Comilla and Noakhali Project - Phase I (Dakatia Unit) BWDB/Netherlands Engineering Consultants, February, 1980)

This report (based upon an Interim Project Feasibility Report of May 1974, prepared by International Engineering Co/Rahman & Associates) considers the provision of full irrigation and flood control to the triangulator area bounded by the Dakatia River in the north-east, the Chandpur Irrigation Project in the west and the Ramganj-New Dakatia River road in the south-east. It was concluded that the provision of irrigation alone was not economically viable, but became so with the addition of full flood protection and drainage. Irrigation water supply was to be via three pump stations on the Dakatia River.

The report acknowledges that its proposals are not directly compatible with the Meghna-Muhuri Water Transfer Scheme (MMWTS) proposals, but reached the conclusion that the latter was unlikely to come into operation within the next 25 years, and therefore could be disregarded for purposes of economic evaluation.

(v) Noakhali Irrigation Project Preliminary Report (BWDB, September 1982)

This report reviewed the previous proposals for the Comilla, Noakhali and Chittagong greater districts, which culminated in the Meghna-Muhuri Water Transfer Planning Report proposals. In the context of the financial constraints preventing implementation of the whole Water Transfer proposals, the Noakhali North component was identified as the next project recommended for implementation (following Muhuri Irrigation Project Phase I and Meghna-Dhonagoda Irrigation Project which were at the time under construction). By this time, the Comprehensive Drainage Scheme out falling at Rahmatkhali Regulator had already been completed.

(vi) Inception Report on Noakhali Irrigation Project (BWDB, January 1983)

This report substantially modified the delineation of the Noakhali North, Dakatia and Little Feni components of the Water Transfer proposals. An enlarged Noakhali Irrigation Project was envisaged extending to the Dakatia River and Laksham in the north and the Little Feni River in the east, and including the coastal char lands in the south, with complete peripheral embankments and an outfall regulator on Noakhali Khal. As well as the pump station into Kamta Khal, another was to be provided further east on the Dakatia (Naodona pump station) feeding into Naodona Khal and thence into Noakhali Khal. Three phases were envisaged, with a gross area totalling 290 000 ha and a net irrigated area of 164 000 ha. It appears that these proposals were not however studied any further.

(vii) **Draft Feasibility Report-Rehabilitation of Old Dakatia and Little Feni River (Sub-Project Nr 19, Rehabilitation of Water Development Project, EPC/Harza/MacDonald April 1988)**

This report describes the existing problems of the Little Feni basin, associated with the sedimentation of the upper reaches and the siltation of Kazirhat Regulator. The construction of a new regulator 15 km downstream of the existing Kazirhat Regulator was considered, but not recommended for immediate implementation because:

- the new regulator might face a similar problem of downstream accretion within a few year. This could be increased by construction of the proposed Sandwip cross-dam.

- the proposal needs to be examined in the context of drainage planning for the whole of the area to the south of the Chandpur-Comilla highway, under the South-East Regional Study.

However, a tentative analysis using the South East Region Surface Water Simulation Model (SERM) was reported to indicate substantial benefit from a new regulator.

Recommendations were thus substantially confined to silt clearance in the upper channel reaches, and annual excavation of a pilot channel for about 4.5 km downstream of Kazirhat Regulator at an estimated annual cost of Tk. 3 592 000 (the latter more or less along the lines of current practice).

(vii) **Feasibility Report-Structures for Little Feni River Sub-Project (Second Small Scale Flood Control, Drainage and Irrigation Project, North-West Hydraulic Consultants Ltd., 1988)**

This Sub-Project is located on the right bank of the Little Feni River immediately adjacent to Kazirhat Regulator. It aims to protect a gross area of about 536 ha upstream of the Regulator from early floods (caused by the delayed opening of the Regulator), through the provision of a sluice. The same sluice also would admit irrigation water. A further area of 103 ha gross downstream of the regulator would be protected from sea-water intrusion through embankment re-sectioning and provision of a sluice. It is understood that a contract was awarded for construction, but the first contractor failed to perform.

(ix) **Water Under the Bridge, The Final Report (186-1989) of the Irrigation and Drainage Component of the Noakhali Rural Development Project - Phase II. (NRDP-II/DANIDA, August 1989)**

This report makes reference to nine irrigation water retention structures at or near the confluences of tributary khals with Rahmatkhali and WAPDA Khals. These structures were constructed under Noakhali Integrated Rural Development Project Phase I in anticipation of an early implementation of the Noakhali Irrigation Project. In the absence of the project, they are more or less redundant.

(x) **Feasibility Report-Sonaichari FCD Sub-Project (Second Small Scale Flood Control, Drainage and Irrigation Project, North-West Hydraulic Consultants Ltd., 1989)**

This sub-project aims to provide irrigation and drainage structures to complement a previous Food For Work programme of embankment rehabilitation along both banks of Sonaichari Khal. Works include two drainage/flushing regulators, three new drainage sluices and the rehabilitation of a further eight, and the installation of twenty 300 mm PVC pipe irrigation inlets. Implementation is still (1994) in progress, as the regulator at the west and of Rotia Khal has not yet been constructed.

There is a section in the report on the regional flooding problems, including the flow reversal in the Old Dakatia River due to sediment deposition from the Kakir River, but the interventions do not address these problems. In particular, there is no investigation of the possible adverse effect of Tungirpar Regulator, which was constructed in the mid 1980s on the New Dakatia River, immediately to the west of the confluence of Sonaichari Khal.

6.2 Present Situation

6.2.1 Climate, Hydrology and Morphology

The project area experiences a typical monsoon climate, with hot wet summers from May to September and cooler dry winters. The mean annual rainfalls at Noakhali, Lakshmipur and Hajiganj are 3 201, 2 551 and 1 996 mm respectively. Evapotranspiration exceeds rainfall for the months of November to April, and boro rice generally requires irrigation. An analysis of rainfall records shows that particularly in the dryer areas towards Hajiganj there are in most years, even in the wet season (April to September), several dry periods of five days or more, when supplemental irrigation of aus and aman crops could be beneficial. Several major cyclones have crossed the area, but damage is mostly limited to that caused by high winds, with the newly accreted land to the south of the project area bearing the brunt of the tidal surges.

With the accretion of this new land, drainage of the project area has been severely affected, due both to the lengthening and siltation of drainage paths to the south, and also because the new land itself is in places a little higher in elevation. The result is the Begumganj depression which, although not in fact remarkably low (above 3.5 m above Public Works Datum), is almost completely encircled by higher ground, and tends to accumulate run off from surrounding areas. As floodwaters rise, the Begumganj depression tends to merge with the Laksham depression to the north. The original natural drainage channel for the Begumganj depression area was to the south, via Noakhali Khal, but the deposition of tidal sediment in this channel means that it is now ineffective.

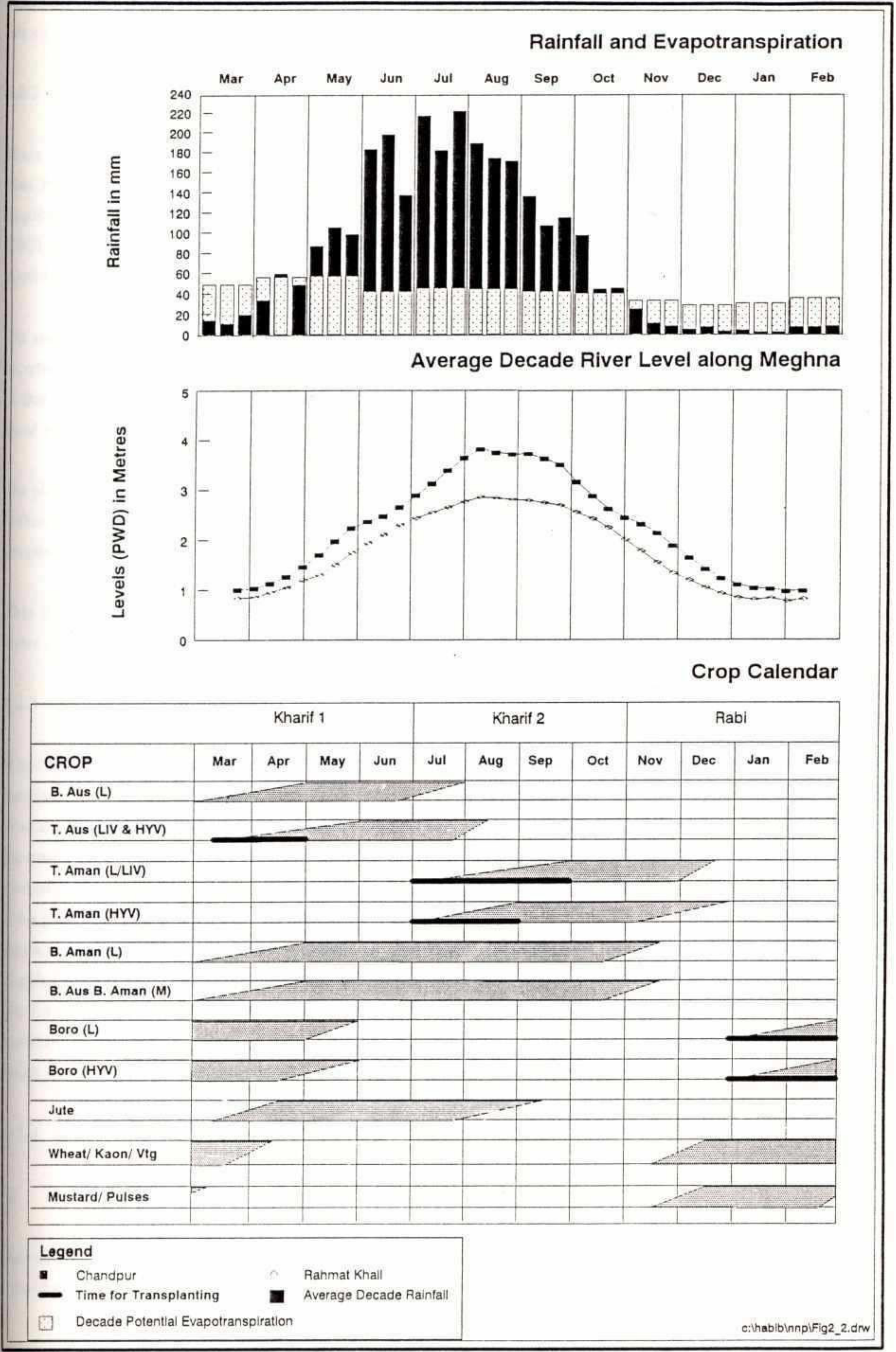
The Lower Meghna carries the combined flows of the Ganges, Jamuna and upper Meghna rivers. The coincidence of seasonal rainfall with peak flood discharges in the Lower Meghna, exacerbates internal drainage problems. Figure 6.2 shows hydrographs of mean decad water levels in the Meghna River, along with mean decad rainfalls over the project area.

The Lower Meghna is the outfall water level control on drainage for most of the project area. The seasonal range in Lower Meghna water levels reduces in a southerly direction towards the Bay of Bengal. At Chandpur, the monsoon seasonal range of water levels is of the order of 2.0m and there is a tidal range of 0.8m in the dry season. At Rahmatkhali the monsoon seasonal range in water levels is of the order of 1.0m, and the dry season tidal range is of the order of 2 m. There is a notable change in water surface slope in the Meghna between wet and dry seasons.

Sedimentation in the main khals has been relatively small over the years and some of this has been caused by excavated material being washed back into the khal during rainstorms. In the Begumganj depression where flow velocities are very low the siltation of the bed might be expected to be at its highest and yet no re-excavation of this section has occurred in the last 20 years and the bed has silted by less than 1.0m in this period. Further

Figure 6.2

Relationship Between Rainfall Evapotranspiration, Floods and Crops



downstream there is no evidence of accretion and as stated previously the problems are more concerned with erosion. The large number of existing embankments criss-crossing the area generally prevent widespread erosion and , therefore, the low levels of sediment reported in the 1988 study are entirely consistent with the perceived rate of sedimentation in the khals of about 0.05 m/yr.

6.2.2 Salinity

There is very little salinity data available for the Meghna River. However the data used in the National Water Plan Phases I and II (Ilshaghat), at the northern tip of Bhola Island more or less opposite Rahmatkhali Regulator, has been updated and supplemented by data collected by the Surface Water Modelling Centre (1991-1992) at Rahmatkhali regulator. The data were plotted as series of monthly maxima for February, March and April from 1966 to 1992, and the results show a clearly declining trend in salinity levels during the dry season.

The main reason for this decline is considered to be the progressive elongation of the Meghna estuary as the accretion of new lands to the south continues. This means that the saline water is driven further out into the Bay of Bengal during the monsoon season and therefore returns to a lower point of the river in the dry season. This trend is expected to continue.

The plotted results show that only twice in the last ten years has a result been obtained in excess of 2000 μS/cm. Unless this level became a common value rather than a very rare peak there would be no adverse effect on irrigated rice.

Thus this study supports and reinforces the NWP II contention that even with forecast upstream development water quality at Ilshaghat and therefore at Rahmatkhali would remain suitable for irrigation.

6.2.3 Rise in Sea Level

It has been postulated that a rise in sea level as a result of global warming would severely affect large parts of Bangladesh including the project area. The consultants are indebted to Dr. Robert Kay of the University of Waikato New Zealand, who provided recent data on this issue. This data shows that progressive revisions of the estimates of the IPCC (1990) best estimates have produced lower values for expected sea level rise. With revised models based on recent IPCC (1992) findings the projected rise for the year 2100 is 0.48m. However, if the project life of 30 years is considered the projected rise is only 0.10m. This would not significantly affect duration of discharges through the regulator. It should also be noted that recent analysis of available data in Bangladesh has been unable to identify any reliable evidence of even relative sea level rise to date. This suggests that for the purposes of this study sea level rise may be considered to be a very minor factor in terms of project viability. In the very long term, if significant sea level rise were to occur, the provision of some additional gated width would provide much longer term sustainability of the tidal drainage system.

6.2.4 Flood Control and Drainage

a) Lower Meghna Erosion

Any development of the Noakhali North project area must take account of possible shifting of the existing bank line of the Lower Meghna, particularly in determining any vulnerability of the Rahmatkhali Regulator.

FAP 9B (Meghna Bank Protection) and BWDB reports relating to erosion problems along the Lower Meghna were reviewed, and field visits undertaken to the area near the regulator and the nature and extent of erosion along the bank line studied. Available aerial photography, SPOT satellite imagery and maps from 1963 to 1990 were also studied. Subsequently a series of LANDSAT images (December 1973 - January 1993) covering part of the area also became available. Lastly the distance from the regulator to the main channel was measured in March 1993.

The principal concern for the project is the stability of the river section at and near the Rahmatkhali regulator. Previous reports have suggested very rapid erosion at this location and one report (LRP 1988) suggested that the regulator could be under threat by the year 2003. However a review of the satellite imagery between 1973 and 1993 does not seem to support this and although there has been substantial erosion. Measurements from the 1989 spot imagery and the 1990 aerial photography suggest distances from the left bank to the regulator of 2.4 km and 2.3 km respectively. A physical measurement, undertaken during this study in March 1993, produced a distance of 2.287 m. Thus it would seem that the situation has stabilised over the last four years. The LRP report mentioned above foresaw this possibility.

Examination of the LANDSAT images (1973-1993) indicate that the meanders of the Lower Meghna are gradually moving downstream, as might be expected, and that the left bank at Rahmatkhali is probably safe for the foreseeable future. Indeed the recent imagery shows some accretion just to the north.

The substantial flows from Rahmatkhali Khal have always kept the mouth of the Khal clear and with the proposed increased discharges in the Khal this is expected to continue.

b) The Noakhali Khal

Historically the Noakhali Khal has been a principal drainage channel from what is now called the Begumganj depression.

Water level records began to be collected for the Noakhali Khal at a station near Noakhali in 1967. The records indicate that from the time records started (1967) until 1974 there was a definite increasing trend in peak monsoon water levels and over the same period there was a substantial decrease in the tidal range. It was over this period that most of the land accretion occurred and, although this has continued, the hydraulic condition of Noakhali khal, at the southern embankment, stabilized at that time and has been largely constant since. Despite several attempts to improve drainage, through re-excavation, the khal has remained ineffective as a drain throughout the last 20 years. The distance from the junction of WAPDA Khal and Noakhali Khal to the sea has increased to 50 km which is further than the distance from the same junction to Rahmatkhali Regulator. Accretion at the mouth of Noakhali Khal is still occurring.

It is clear, therefore, that there would be severe problems in making Noakhali Khal into an effective drain since to do this would require major re-excavation over a very long distance and the construction of a large regulator at a site where accretion is continuing. This would present severe obstacles to sustaining a silt free outlet.

c) **The Existing Scheme**

The Noakhali Comprehensive Drainage Scheme was conceived and designed in the late 1960's as it became apparent that the accretion of the southern polders was causing drainage problems in the old coastal polders 59/1A and 59/1B. The system operated largely as intended but owing to the situation in Noakhali Khal, as described above, the system and its principal structure, the Rahmatkhali regulator became heavily overloaded. This has had a number of negative effects as described below:-

i) The Khal system, being overloaded, is operating at higher than design discharge and with correspondingly high velocities which has caused erosion of banks and destruction of homesteads, orchards and fish ponds. Such losses were reported in local newspapers during the feasibility study.

ii) The Rahmatkhali regulator is currently discharging nearly double its design discharge. It is testimony to its good design and construction that despite this it is still operational 20 years later. However there has been serious downstream erosion of the khal bed and sides with classic erosion patterns being formed on either side of the outlet. Extensive repair work is currently being carried out to the sides of the downstream channel.

iii) The restriction of flow through the Noakhali Khal and the consequent overloading of the Rahmatkhali Khal, and the principal khals which supply it, has meant that the Begumganj depression and indeed the entire area south of the Dakatia and west of Chandpur Irrigation Project (CIP) is flooded more deeply than was previously the case. This has severely limited monsoon season cropping.

6.2.5 Impacts of Floods

As in many places in Bangladesh normal floods are not seen as a "Problem" since it is what the people expect and what they plan for in terms of cropping and work. However it is quite clear that what is normal today was not normal thirty years ago. In those times there was a great deal more aman season cropping since drainage congestion did not exist to the same extent as now. Older people in the area remember times when drainage was better. The more recent generations have never known anything different from the present situation.

However there is evidence that the communities go to considerable effort to try to improve their flood conditions by the construction of local area drainage schemes. Although these can be quite effective, they can make conditions for others worse since the water is not removed from the project area.

The public participation meetings identified that whilst people make the best of their situation as they see it there are widespread misunderstandings about the cause of the floods and what may help to solve them. The water level records collected during the last seven years by the SWMC and the resulting calibrated model both demonstrate that most of the flooding is caused by local rainfall and is not imported from the Dakatia and Little Feni catchments.

At local participation meetings at villages adjacent to the Dakatia it was learnt that over spill from the river was not considered a problem to boro crops and therefore embankments were not favoured. However further away from the river villagers believed their flooding to be coming from the river.

In fact what is happening is that rainfall fills the low lying areas and cannot drain out as the river fills to a level which does not permit drainage. It is also interesting that most farmers tend to overestimate the depth of flooding on their fields. This fact was confirmed by the farm surveys, the plot surveys and the observed SWMC records. The farmers actual cropping patterns tended to confirm this overestimation since they could not grow their stated cropping patterns on land flooded to the depths they claim.

The project area has a more consistent flooding regime than some areas. This is because the main problem is poor drainage rather than main river overspill. The limitations of the drainage channels and the main regulator severely impedes the drainage of the system and results in water levels much higher than necessary. The records show and the model confirms that in the project area the 1988 flood was not a particularly exceptional event (Approx 1 in 10 years). Indeed 1987 was of a similar severity and if today's conditions had prevailed in 1974 then that year would have recorded much the greatest flood levels in recent history (1 in 50 years).

This situation reinforces the logic of the proposed intervention which is to achieve, as far as possible the drainage conditions prior to the accretion of the southern polders so as to restore the aman season cropping opportunities, to eliminate non-agricultural flood damage and, at same time, to provide increased opportunities for irrigation.

6.2.6 Groundwater

a) Geology

The surface deposits of the project area assigned to the Meghna River and Tidal Floodplains (FPO/UNDP 1988). However, the sediments of the shallow sub-surface belong to what Bakr (1976) described as the Chandina Formation. The deposits are mainly grey, unweathered highly micaceous sends and sandy silts. Further north (Muradnagar thana) the sediments have been described as of estuarine origin and, therefore, it is likely that the sediments in the study area will have more marine affinities. The thickness of the Chandina Formation is not known but is unlikely to exceed 130 m. This formation contains connate water in some areas which is maintained by the occurrence of deeper clay aquitards. Also these recent sediments contain organic material which decomposes to cause discharges of gas.

The Chandina Formation is presumed to be underlain by the Plio-Pleistocene Dupi Tila formation, which is widely found in Sylhet and the Eastern Hills. It usually consists of yellowish brown, highly weathered fine to medium sands. The Dupi Tila Formation is generally hundreds to more than a thousand metres thick.

b) Hydrogeology

Groundwater has not been much developed in the project area because of the widespread salinity hazards in the Chandina Formation. However in some areas shallow wells can produce fresh water provided they do not disturb the underlying saline water. This tends to mean that only relatively small quantities of annually recharged water can be skimmed off the top of the shallow aquifer.

Until very recently the deeper aquifer in the Dupi Tila formation had been largely ignored except for drinking water wells. However since 1990 BADC have drilled a substantial number of wells in Lakshmipur and Chatkhil Thanas and this has almost doubled the area of groundwater irrigation during the last two or three years.

There is little information about this deeper aquifer and although it is clearly a useable resource there is virtually no data concerning its recharge (lateral), spatial extend or its degree of separation from higher brackish or saline aquifers. It is considered important that investigations are carried out in the near future to provide information which will allow a proper assessment of the potential so that policies can be developed and implemented to ensure that any development is sustainable.

c) **Shallow Aquifer**

There will always be difficulties in development of the shallow aquifer because of the need for careful settings of screened casing to avoid the entry of saline water. Also in the areas to the east of the Begumganj depression (eg Senbag) conventional STW technology has difficulty in maintaining suction during the dry season as water levels fall and sometimes there are gas related problems.

Both these problems could sometimes be overcome by the use of shallow force Model Tubewells (SFMTWs) and as these become more widely known there will be some scope for further development of the shallow aquifer. However it is considered unlikely that the development will be significant and only in areas away from locations where surface water may be obtained.

d) **Deep Aquifers**

Much of the project area is underlain by the Dupi Tila formation which contains a deeper fresh water aquifer generally below 130m. The recent exploitation of this aquifer in Lakshmipur and Chatkhil Thanas may be expected to continue whilst BADC stocks last. It is interesting to note that most of the recently developed wells are outside the zones where the Noakhali North Project expects to increase surface irrigation. This report has assumed that future development of this aquifer will be limited to about a further 1000 ha in the project area using existing BADC stocks. There after it is anticipated that the cost of deep tubewell technology will restrict development to areas where there is no alternative source of supply. This is discussed in the South East Regional Plan where recommendations concerning investigation and development of this aquifer suggest that priority should be given to other areas for utilisation of this resource.

In any case extensive development of the aquifer cannot be recommended until proper investigations are completed to confirm its extent and recharge and to ensure that it is sufficiently confined to prevent leakage of saline water from above. Monitoring of the existing wells combined with a well managed investigation through trial holes and piezometers could yield urgently needed data to confirm the sustainable development which could be achieved.

6.2.7 Minor Irrigation

Irrigation Areas

A summary of existing irrigation in the project area is given in Table 6.1. This data is taken from the AST data for 1991 and has been updated to include known additional recent groundwater development. As described in the feasibility study there is substantial disagreement between this data and the areas of reported boro cropping by BBS, DAE and the project farmer surveys. The reason for these sometimes, significant differences was not at first obvious but by evaluation of other supporting data it has been possible to make some adjustments to the AST data.

TABLE 6.1

Adjusted Irrigated Areas by Zone

Zone	A	B	C	D
	AST 1991 Irrigated Area (ha)	Increase in LLP Area with Dual use (ha)	Assumed Increase in Area 1991-992	Adjusted AST Irrigated Area (1992) (ha)
A	3,557	508	203	4,268
B	7,994	1,042	452	9,488
C	8,799	1,929	535	11,265
D	18,744	4,462	1,160	24,366
Total	39,094	7,941	2,350	49,387

These adjusted areas are very close to those used in the project economic analysis which were based on an average of the unadjusted AST data and the farmer surveys.

Fortunately the remaining variations between the adjusted AST data and the farmer survey data are small when the areas specified for new irrigation supplies are considered. This is because most of the newly irrigated areas are in Zones A and C where the adjusted AST data and the farmer surveys produce quite similar answers.

According to the AST data and, even more so, according to the farmer surveys, the dominant irrigation mode is LLP which accounts for over 75% of all irrigation in the project area with traditional irrigation being the next most important. Groundwater accounts for less than 7% of irrigated area.

6.2.8 Agriculture

The net cultivable area (NCA) within the identified project boundaries is estimated at 108,718 ha, out of a gross area of 160 814 ha. The remaining 52,097 ha comprises roads, other infrastructure, fish ponds and homestead areas. These areas amount to 32.4% of the gross project area and include substantial areas of orchards.

The average cropping intensity as identified by the farmers surveys is approximately 166% although there are variations between the different zones of the area. Boro is widely grown but the farmer surveys, BBS data and the Agricultural Sector Team census give differing estimates of the extent of this important crop. It is considered likely that much of the crop is grown under sub-optional conditions which is due to the generally poor availability of irrigation water, particularly in the later part of the season. At this time much of the crop relies on residual soil moisture and unreliable rainfall and suffers severe stress towards the end of the growing season. This is almost certainly linked to the generally low fertilizer inputs used and the correspondingly lower yields obtained compared with those in some other parts of the south east region.

The popularity of the Boro crop is partly due to the prolonged flooding which reduces the cropping potential during the Aman season.

6.2.9 Present Practises and Problems Irrigation and Drainage

The project area has suffered from impeded drainage for over 30 years and the peoples of the area have largely adapted to this by adopting a number of practices which produce the maximum returns under the existing circumstances but also create a number of social conflicts of interest which are sometimes local but also sometimes inter thana and therefore less obvious.

There are many existing embankments all across the project area. These embankments are of different heights and many of them serve as roads either under LGED responsibility or as local farm roads. There are also a number of embankments which have been built specifically to isolate small areas (normally less then 100 ha) which are then pump drained by the local communities using their irrigation pumps to reduce flood levels.

These local area drainage schemes provide improved drainage conditions for the farmers within them but since the water is not removed from the sub-region the water is merely being pumped from one piece of land to another. If this practice became widespread the water levels outside such schemes could rise substantially.

A significant proportion of the area grows no rice crop in the aman season, or only a high risk low yield variety owing to the flood status of the land. As a result the boro crop has become the principal crop in these areas and the entire agricultural calender is arranged to get a boro crop as the primary source of food and income. However because they have an unreliable source of water as soon as the flood begins to recede the people construct small dams across the local khal to retain water for irrigation. This impedes drainage of more remote areas which may be lower and require drainage for longer periods before they can transplant their boro seedlings. This can lead to disputes with successive construction and demolition of the cross dams. Also as the water is used up competition for the water becomes considerable. Only in very limited areas is there sufficient water throughout the season. These areas are those near to the Rahmatkhali regulator and those near to the Dakatia river and Kamta Khal. Even those areas having access to a low lift pump (LLP) often go short of water at critical periods. Since the quantities which can be stored in the Khals is grossly inadequate to supply the areas within command of the pump. The scarcity of water results in relatively high charges to farmers for irrigation water.

There are also conflicts of interest in the operation of the regulator gates with local fishermen often wanting gates open when farmers upstream would want it retained. The proposed project could substantially reduce these conflicts by making the construction of cross-dams unnecessary and allowing improved fish access to the khal system.

The present practice is to distribute water quite long distances from the more reliable irrigation sources. Indeed on the banks of the Dakatia there are two or three substantial floating pump stations which supply up to 1000 ha. The largest unit, in fact, supplies areas on the north side of the Dakatia which is outside the project boundary but it serves to illustrate that very substantial private initiatives are undertaken where a reliable source of supply is available. The pump survey undertaken as part of the topographic survey indicates that LLP commands average about 20 ha where supplies are more reliable.

The farmers of the area have shown considerable ingenuity and it is anticipated that any water which can be made available will be taken up. Demand, at present, far exceeds supply and this is likely to remain the case in future.

6.2.10 Physical Objectives of the Project

The previous sections have described the existing situation and the principal objectives of the project are improvement of drainage conditions throughout the project area and also improved irrigation supplies to as large an area as possible.

The intention is to devise a system which will reduce the existing conflicts of interest described in section 8.2.9 above whilst causing the minimum permanent disturbance to the population through any necessary land acquisition.

These objectives are to be achieved through enlargement of the principal khals of the area, modification of the existing regulator, addition of a new regulator and deepening the existing larger secondary khals.

By these means it is intended to lower peak water levels in the area to delay the rise of the flood and to hasten its recession.

6.3 Fisheries in the Project Area

The importance of freshwater fish as a source of income and cheap protein for a large proportion of the human population in Bangladesh has been widely recognized. However, ecological and biological data regarding fish, especially for the smaller species, and their utilization appear to be lacking.

In the Noakhali North study area, there are a number of rivers, Khals and ponds, although Beels appear to have disappeared to give way to various agricultural activities. A considerable portion of the area is however subject to flooding which enhances fisheries by carrying migrating species from the rivers and Khals onto the floodplain for breeding, feeding and dispersal purposes. Thus, capture fisheries occur over a large area and it plays an important role in subsistence fisheries.

Man-made Khals and other types of depression such as road-side borrow pits and canals act as fisheries production sites and are good settings for the cultivation of commercially important species. The Raipur Hatchery and Training Centre is located near the study area and supplies some of the privately owned ponds with fish fry or fingerlings. There are also many privately owned hatcheries and nurseries now supplying this sector.

Part of the study area has already been embanked and it is easy to appreciate that habitat alterations have taken place. Nonetheless, it is not easy to assess the extent of these alterations and their effect on the general ecology, fish diversity and fisheries of the area. However, there is a need to evaluate the existing fish diversity and fisheries in the area and the potential ecological impacts that any further control projects might have on their life cycles and on the natural environment.

To carry out such an evaluation properly, detailed fisheries and ecological assessments and their interaction with the local human population are necessary. Given the short period of time available for this study, it is beyond the scope of this input to attempt to assess the existing environmental situation in detail.

The main objective of the fisheries component of the Noakhali North Feasibility Study was to carry out an evaluation of the existing fisheries resources of the area and make an assessment of the impact of proposed interventions on capture and culture fisheries. An assessment has been made on the likely effects of the intervention on the fisheries resources.

Given the importance of open water floodplain fisheries in the region, the focus was placed on these activities and it is hoped that information gathered in this study will form a much needed baseline for the further analyses, necessary to fully evaluate the fish systems of the area.

6.3.1 Data Collection

The FPCO Guidelines for Environmental Impact Assessment recommend that for Feasibility Studies detailed investigations entailing data collection and consideration of seasonal cycles should be undertaken. However, timing and funding of the present study were not resourced to fully comply with the basic requirements for ecological and/or biological cycles to be taken into account and this was fully understood at the time the decision to proceed was taken. Nevertheless, these guidelines were used in the present study where possible.

a) Secondary Data Collection

Data collected from secondary sources have been used to evaluate the status of the existing fisheries in the area. The majority of the statistics have been obtained from the Fisheries Resources Survey System (FRSS) of the Directorate of Fisheries (DOF) sources in Dhaka. However, it is recognized that the use of these data is of limited value due to the unavailability of up to date information. The latest complete set of available figures for this study correspond to 1988-89, as riverine data for 1989-90 is missing. Furthermore, the present system has many weaknesses such as small sample sizes, very few sampling villages and a backlog of data due to insufficient processing capacity.

All Thanas Fisheries Offices in the project area were requested to provide information on the number of fishermen and categories of operation, i.e. full-time, part-time, occasional (FAO/UN, 1962). Additional information resulting from this survey includes fish production estimates, dominant species caught per Thana, fish species occurring in the area, fisheries developments and main problems related to fisheries in each Thana.

Information on hatcheries and nurseries in the area was gathered from secondary sources, mainly FRSS, and Thana Fisheries Offices.

The number of fishing households in the Noakhali North Project area has been estimated from information received from the Thana Fisheries Office survey. This indicates the number of fishermen per Thana and the number of households in the area as per the 1981 census (BBS, 1981). It would be valuable to verify these data from the 1991 BBS census when this becomes available. Table 6.2 shows details of these results per zone.

TABLE 6.2

Number of Fishing Households in the Noakhali North Study Area

	Number of Fishing Households								
	Number of Households	Full-Time	%	Part-Time	%	Occasional	%	Total	%
Zone A	50,755	3,294	6.5	633	1.2	6,030	11.9	9,957	19.6
Zone B	114,383	927	0.8	393	0.34	12,081	10.6	13,401	11.7
Zone C	87,462	2,070	2.4	471	0.54	12,335	14.1	14,876	17
Zone D	145,841	10,061	6.9	2,392	1.6	10,011	6.8	22,464	15.4
Total	398,441	16,352	4.1	3,889	0.98	40,457	10.2	60,698	15.2

Source: 1991 Estimates of population and BBS 1991 Census for Number of Households. Noakhali North Thana Fisheries Office Survey for Number of Fishermen.

b) Primary Data Collection

A short fishery survey of eight weeks duration was undertaken in an attempt to gather useful information regarding the project area in particular.

Although great care was taken at all stages of this study, it should be reiterated that this type of survey is inadequate both in terms of time and funding, to adequately describe the fisheries and to predict future changes in a complex system such as that which exists in the Noakhali North Project area.

This study was carried out during the period from September 1992 to February 1993, and field data were collected during mid-October to early December 1992. Fishing patterns, gears used and operators were addressed for each type of capture fishery system. Unpublished data from the TFOs were used for estimations of pond fish production.

Unfortunately, the results from this short field study cannot be crossed checked with existing data from the DOF (1983-90) as their data for the last 3 years is not yet available. Furthermore, given that this catch assessment survey was carried out in collaboration with the local fishermen, most likely to be full time and part time fishermen, the recorded catches are assumed to be commercial catches whereas those reported by DOF are for subsistence household fisheries. Subsistence fishing is defined in this report as being carried out by people who directly catch and consume "common good" fish resources for a large proportion of the animal protein in their diet and who are mostly landless and poor.

However, a bench-mark has been set for the assessment of the impacts and subsequent monitoring of the fisheries resources of the Noakhali North Project area.

Catch Assessment Survey The emphasis of the catch assessment survey was placed on the capture floodplain fisheries and thus data were collected for some Khals and sections of rivers within the project area. The FRSS catch assessment forms were used to record leasing arrangements and fish catches in the area.

Thana Fisheries Survey All Thanas Fisheries offices in the project area were requested to provide information on the number of fishermen and categories of operation, i.e. full-time, part-time, occasional (FAO/UN, 1962). Additional information resulting from this survey includes fish production estimates, dominant species caught per Thana, fish species occurring in the area, fisheries developments and main problems related to fisheries in each Thana.

6.3.2 Rationale for Estimating Fisheries Losses Due to the Proposed Intervention in the Noakhali North Study Area

The proposed intervention for the Noakhali North Study Area (See Section 6.4) includes Khal re-excavation of approximately 17 % of the major khals in the area. The existing regulator will be altered and the gates will be replaced with gates which open wide under low heads and with low velocities of flow. However, the main intention of this scheme is to drain a large proportion of the floodplain in the area to improve conditions for agriculture. It should be pointed out that this area has already been impacted to a certain degree and that any further alterations to the habitat, such as increased drainage will cause further degradation as a fisheries system.

a) Main Rivers

It has been assumed that major rivers such as the Meghna (to the west of the project area) and the Dakatia, to the north, will not be affected by this scheme. However, it is clear that even if such is the case, migratory fish entering the system will not be able to thrive without the floodplain. Furthermore, fishermen in the area will most likely take advantage of the situation and will over-fish the Khals and rivers where most of the fish are expected to be concentrated.

b) Internal Rivers and Khals

The total length of main and secondary Khals in the project area is approximately 1,008 km of which 172.5 km (17 %) will be re-excavated under the proposed intervention. Difficulties in estimating changes in fish production are due to the lack of information on the distribution and abundance of the fish species in the study area. It has been assumed that there is a direct relationship between water volume and fish production and thus, fish production has been increased or decreased by the appropriate proportion.

In order to calculate the change in depth of water due to Khal re-excavation, existing bed and water levels, and therefore mean water depths were analyzed for each month throughout the year for a without project and with project situation. From this analysis it was possible to estimate that under this intervention there will be an overall increase of 84 % in water depths in those Khals that are going to be excavated, whereas there will be a decrease of 19% in water depths in those Khals which are not. Most of the re-excavated Khals (around 50 %) lie within Zone A, with approximately 10% of these in Zone B, 30 % in Zone C and 10 % in Zone D. An analysis of the changes in production due to the re-excavation of Khals was carried out taking into account the proportion of the increase in fish production which corresponded to each zone.

c) **Floodplain**

Under this intervention, the floodplain will be severely impacted. Overall, it has been estimated that 62 % of the floodplain within the project area will be lost and a further 69 % of area of floodplain immediately adjacent to the study area will also be lost. The area of floodplain lost in Zone A amounts to 100 % (but very small area) 81 % in Zone B 62 % in Zone C and 34 % in Zone D. Fish losses have been related directly to the area of floodplain available to the fish.

d) **Ponds**

The fish production from ponds has been assumed to remain unchanged (other than trend changes) although this will depend on the capacity of the ponds and on their ability to retain water. These ponds are thought to be affected by water levels and any decrease in the surrounding water levels may affect the levels inside the ponds.

6.3.3 Trends in Fish Production

Trends in fish production used in this study are similar to those used in the Jamalpur Priority Project Study (FAP 3.1) and the Gumti Phase II Feasibility Study these were -1.5% per annum for production in open water systems and +4.5% for pond production. A major review of DOF data is being carried out by FAP 17 and new production trends will emerge. Unfortunately they will be available too late for incorporation in this study.

6.3.4 Estimated Fisheries Benefits and Disbenefits under the Proposed Scheme

Table 6.3 shows details of the changes in the estimated fish production for the intervention and for each of the fisheries systems. Overall, the open water fish production loss as a result of the scheme was estimated to be 3,626 MT representing a mean loss of 13.2% within the study area and if the areas outside but adjacent to the project area are included this loss rises to 14.7 %. Changes in estimated fish production for each fishery system are described in the following sub-sections.

The relative importance of pond culture in this project area is clearly seen from the table where over 65 % of the existing production is from ponds. With the intervention this rises to nearly 84 %. The total production in the area both inside and adjacent to the project boundaries is expected to decline by 2.6 % from the present to the future with situation (WI year 6).

a) **Internal Rivers and Khals**

In general, the fish production for this system was very low with an estimated present annual yield of 134 MT. Table 6.3 shows the estimated fish production per Zone and the changes in production resulting from the intervention. Overall, there was a decline of less than 0.5 % in the estimated fish production due to Khal re-excavation which was rather surprising as a positive and more noticeable change was envisaged. Unfortunately, despite the increase of 84 % in the water levels in the re-excavated Khals, fish production was not benefited in any substantial manner as the initial production from this type of system was rather low representing around 10 % of the total catch. Most benefits were estimated to occur for Zones A and C with nearly 36 % and 28 % increase by year 6 representing 6 MT and 4 MT respectively.

TABLE 6.3

Change in Fish Production Estimates in the Noakhali North Study area due to the proposed Intervention Without Mitigation and Management

		NOW	% Total Catch	WO Year 6	% total Catch	WI Year 6	% Total Catch	Difference in Year 6 WI and WO %
Zone A	Rivers	0	0.00	0	0.00	0	0.00	0.00
	Khals	27	0.11	25	0.09	33	1.14	35.78
	Floodplain	0	0.00	0	0.00	0	0.00	0.00
	Ponds	1,324	5.61	1,724	3.27	1,724	7.23	0.00
	Sub-Total	1,351	5.73	1,749	6.36	1,757	7.37	0.50
Zone B	Rivers	0	0.00	0	0.00	0	0.00	0.00
	Khals	29	0.12	26	0.10	26	0.11	-0.59
	Floodplain	1,841	7.81	1,681	6.11	319	1.34	-81.00
	Ponds	4,387	18.60	5,712	20.77	5,712	23.94	0.00
	Sub-Total	6,257	26.53	7,420	26.98	6,058	25.39	-18.36
Zone C	Rivers	0	0.00	0	0.00	0	0.00	0.00
	Khals	25	0.11	23	0.08	29	0.12	27.60
	Floodplain	1,441	6.11	1,316	4.79	500	2.10	-62.00
	Ponds	4,446	18.85	5,789	21.05	5,789	24.27	0.00
	Sub-Total	5,912	25.07	7,128	25.92	6,318	26.49	-11.36
Zone D	Rivers	105	0.45	96	0.35	96	0.40	0.00
	Khals	53	0.22	48	0.18	33	0.14	-32.02
	Floodplain	4,723	20.03	4,314	15.69	2,847	11.93	-34.00
	Ponds	5,181	21.97	6,746	24.53	6,746	28.28	0.00
	Sub-Total	10,062	42.67	11,203	40.74	9,721	40.75	-13.23
Total	Rivers	105	0.45	96	0.35	96	0.40	0.00
	Khals	134	0.57	122	0.45	122	0.51	-0.43
	Floodplain	8,005	33.95	7,311	26.59	3,666	15.37	-49.85
	Ponds	15,338	65.04	19,970	72.62	19,970	83.72	0.00
Project Area Total		23,582		27,499		23,854		-13.25
Total								
Dakatia River	Floodplain	862		787		680		-13.70
Eastern Side	Floodplain	1,725		1,575		945		-40.00
Total External Floodplain		2,587		2,362		1,628		-13.20
Grand Total		26,169		29,861		25,479		-14.7

b) **Floodplain**

By far the greatest losses in estimated fish production were incurred by the floodplain with an overall decline of nearly 50 % representing a annual yield of 3,645 MT. The greatest floodplain loss in percentage terms was estimated to be 81 % for Zone B representing a decline of 1,362 MT in the production by year 6. Zone D was also substantially affected with an overall loss of 1,467 MT (34 %) by year 6 representing a decline of 34 %. The fact that most of the intervention is outside this particular Zone, makes this loss of more concern.

c) **Ponds**

No change in production of ponds has been made when comparing the without and with project conditions. There is potential for increasing pond production and this could be considered as an essential component of the mitigation measures to be prepared as part of the recommended further studies (see section 6.5). The degree to which such measures can be successful in terms of mitigation will greatly depend on the pond tenure or lease and hire arrangements.

d) **Fish, Nutrition and Diet**

These aspects are described in the Environment Annex H of the feasibility study.

6.3.5 Possible Mitigation Measures

In general, the main issues concerning possible mitigation measures centre around water and fisheries management. These two aspects have been described briefly below.

a) **Water Management**

Water resources management is, and will continue to be, possibly the most crucial factor in the development of any activities in the country, the region and the subregion. It will thus be vital to establish priorities as to how and where the water will be directed, and for whom. It includes the following components and possibilities for fisheries.

i) **Re-Excavation of Khals**

Possible re-excavation of Khals, and their interconnections, with an aim of ensuring free and timely flow of water and fish (both breeding adults and fry). This could be most important during the dry season when Khals become refuge areas for some species.

ii) **Gate Design and Operation**

Gate design, operation and location of structures is extremely important. These would ensure the timely flow of water and fish, and would be crucial for maintaining water levels in the system throughout the year, and particularly at times critical for fish.

6.4 Project Proposals

The project has the twin objectives of alleviating the two most frequently articulated water related problems of the local population, namely:

- Congested drainage
- Shortage of water for irrigation

The project concept seeks to do this by improving the existing infrastructure of the Noakhali Comprehensive Drainage Project which was constructed in the early 1970s.

There are a number of additional factors which have come to light though the public participation programme which have affected the design of the scheme and the proposals for implementation. These include:

- widespread dissatisfaction with the way influential people were able to change the chosen course of the WAPDA khal when it was constructed, with the result that:
- the WAPDA khal now follows a tortuous route and there are problems with erosion of the banks.
- dissatisfaction with the way land acquisition was carried out with inadequate compensation received by many farmers.
- inefficient execution of previous work.
- poor maintenance.

These issues have guided the consultants in framing the present proposals.

6.4.1 Project Concept

The approach to project development is based on a number of concepts which have been kept in mind throughout the study. These concepts are as follows:

- the proposals should not create "insider/outsider" perceptions. In other words no one should feel excluded.
- the operation of the scheme should be as simple as possible with minimum interventions required by project staff for satisfactory functionality.
- following directly from above there should be the minimum number of structures which can be interfered with by vested interests.
- by making the same infrastructure serve both drainage and irrigation needs all zones of the project will receive some benefit and none will have reason to frustrate it.
- land acquisition should be kept to a minimum.

The first of these concepts requires the abandonment of the polder or complete protection concept. The concept views the project area as part of a sub-regional drainage scheme which has no fixed boundaries. The studies are aimed at proving that this concept can produce useful benefits at reasonable cost to produce a viable project.

The possibility of turning part of the scheme into a polder was considered but it would require many additional structures which could require a very sophisticated level of management and even more seriously could easily be frustrated by the local population who were on the "outside" of the polder. Therefore this concept was not pursued.

The concept relates to macro-drainage, that is removing large quantities of stored rainfall from the area so that a substantial part of the resident population can once again farm the area during the monsoon season as they were able to do in the early 1960s and before.

A further consequence of the approach outlined above is that it is not possible to design the project using conventional or traditional hydrological parameters because the project boundaries are unknown and the areas draining to each of the outlets varies during the season

It is therefore necessary to design the system using hydrodynamic modelling techniques. These techniques have been recently developed in Bangladesh to a degree of accuracy which now allows a reasonable evaluation of the Noakhali North project area by this method. As explained elsewhere the model can and should be progressively improved but its present accuracy in this area leads us to the view that it can be relied on sufficiently for feasibility study evaluation.

At the recently held "Third Conference on the Flood Action Plan" (Dhaka, May 17th-19th 1993) the consultants were asked why they had not considered compartmentalisation for this area. Apart from the fact that in this large area this would pose the same problems as the polder approach discussed above there is a more important factor. The flooding in this area is not caused by main river flooding. The principal cause is sub-regional (local) rainfall collecting at a faster rate than the drainage system can accommodate. Thus one cannot develop rules which allow exclusion of main river flows to protect prescribed areas and even less can one predict when such systems will need to be operated. The rainfalls have a much less regular pattern than main river levels. Compartmentalisation could interfere with the "natural" drainage system proposed and this is considered unsuitable in this particular situation.

a) Drainage

The first objective of improving the severe drainage congestion of the area must be dependent on utilisation of the low tide periods effectively since at high tides, unless preventive measures are taken, water will flow into the project area.

At the present time the existing infrastructure drains the area near the Rahmatkhali regulator very effectively (Zone A) but further away water levels gradually build up to levels which produce deep and prolonged flooding in what is commonly known as the Begumganj depression and further north.

In order to alleviate this situation a number of improvements concurrently:

- Lower water levels at all points in the system (the project must not increase levels anywhere).

- to achieve this it is necessary to flatten gradients across the area. Since levels at the outfall are controlled by the tide only small improvements at this location will be possible.

- to achieve flatter gradients it is necessary to have lower velocities in the main channels. This will also help in reducing erosion problems.

Therefore in selecting the design option great care has been taken to ensure that all three of these objectives are met. The only method which can achieve these objectives is a balanced improvements of the main structure and the main channels by increasing their capacity.

Local people have expressed a preference for deepening rather than widening the channels and this has been done to the maximum extent possible since this also keeps land acquisition to a minimum. However it is important that the channels are kept to a minimum stable width to prevent erosion and meandering of the channel.

b) **Irrigation**

As already explained there is very limited potential for groundwater development for irrigation in the project area and yet there is abundant evidence that there is pent up demand for irrigation facilities. At the present time there are large areas already irrigating from sources which are extremely unreliable and although the year of survey (1992) showed good yields there are reports of failures the previous year since in many areas farmers are still partially dependent on rainfall. Also the rates currently charged by LLP operators suggest a "scarcity premium" on water. Almost 75% of respondents to the pump operator survey complained of inadequate water supply as the limiting factor affecting cropping in the boro season. At public participation meetings irrigation was the most commonly mentioned "demand" of the people.

It was therefore, decided at an early stage of the studies that the project should incorporate proposals which could substantially increase the area of irrigation in the project area. As the studies progressed it became apparent that it was unlikely that taken separately either drainage or irrigation development of the existing system would prove economically viable. This leads to the inevitable conclusion that it is essential to develop an infrastructure which is truly dual purpose so that all the investment serves both irrigation and drainage objectives.

Thus the irrigation network is the khal system itself which as it is enlarged provides better drainage and at the same time more storage for irrigation water.

In exactly the same away as low tides are used to achieve drainage in the monsoon season so high tides are used to recharge the Khal system for irrigation twice daily and the entire Khal system acts as a night/tidal storage system. Once again for maximum effectiveness this requires minimum regulation and automatic functioning of the control structure.

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6.4.2 Selection of Recommended Option

The selection of the recommended option was based on a series of tests carried out on the hydrodynamic model. After preliminary runs aimed at identifying and optimising the impact of the major changes proposed various, tests were carried out to evaluate the influence of other possible interventions as follows:-

i) the construction of a new regulator downstream of Kazirhat
ii) the construction of a regulator on the Dakatia upstream of Chabagadi
iii) the effects of upstream projects
v) the effect of a pump station at Rahmatkhali

None of these possibilities has a significant effect on the expected benefits since the changes in water levels at critical points in the system were negligible. Thus the selected option is insensitive to outside influences as tested.

The option of an embankment on the South side of the Dakatia upstream of Chitoshi was abandoned once the early monsoon benefits of the proposed scheme were identified.

The selected option is shown in Figure 6.3 and its principal features are described below.

a) Rahmatkhali Regulator

It had been widely supposed that the existing regulator was the currently limiting constraint to improved drainage. However, this was shown not to be the case and indeed the flooding patterns also confirm this. The existing regulator has been tested on the model in a number of configurations (various sill levels) to try to improve the hydraulics through the structure. Raising the sill also prevents excessive draw down upstream and therefore limits upstream velocities at low tide and it achieves this without reducing the volumes of flow through the regulator and without increasing the peak water levels. This is achieved because weir flow conditions obtain for a larger proportion of time.

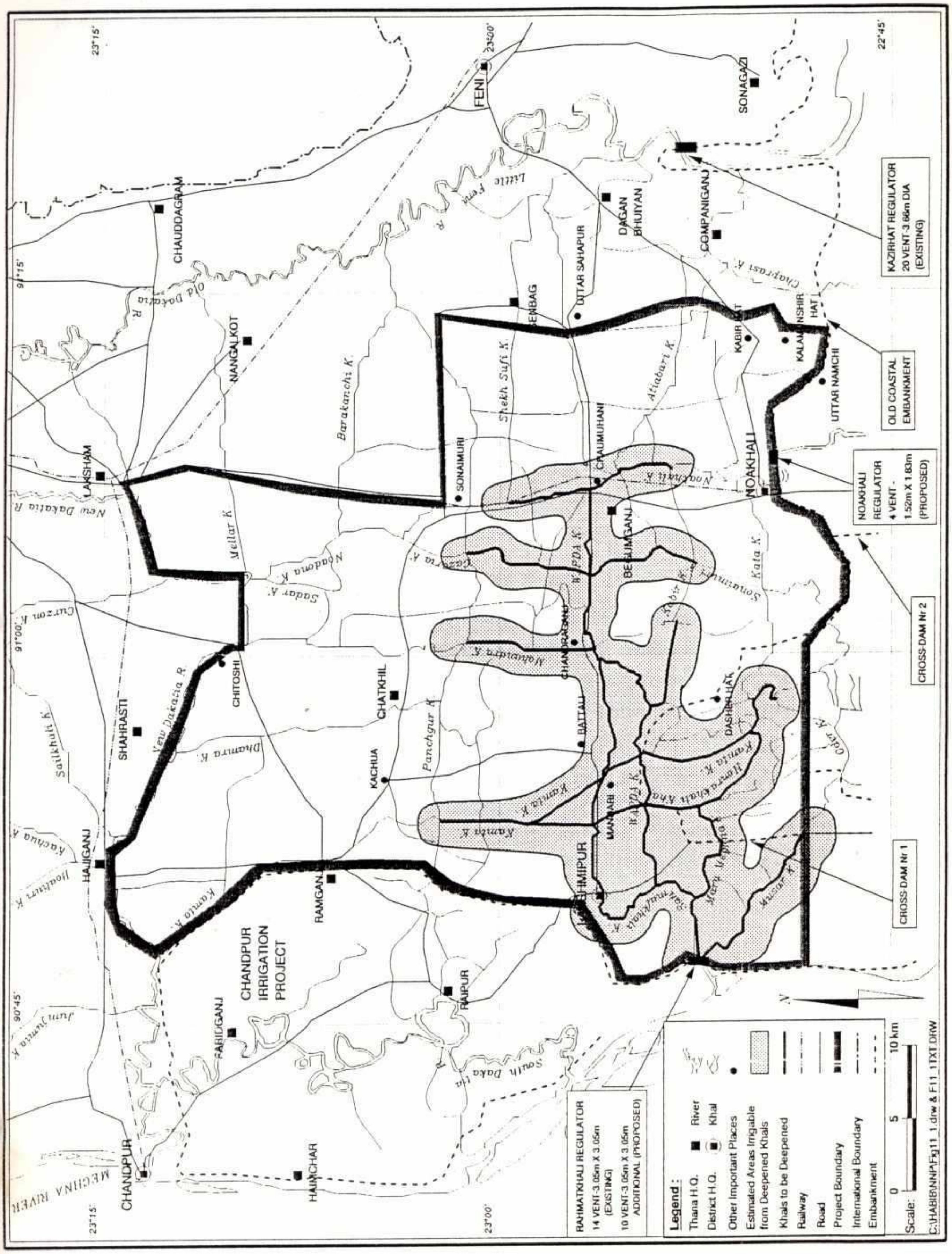
Having achieved this the provision of an additional, parallel structure to increase discharges was tested in various combinations with increased Khal sizes. All these options, assumed similar sized gates and the same sill levels as on the existing regulator.

The principal elements of the proposed improvements to the existing structure are set out below:

i) Existing Regulator

a) Raising the sill level of the existing structure by approximately 1.00 m.
b) Replacing the single hinged existing flap gates with double hinged flap gates and adding a simple hoist mechanism for use in the dry season.
c) Replacement of the existing sector gates with counterweighted flap gates set to open inwards (Khal side) to allow inflow at high-tides during the dry season and to close when inflow ceases.
d) Additional downstream (river side) protection works to the bed of the channel to reduce scour problems.

Figure 6.3
Proposed Intervention



ii) **New Regulator**

An entirely new regulator to be built on the alignment of the original Khal route. This regulator would have 10 number 3 m x 3 m vents and have the following arrangements:

a) Sill level at the same level as the revised level of the existing structure
b) Double hinged counterweighted flap gates downstream (river side) for drainage.
c) Similar double hinged counterweighted flap gates mounted in the reverse direction upstream (Khal side) in exactly the same manner as described in i) c) above.

An outline of the proposed gate arrangements is shown in figure 6.4.

b) **The WAPDA and Rahmatkhali Khals**

The previous section indicated that it is the khal system which presently limits the drainage capacity from the project area. The without project water profiles and the seasonal build up of water levels suggest that this limitation applies throughout the monsoon season and not only at peak storm periods which is why the peak water levels occur much later than the peak rainfall periods. The approach to Khal improvement was to test various sizes of channel gradually increasing the dimensions and plotting the improvements in water levels achieved for the design year (1983). This design year was selected from the results of the "without project" 25 year simulation run as it gave close to 1 in 5 year conditions for almost all flood durations at a selection of locations throughout the project area.

The first enlargement tested utilized the existing top width and maximum channel depths as far as possible except in a 10 km reach at the upstream end of WAPDA Khal where the existing channels is seen to be very small; here some widening was incorporated even in this first option. Successive widening of the channel was considered in combination with some further deepening until sharply diminishing returns in terms of improved (lower) peak water levels were seen.

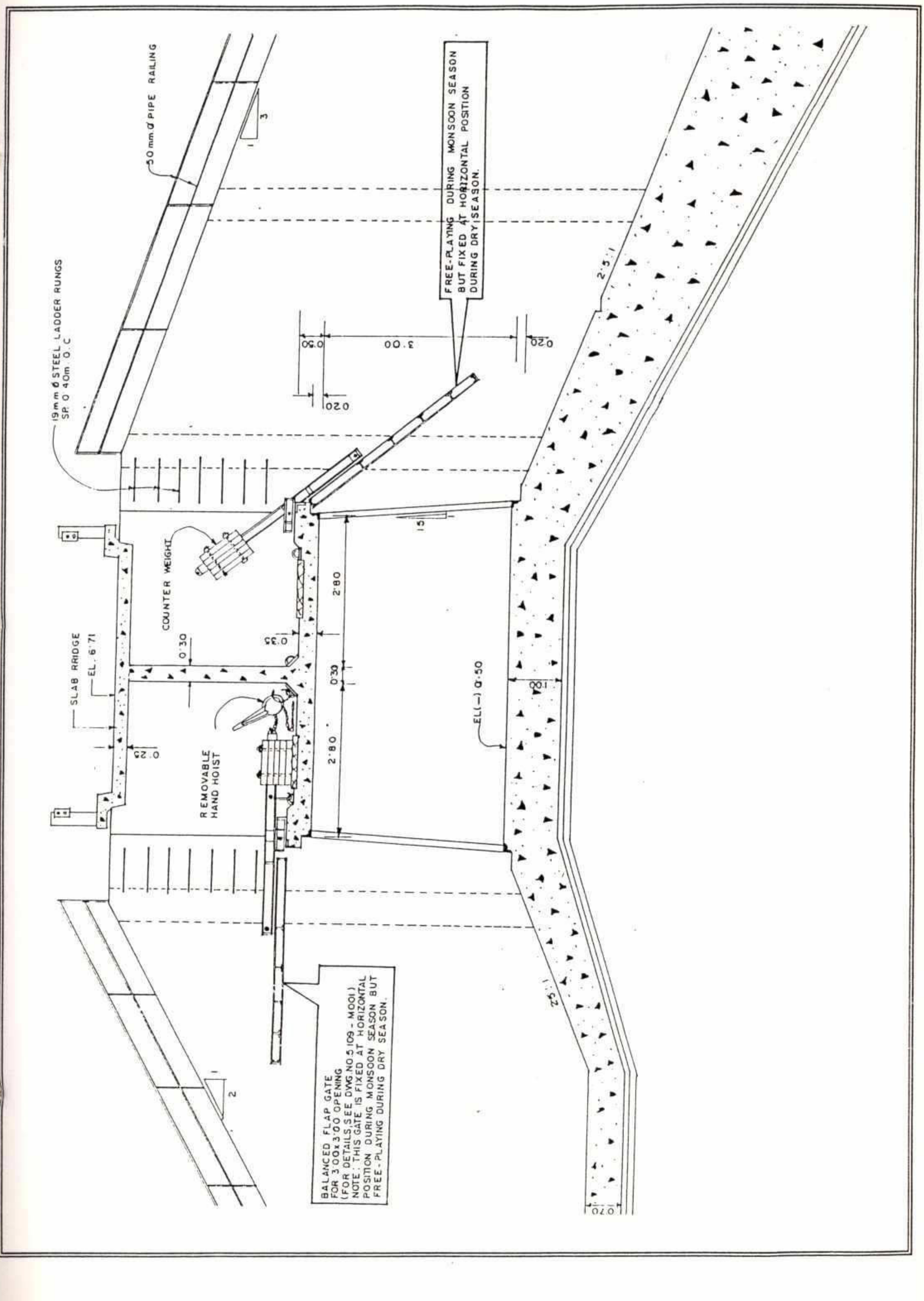
The recommended option involves substantially reduced widening compared with that foreseen at the time of the pre-feasibility study. This has been achieved by some further deepening at the downstream and of WAPDA and Rahmatkhali Khals. It is also a reflection of the more accurate analysis possible with a calibrated tidal model.

The principal features of the proposed works comprise:

a) Widening and deepening WAPDA Khal
b) Deepening Rahmatkhali Khal within its existing section and embankments (where existing)
c) Bed protection to and modification of existing bridges as necessary to accommodate the enlarged channel sections.
d) Some loop-cuts to straighten out the Khal alignments where possible
e) Where loop-cuts would be very difficult or expensive proposals for bank protection works are incorporated to prevent erosion on the outside of sharp bends.

Figure 6.4

Rahmatkhali Regulator Gate Arrangements



The selected design option sections provide both flatter water gradients and slower channel velocities when compared with the existing channels even though the discharges are greatly increased. The maximum velocity identified at peak 1 in 5 year discharges (1 hour) anywhere in the system is approximately 0.80 m/s. This may be compared with velocities of upto 1.25 m/s at various points of the existing system. The combination of reduced velocities, loop-cutting and bank protection are designed to eliminate the current erosion problems.

The selected option produces huge quantities of excavated spoil which must be disposed of.

c) Secondary Khals

The WAPDA and Rahmatkhali Khals provide the main drainage routes to the downstream control structure. In order for the drainage flows to reach these Khals there is a need for a secondary feeder Khal system. This system already exists but is often substantially silted. This is often because excavated material has been piled immediately next to the top of the bank with the result that it is washed back into the channel during the monsoon. Also sides slopes are sometimes too steep and over the years the policy has been to use a design bed level of about +0.91 m PWD)+3.00 ft PWD).

The extensive data collected from the topographic surveys of the study were reviewed and it was observed that the principal secondary Khals (including Kamta, Mohendra, Sonaimuri and Noakhali) usually had top widths close to or more than 20 m. It is also apparent that the natural side slopes are about 1:2 or steeper. The current practice of the BWDB is to remodel sections of khal using side slopes of 2:3 but for this study the 1:2 slope has been used to ensure stability with the increased depths proposed.

The ground levels in the area suggest that if top widths of 17-20 m are used then a bed level of -0.50 m could be achieved with 1:2 side slopes and a minimum bed width of 1.0 m. This section was chosen to test both drainage and irrigation conditions. For drainage conditions the bed levels and widths are not critical but for irrigation it was perceived that the maximum depth possible should be obtained. In both cases the overriding consideration was to ensure that the section could be accommodated with minimal land acquisition. The analysis of the surveyed sections suggest that less than 1 ha of land acquisition would be required for the 114 km of secondary Khal adopted for deepening in the selected option.

Again there are very substantial quantities of excavated spoil which require disposal and this is discussed in Chapter 13.

6.4.3 Other Works

A four vent regulator with vertical lifting gates is proposed for Noakhali Khal at the point where it flows through the old coastal embankment. It is intended that during the monsoon season the regulator is kept open (May to October) to allow free drainage from the project area as required. The regulator's designed capacity is similar to the maximum simulated values from the hydrodynamic model results so that drainage is unaffected. However it is proposed that during the dry season the gates are closed to prevent ingress of saline water during peak high tides. This will ensure that the irrigation water in the khals remains fresh and it will also remove the need for construction of cross dams as occurs at the present time although these are constructed too late to be totally effective since saline water enters the system before these dams are completed.

It has been proposed to refurbish and reequip the BWDB offices at Lakshmipur, Noakhali and Feni so that they can function efficiently with a suitably enlarged staff for the supervision of construction stage and thereafter for operation and maintenance of the scheme.

6.4.4 Benefits of the Selected Option

Effectiveness of the proposals may be expressed in a number of ways as follows:

- Changes in water levels at particular locations at various times
- Changes in flood phases
- Changes in potential cropping patterns
- Reduced agricultural and non-agricultural damage.

The percentages of F0 and F1 land by minute square for the entire project area for the without project and the with project conditions are shown in Figures 6.5 and 6.6 respectively.

As stated earlier there are no absolute boundaries to the project area on its northern and eastern sides . However for the purposes of investigation and analysis the chosen boundaries provide a good indication of the likely benefits.

The benefits may be summarised as follows:

i) **Irrigation**

a) Additional potential for irrigation on over 18,500 ha mostly in Zones A and C and to a lesser extent in Zones B and D. The calculations and assumptions in arriving at this figure are described in Annex 1.

b) Improved irrigation supplies to existing irrigated areas of approximately 10,000 ha.

ii) **Drainage**

a) Substantial improvements to monsoon season cropping potential in Zones B and C and more limited improvement in the southern parts of Zone D.

b) Improved protection for boro crops by the reduction of early monsoon water levels (May). This will be of benefit principally in Zone D.

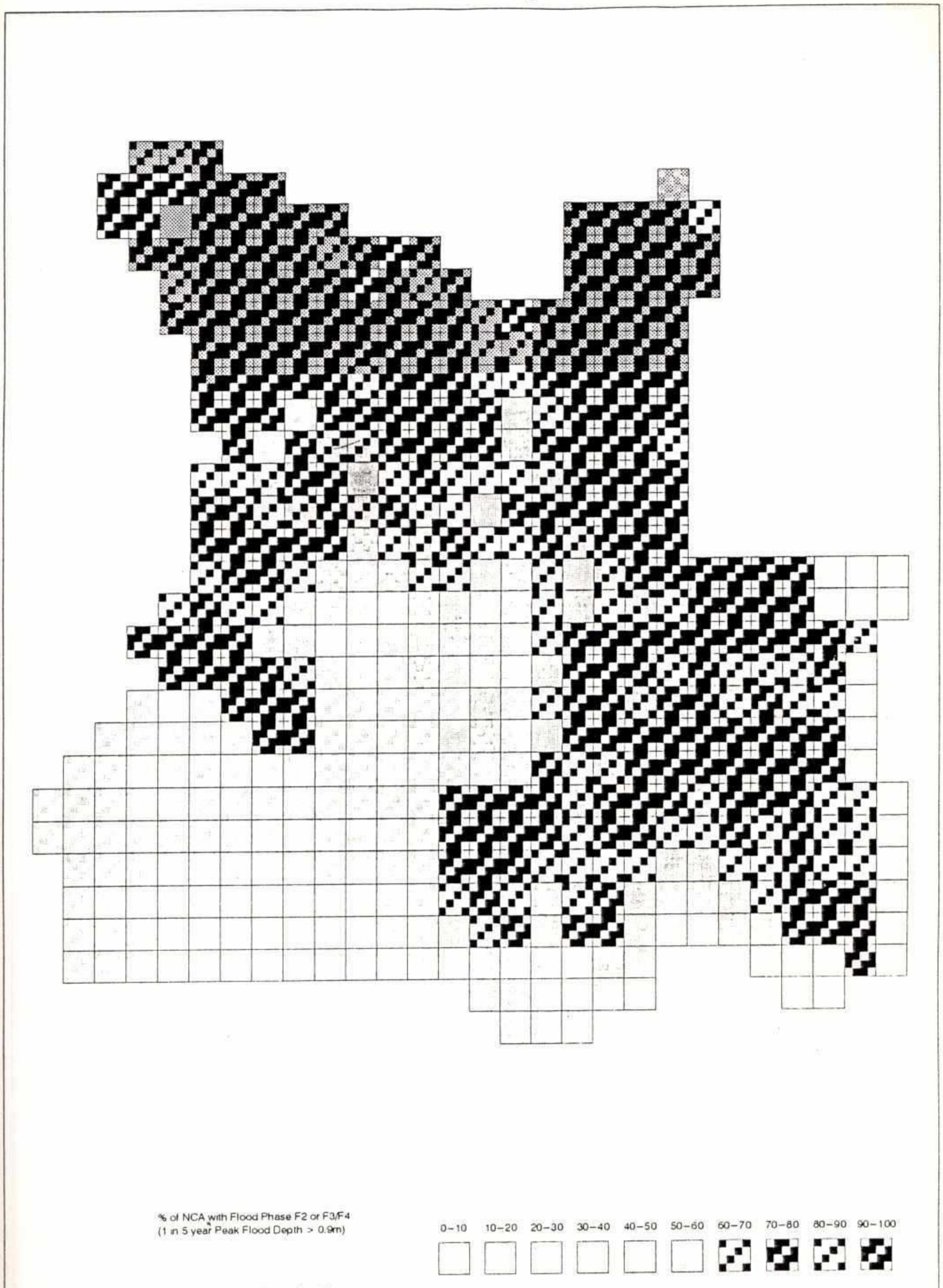
iii) **Reduced Crop and Non Agricultural Damage**

Reduced damage in Zones B and C owing to the substantially reduced water levels even in exceptional years. For example in the Begumganj depression the water levels in year 1987 and 1988 in the with project situation would be reduced to well below those of a 1:2 year event in the without project situation. Even the most extreme year recorded (1974 approximately a 1 in 50 year event) the levels would be reduced to those presently occurring 1 year in 2, which produces no damage.

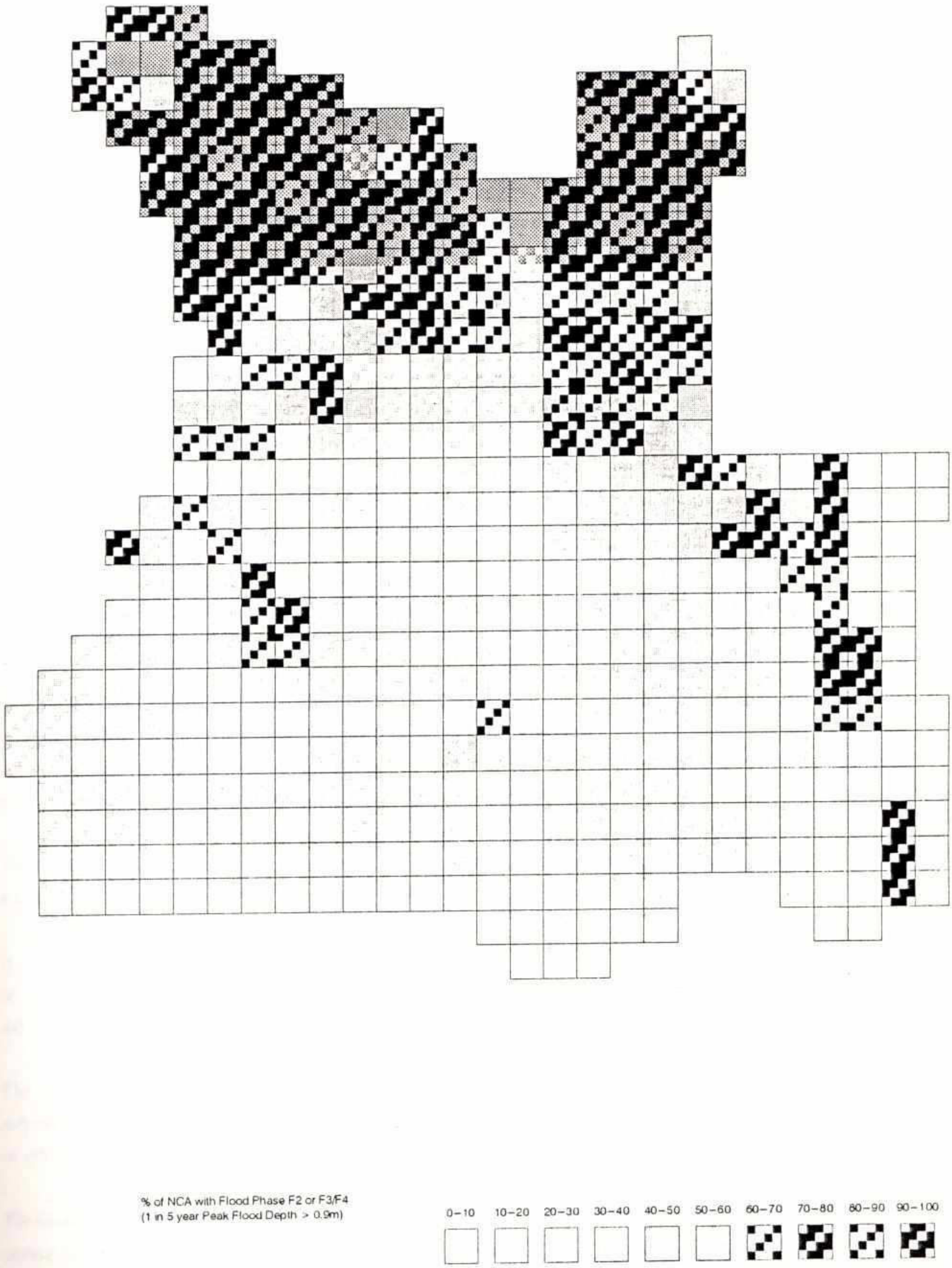
These benefits will accrue to housing, fish ponds roads and other infrastructure.

Figure 6.5

Noakhali North - Without Project 1 in 5 Year Peak Flood Phasing



With Project 1 in 5 Year Peak Flood Phasing



6.4.5 Dis-benefits and Mitigation

The principal dis-benefits of the proposed development are twofold

i) Reductions in the area of floodplain will cause losses to capture fisheries
ii) Land acquisition requirements although reduced will affect those who are displaced either in terms of homestead or farmed areas.

It is an incontrovertible fact that an effective drainage scheme will reduce the area of floodplain within its area of influence. To the extent that capture fisheries are directly dependent on areas of floodplain they will be correspondingly affected. This study has assumed that the effect of any reduction in floodplain area will result in a one for one reduction in fish production. This is open to argument. For example in areas where floodplain fish populations are evidently already reduced owing to limited access (i.e. Noakhali North) a limited reduction in floodplain (Zone D) may not produce any corresponding reduction in net production but merely concentrate it in the reduced area and so increase the production per unit area nearer to that in areas with higher fish populations. Other counter arguments are also possible. Thus in the absence of more reliable information the one for one approach has been accepted for evaluation of fisheries losses.

a) Capture Fisheries

The presently estimated potential losses to capture fisheries are presented in Section 6.3 and their economic significance is discussed in Section 6.8.

The possible mitigation options for the affected communities are discussed here and these aspects are also examined in the environmental impact analysis.

Capture fisheries account for approximately one third of the total fish production of the project area and the estimated loss of production accounts for about 45% of the capture fishery or 15.5% of the total production. It is considered that there is potential within the culture fishery to make good the loss of capture fishery production but this is not the problem and not necessarily the answer.

The problem concerns who benefits, or rather loses from the reduction of capture fisheries production. There are several groups who may be affected as follows:-

i) the Landless who fish part time or occasionally
ii) Marginal and small farmers who supplement their family incomes with occasional or part-time fishing.
iii) Professional fishermen.

The marginal and small farmers will generally benefit directly from the improved cropping opportunities by substantially more than they lose from their fishing. Thus they can replace their lost fish by either bought fish or other protein as they so choose and will remain net beneficiaries of the project.

The landless and functionally landless will benefit from the increased labour requirements which will occur both during the monsoon season (increased aman cropping) and during the dry season (boro cropping). This is particularly so in the areas most affected by reduction of flood plain areas (Zones B and C). In Chapter 15 it is estimated that if only half the additional agricultural labour requirements were available to non-farming family labour then its value more than compensates for all fish lost to all types of fishermen.

Therefore it is anticipated again that the landless could afford to replace their lost animal proteins from the benefit of their increased labour opportunities if they so choose.

The losses to professional or full time fishermen are more problematical because although theoretically they could join in and obtain benefits from the increased labour opportunities on farms as outlined above they may be unlikely to do so sufficiently for cultural reasons.

There are at least two possible scenarios for these professional fishing households whose numbers are given in Section 6.3.

They will all continue to fish with substantially reduced catches and thus the need to supplement those catches by other means or some will give up fishing in the area and move elsewhere or will take up alternative employment as best they can.

As regards the fishermen in Zones A and D they are likely to be the lest affected by the project both because the flood plains are less affected in these areas and because substantial numbers are involved in fishing in the Meghna (Zone A) and Dakatia (Zone D) rivers. The Meghna river will be entirely unaffected by the project and although the Dakatia will have a 34 % reduction in flood plain in Zone D the contribution from the northern (right bank) floodplain is much less affected.

However there can be no doubt that the fishermen of Zones B and C will be very severely affected and these comprise about 30 % of the total (67 % of the estimated capture fishery losses of 45 % may thus occur in these zones).

It has been noted during the social impact studies that professional fishermen already manage or operate some cultured ponds (see Annex G Chapter 4) and most ponds owners arrange for the catch to be carried out by professional fishermen and this widerspread activity is expected to increase. A second practice is for wealthy land owners or businessmen to bid and obtain large areas of water bodies which are then sub-leased to fishermen at much higher prices. Proper implementation of the fish act and strict limits on maximum areas which can be leased to individuals or groups could ensure better net incomes for fishermen even with reduction in gross catches.

Thirdly there are a substantial number of currently derelict or culturable ponds or other water bodies such as borrow pits which could become valuable assets if improved and leased to fishermen.

All these potentials for mitigation need to be examined as part of the further fisheries studies proposed in Chapter 4 and elaborated in Chapter 12. The costs of implementing these proposed measures are not expected to be large and should be offset by the ensuing benefits. Since all the fisheries losses have already been included in the economic analysis it is not considered that this aspect should delay a decision as to whether to proceed with the project but it is entirely reasonable that the implementation should be coordinated with and tied to the execution of these fisheries studies and the implementation of their recommendations for mitigation measures.

b) **Land Acquisition**

This issue is always contentious and for this reason the consultants have taken great care in the evaluation of what might be required and in devising options which could reduce the amount required to the absolute minimum.

In the consultants view this is likely to be the single most important element in terms of effective project implementation.

It is for this reason that the consultants have gone to some considerable effort to obtain as much information as possible concerning land values, present ownership, and the local populations' views concerning various methods of implementation.

There are two separate elements in terms of land acquisition as follows:

- Land required to achieve the proposed sections of the Khals.
- Land for depositing spoil excavated from Khals.

The different aspects of these two elements are discussed below:

i) **Land Required for Excavation of Khals**

This cannot be avoided if the scheme is to be effective. The total amount of area to be acquired including loop-cut areas and the Rahmatkhali regulator amounts to 76 ha. Out of this the areas of the loops themselves could be filled with excavated spoil and reclaimed to provide homesteads and farm land of area at least as great as that taken by the new cuts and probably more. Thus no net land loss need be accounted for by these loop cuts and this reduces the net area of land to be acquired to by 19 ha. This reduction has not been deducted from project costs. Of the remaining 57 ha a large proportion is believed to be already owned by BWDB because a wide strip of land was purchased during the construction of WAPDA Khal in the early 1970's. The study team obtained copies of the old land acquisition plans and in general the widths then acquired are more than adequate to accommodate the new proposed sections. However it is not possible to identify where the existing Khal lies within those acquired limit and in some cases the existing khal line appears to be outside the acquired areas. Therefore a completely new survey will be required and no allowance for BWDB owned land has been made in the project estimates with all land costed at full value and allowing a premium on land values for compulsory purchase in accordance with recent policy.

Thus the project has assumed full compensation for all land to be taken for construction of the enlarged Khals.

ii) **Land Required for Disposal of Excavated Spoil**

When WAPDA Khal was built in the early 1970's land was acquired for spoil banks and some remnants of these banks are still visible. However in most cases the material has long since been removed. The material has been used for a variety of purposes but most of it has been spread over the farmland and the bank areas reclaimed for farming. Members of the study team have also witnessed the spreading of dredged spoil over farmland in the Gumti area and the use of excavated material (from Khal beds) for raising land for planting orchards (this was near Ramganj in Noakhali North Project area). The team's sociologists were requested to question local groups in informal discussions concerning what should be done with the large quantities of earth which require disposal and what methods should be used. All suggestions come from the local people and these included:

- Embankments at edge of Khal
- Roads Embankments
- Homesteads and Markets
- Spreading Spoil

Although the use of spoil for road embankments and homesteads is entirely practical it could not account for more than a small proportion of the volume to be disposed of. The study has therefore costed both the other suggested alternatives as follows:

- **Embankments or Spoil Heaps**

These are assumed to be 2.5 m high and could be arranged either as intermittent embankments, to allow drainage, or as more concentrated areas as potential orchard or homestead areas. The method would be to strip top soil, dump the spoil and respread the top-soil leaving areas ready for development as described above. This method requires the purchase of the land and, allowing for some disposal in the cut-off lengths near loop-cuts, it is estimated that the amount of land required would be 456 ha.

- **Spreading Spoil**

This has been costed by assuming that all the spoil would be spread over farmland at a depth of 0.30 m. Although this method was acceptable to a majority of people interviewed it was not accepted by all and several expressed doubts as to the quality of the material whereas others thought it would be good.

The samples taken by the team have indicated that a substantial proportion of the spoil may be too sandy to be acceptable. For areas where spoil is of unacceptable quality the proposed method would be to strip the existing top soil, store it, spread the excavated material and replace the top soil. For costing purposes half of the area has been assumed to require this treatment. It would be possible to spread spoil to a greater depth when using this method thus requiring less area but this has not been allowed for in the estimates.

The costing of this method has also allowed for full compensation of the farmers whilst the process is completed. The entire process should be completed within one cropping season on any particular piece of land and compensation could be either in cash or kind (crop) equivalent to the net return the farmer could expect. This has been set at an average 15 000 Tk./ha. In addition the farmer would be given fertilizer sufficient for the following crop valued at 1 000 Tk./ha. The total area affected if this method were applied everywhere would amount to 3 633 ha (if the depth of spoil were increased the area would correspondingly reduce). As stated above based on the results of soil investigations half the area is expected to require this treatment (1816 ha).

The economic analysis suggests that there is little difference between these methods in terms of EIRR but clearly there may be a difference in terns of acceptability to the population. It is considered that the alternative approaches need to be taken to the people and if necessary a combination of the two methods could be applied.

There is one further method which would involve the removal of all the material for disposal in the Meghna or where the contractor could make suitable arrangements. It has been estimated that such on operation could increase the total project costs by up to 25 %.

The solution of using embankments is not favoured since it encourages the practice of piling earth on the edges of the cut sections thereby increasing the likelihood of its being washed back into the excavated section. Also, more significantly, the acquisition of such a large area (456 ha) could prove socially disturbing. However it should be borne in mind that these raised areas could potentially be considered an asset as orchards or homestead areas.

6.5 Environmental Impact Assessment

Environmental Impact Assessment for proposed development programmes attempts to place any considered interventions within a context of environmentally sound and sustainable development. The aim of the environmental component to the Noakhali North Drainage and Irrigation Study was to review a proposed intervention that had already been put through a selection screening process as part of the FAP 5 Regional Study work. The aim was to see if this proposal was basically sound from a broad environmental standpoint, and investigate possible dis-benefits to see how severe these might be and how they could differ across and outside the study area. Proposals were then to be made as to ways of avoiding or mitigating any likely major negative impacts within the framework of an Environmental Management Plan.

The proposed intervention has direct hydraulic consequences on an area much larger than the proposed Khal deepening works. For this reason the study area includes those areas where it was thought likely there would be impacts. The northern limit is the Dakatia river and the western the is the Chandpur project eastern embankment. The southern boundary follows the old coastal protection embankment, which was the coastline prior to the construction of long cross-dams which resulted in major coastal accretion. There is however a small piece of the study area in the south west which lies south of the old coastal embankment and is newly accreted land. The eastern boundary is essentially the watershed line of the Feni river system. However as a result of the hydraulic modelling of the proposed intervention it has become apparent that the extent of the hydraulic impacts spreads further eastwards than the Feni watersheds, as due to the shallow hydraulic gradients it moves the catchment boundary eastwards. An immediately adjacent external area has therefore been included in the impact analysis. Similarly the hydraulic modelling indicated that the right (north) bank of the Dakatia was affected by the intervention and all the way westwards to the Meghna river. This area has also been considered as an adjacent external impact area.

6.5.1 Environmental Procedures and Guidelines

The basis for integrated environmental assessment is laid down in the World Bank Operational Directive 4.01 of October 1991 and is rapidly being accepted internationally as the basis for most of this type of work. For work in Bangladesh the FAP 16 environmental component has drawn up Environmental Guidelines as a self-standing document in its own right and also as part of the Guidelines for Project Assessment (GPA) for FPCO. The FAP Environmental Guidelines have recently been reviewed by the Bangladesh Department of the Environment and are now to be adopted as the National Guidelines for water sector work throughout the country. In addition the second draft of the National Conservation Strategy (NCS) is now under consideration as part of the National Environmental Management and Planning programme (NEMAP). The Noakhali North

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feasibility study environmental component followed the spirit of these Guidelines as far as was possible and appropriate within the very severe constraints of time and resources allowed for the study. The study thus identifies the major issues and where possible quantifies these and makes recommendations as to mitigation measures and the format for detailed studies so an Environmental Management Plan can be put together, including a Resettlement Plan under World Bank Operational Directive 4.30, in the following detailed studies phase, if a decision is taken to proceed further with the proposed project.

6.5.2 Identification of Major Environmental Issues

The major likely environmental issues in the study area were identified during the reconnaissance stage of the study and listed in the Inception Report of November 1992 which was included in the FAP 5 Second Interim Report. These issues are shown in the environmental rating matrix given as Figure 6.7 and are listed down the left hand side. They are ordered logically by the natural and then the human environment, followed by external constraints and possible impacts to and of the intervention. The environmental issues considered to be priorities are indicated in two columns, the first from a detached technical viewpoint and the second from the local peoples perceptions as indicated in the public participation work.

In terms of the proposed intervention, the major impact issues stem directly from the implications of changes in flooding regimes. Specifically the reduction in flood plain area and changes in timing, duration and depth of these. In addition the deepening of Khals has the effect of draining the non deepened Khals quicker than previously, resulting in slightly shallower mean water depths and longer periods when they will be dry. This may therefore marginally reduce the dry season availability of surface water still further in these areas.

The encouragement given to surface water irrigation by providing all year water in the Khals is likely to result in greater intensification of agriculture and all year cropping in some areas. It is predicted that the mean agricultural cropping intensity will increase from 166% to 183%, however this is likely to be very variable across the zones, the predicted increase in rice production being as high as 67% in Zone A as opposed to 7% in Zone D with B and C around 25%. It has been predicted that agricultural labour demand will be increased by 4.3 million person days per annum. These estimations are calculated using the FAP Guidelines methodology with the stipulated crop prices.

6.5.3 Impact Assessment Matrix

The aim of the Impact Assessment Matrix is to identify likely major impacts of the proposed intervention, especially negative impacts, as this then allows closer consideration of these problematic issues. This is considered a useful tool as it allows scarce resources to be concentrated on the issues that matter and not be wasted on peripheral aspects or worse still deprive needy dis-beneficiaries of attention. The matrix differentiates impacts by planning zone, including the adjacent external areas.

The comparative impact assessment matrix for the proposed intervention is given in Figure 6.7. The issues are listed down the left side and systematically cover the natural and then the human environment. External issues are then covered, both upstream and downstream of the study area, and in terms of constraints to the intervention and impacts caused by it. It should however be noted that the immediately adjacent area is covered separately in more detail as a Zone (EX) in itself. The last section covers major broad direct construction impacts. Those issues that are considered, from a technical standpoint, to be priority ones in terms of policy

Figure 6.7

Environmental Rating Matrix of Proposed Intervention by Zone

ISSUES	P	LP	NOW	WO	ZA	ZB	ZC	ZD	EX	MP	MC
THE STUDY AREA NATURAL ENVIRONMENT											
Hydrology											
Surface											
Flood Damage Land & Crops		*	0	-1	0	+2	+1	+2	+1		
Drainage Problems	*	*	0	-2	0	+4	+3	+2	+1		
Surface Water Availability	*	*	0	-2	+3	+2	+2	-1	-1		
Dry Season Irrigation	*	*	0	-2	+3	+2	+2	-1	-1		
Groundwater Availability	*	*	0	-1	-1	-1	-1	-1	-1		
Domestic Water Supply	*	*	0	-1	-1	-1	-1	-1	-1		
Erosion - Internal			0	0	0	0	0	0	0		
Meghna	*		0	-2	-2	0	0	0	0		
Sedimentation											
Internal Khals and Drains			0	-2	+3	+3	+3	+1	+1		
Land Accretion			0	+1	0	0	0	0	0		
Within Project Area											
Clogging/Smothering			0	-1	+3	+2	+2	+1	+1		
Soil Fertility			0	0	0	0	0	0	0		
Navigation			0	-1	+2	+1	+1	-1	-1		
Water Quality											
Domestic Water Quality			0	0	-1	-1	-1	0	0		
Agriculture Water Quality			0	0	+1	+1	+1	0	0		
Land Resources											
Soil											
Quality/Chemistry			0	-1	-2	-2	-2	-1	-1		
Waterlogging			0	-2	+2	+2	+2	+1	+1		
Erosion			0	0	0	0	0	0	0		
Ecology											
Flora			0	-1	-2	-2	-2	-1	-1		
Fauna			0	-1	-2	-2	-2	-1	-1		
Fish	*		0	0	+1	-4	-3	-2	-2	VD	
Seismic Activity (#)											

EXTERNAL FACTORS	P	LP	NOW	WO	ZA	ZB	ZC	ZD	EX	MP	MC
-DOWNSTREAM CONSTRAINTS											
Meghna River Water Levels	*		0	?	+1	+4	+3	+2	+2		
-DOWNSTREAM IMPACTS											
Knock-on Flooding			0	0	0	0	0	0	0		
-UPSTREAM CONSTRAINTS											
Increased Flooding			0	?	0	0	0	0	0		
-UPSTREAM IMPACTS											
Peak Back-Up Flooding			0	0	0	0	0	0	0		
DIRECT CONSTRUCTION IMPACTS											
Permanent Land Acquisition	*		0	0	-3	-1	-2	-1	0	PO	
Forced Resettlement	*		0	0	-3	-1	-2	-1	0	PO	
Temporary Land Acquisition			0	0	-3	-1	-2	-1	0	PO	

LEGEND

RANKING OF IMPACT

-5 Severe Irreversible Negative Impact
-4 Major Negative Impact
-3 Significant Negative Impact
-2 Moderate Negative Impact
-1 Slight Negative Impact
0 Present Baseline Situation and No Change
+1 Slight Positive Impact
+2 Moderate Positive Impact
+3 Significant Positive Impact
+4 Major Positive Impact
+5 Highly Significant Positive Impact

VD = Mitigation Very Difficult
PO = Mitigation Possible
CO = Mitigation Costly
PC = Mitigation Prohibitively Costly
N = Mitigation Not Possible

ABBREVIATIONS/HEADINGS

P = Expert Priority Issues
LP = Local Priorities
NOW = Present Situation
WO = Without Project Situation
ZA = Zone A
ZB = Zone B
ZC = Zone C
ZD = Zone D
EX = External Area
MP = Mitigation Possible
MC = Mitigation Costly?
(#) = A Constraint not an Impact
* = Major Issues
F = In Times of Flood
LF = In Low Flows
PF = In Peak Floods
? = Insufficient Data to Assess

NOTE: The predicted impacts are assumed to be those some six years after completion of construction of the proposed interventions.

THE STUDY AREA HUMAN ENVIRONMENT	P	LP	NOW	WO	ZA	ZB	ZC	ZD	EX	MP	MC
Economic Livelihoods											
Risk			0	0	+2	+3	+2	+1	+1		
Settlement			0	0	0	+1	+1	+1	+1		
Land Tenure											
Scarcity			0	-1	-2	-2	-2	-1	-1		
Agricultural Land Values			0	+1	+2	+4	+3	+2	+2		
Common Resource Rights											
Fish			0	0	0	-4	-3	-2	-2	VD	?
Fuelwood			0	-1	-3	-2	-2	-2	-1	PO	
Grazing			0	-1	-3	-2	-2	-2	-1	PO	
Fodder			0	-1	+1	+1	+1	0	0		
Agricultural Output			0	+1	+4	+3	+3	+2	+2		
Fishing ("Professional")			0	+1	0	-1	-1	-1	-2		
Forestry and Fuelwood			0	-1	-3	-2	-2	-2	-1	PO	
Livestock			0	-1	-1	-1	-1	-1	-1		
Wage Paid Employment	*	*	0	-1	+2	+4	+4	+1	+1		
Industry			0	+1	+3	+2	+2	+1	+1		
Drinking Water Availability	*	*	0	-1	-2	-1	-1	-2	-1		
Human Health	*										
Waterborne Diseases	*										
Diarrhoea	*	*	0	-2	-2	-2	-2	-3	-2	PO	
Cholera	*		0	-2	-2	-2	-2	-3	-2	PO	
Insect Borne Diseases											
Malaria			0	-2	-2	-2	-2	-1	-1		
Kala-azar			0	0	0	0	0	0	0		
Drinking Water Quality	*	*	0	-1	-1	-2	-2	-1	-1		
Sanitation			0	-1	-2	-2	0	-1	-1		
Nutrition	*		0	-1	-2	-1	-1	-2	-1		
Mental Health			0	-1	?	?	?	?	?		
Access and Transport Infrastructure											
Waterborne											
Dakatia River			0	0	0	0	0	-1	-1		
Internal Rivers and Khals		*	0	-2	+1	0	0	-1	-1		
Within Flood Plains			0	0	0	-2	-1	-2	-2		
Railway			0	0	0	+1	+1	+1	0		
Road			0	+1	+2	+2	+2	+2	+1		
Archaeology and Cultural Sites			0	0	-1	-1	0	0	0		

objectives are indicated in the first column (P), where as those which are of concern to local people are indicated in the second column (LP). The present situation (NOW) has been set at a steady state zero to allow a comparative assessment to be carried out. However this hides the fact that for some issues the present situation is already in dis-equilibrium. The WO column is an indication of the likely general situation over the study area if the intervention were not implemented. Whilst this gives a guide as to the likely future trends, it is notoriously difficult to predict these, especially for the natural environment. It also hides important zonal differences which can not be addressed due to a lack of data, particularly on fisheries trends and the BBS 1991 census work. Analysis of zonal differences is also not helped by the fact that the Zonal boundaries are misaligned for some aspects of impact assessment work. The following five columns are each of the zones, including the immediate external areas (EX). The last two columns indicate the mitigation possibilities for the most serious negative impacts, and if mitigation is possible, how costly it is likely to be. The definition of the ratings is given on the last page of the matrix and covers a scale from -5 to +5 with 0 being the present situation. It should be remembered that the ratings are the actual situation in comparison to that of the NOW column. To give differentials of the situation in six years after the construction period has finished, the WO column rating should be borne in mind when viewing the zonal rating. The period used for assessment of the likely impacts is six years from the completion of construction, as it is considered unrealistic and unreliable to predict further forward than this, especially for issues concerning the natural environment. No statistical weights or totals are used in these matrices as this is considered unjustifiable and would be deceptive giving the work spurious credibility. There is simply not the data available to do this, especially for such a complex and diverse area and with the time and resources given to do the work. The matrix aims to highlight the major issues so that more detailed follow-up work can be targeted on these. The more severe impacts with a rating of -3 and higher are discussed individually in Section 6.5.4 and those lesser issues with a rating of -2 are dealt with in broad terms.

6.5.4 Principal Negative Impacts of the Proposed Intervention

As stated in the proposed approach and methodology to the study (FAP 5 Second Interim Report, Section 9, November 1992), the resources and time period made available to the environmental component of the study are inadequate to address the likely impacts of the proposed intervention according to both the FPCO Environmental Guidelines and the World Bank Operational Directive 4.01. Consequently it was decided to concentrate the available resources on the most serious negative impacts, with the aim of identifying these and where possible undertaking sufficient work to quantify and value the most serious issues. Considerable additional work with a field data collection period of a minimum of 12 months will be required to bring the environmental component up to the level of a fully integrated assessment with full quantification, mitigation arrangements and an Environmental Management Plan. An outline for this is given in Section 6.5.5. The main negative impacts are those with a rating of -3 or more on the matrix, there are only four of these:

- Losses to Floodland Fisheries
- Socio-economic and Livelihood Impacts - mainly due to professional fisheries losses and the requirements for land acquisition and resettlement.
- Fuelwood and Grazing Decline
- Changes in Waterborne Diseases

The last two impacts are issues that are likely to emerge irrespective of the intervention but are accelerated by it.

a) **Changes in Flood Risk and Timing**

The results of the hydraulic modelling for a with and without project situation in a "normal" and high "normal" flood have been interpreted using differential flood mapping. The conclusion from this is that the reduction in area of flood plain due to the intervention is quite considerable although this varies greatly from zone to zone. The peak extent falls by some 36% in the study area and 30% in the external area in a "normal" year. However the mean annual reduction over a full "normal" year is much greater at 48% in the study area and 40% outside it. This is due to the rising flood being delayed and the falling flood starting earlier. Whilst this demonstrates the effectiveness of the intervention in terms of reducing flood damage and allowing monsoon season agriculture and earlier planting in many areas, it is a dis-benefit to the flood plain fish habitats. This has implication for the ecology of the area as well as fisheries production and hence the availability of animal protein as a food source. In addition, the promotion of irrigated dry-season farming is likely to result in the intensification of the agricultural system with a move towards longer periods of rice monoculture. There will also be some parts of the study area outside the Khal deepening and irrigation area that will no longer have seasonal flooding. These areas will have slightly longer periods with no water in their Khals and will not have access to dry season surface irrigation water provided by the intervention. They will be reliant totally on rainfall with limited residual moisture from infiltration and none from standing flood water. These changed hydraulic parameters underpin the thinking behind the assessment of the likely environmental implications of the intervention.

b) **Losses to Floodplain Fisheries**

The most serious negative impact of the proposed intervention would appear to be on floodplain fisheries. The detailed work on fisheries assessment is given in Annex F of the feasibility report and the estimated production changes for the intervention by fishing system and zone are given in Table 6.3. These changes are shown as percentage differences relative to a predicted without project situation for a time at 6 years after completion of construction. This has used assumed national fish production changes of -1.5% per annum for all systems except ponds where +4.5% has been used. These rates have been obtained from FRSS data in collaboration with FAP 17 (the FAP Fisheries Special Study) and are also the same rates of change used by FAP 3.1 and the 1993 Gumti Phase II Feasibility Studies. However there must be great concern as to how valid these national figures are for a specific study area. For Noakhali North it may be that the pond increase is perhaps high as pond production in the area has already been significantly increased.

The main effects of the intervention are the reduction in floodplain area available for fish habitats and the increase in all year water availability in the deepened Khals and drains which should allow increased dry season fisheries retreat areas. It has been predicted that, with the intervention, fisheries production will be less than the without project situation by 3645 tonnes (13% of the total) in the study area and 737 tonnes less in the external areas. However this varies greatly by zone, with the most effected being Zone B at -18% followed by Zone D at -13%, C at -11% and a very small increase in Zone A. It has not been possible to quantify the present production in the external areas and hence change estimates can only be given for the floodplain areas with no indication as to how important these are to the overall level of fish production.

The main effect is in flood plain fisheries production, which is predicted to be 50% less in the study area and 31% less in the external area when compared to a no intervention situation. However this is very variable by zone, with no loss in Zone A (in fact a small gain due to more water in Khals), an 81% floodplain catch loss in Zone B, a 62% floodplain loss in Zone C and a 34% loss in D. The floodplain catch loss in Zone B may however be offset to some extent by high levels of pond production (over 3 times the floodplain production) which according to the nutritional study are being used for direct consumption by many small scale operators/owners. The same may be true to some extent in Zone C, although the nutritional study has not shown this to be the case but the sample sizes were very small. In Zone C there are 28% gains to Khal fisheries but these are only a very small proportion of the total fish catch and do not act as a significant mitigation measure. In Zone D there is a 34% loss to flood plain and 32% loss to Khal fisheries and this constitutes an overall loss of 13% to all fisheries production.

The procedures for valuation of the fisheries resources are given in Annex F of the feasibility study and have been incorporated into the financial analysis of the intervention, both in terms of lost value of production and loss of wages/income to fishing households. The cash valuation of the catch is based on market prices and it must be remembered that the fisheries work covers only the fish caught by full time and part time fishermen and excludes occasional fishermen who are far more numerous in all zones except D where they are similar to the numbers of full-time fishing households. Overall there are about twice as many occasional fishing households than full or part time ones, the occasional fishing households catching fish for self consumption.

According to the apportioned 1991 census data, some 10% of all households in the study area carry out occasional fishing. The nutritional study has indicated that the fish consumption levels in the study are very high (over 45% had eaten fish in their last meal and 82% in the last three days), especially in comparison to Dhal (18% and 45%) and meat (4% and 10%). In the dry season period of a very dry year when the nutritional surveys were undertaken the source of fish was the market for 80% of households, own ponds were 15% (although 40% in Zone B) and self caught in Khals was 3%. This later figure seems to roughly fit the 4% of households who are recorded as being professional fishermen but can only be reconciled with the 10% of occasional fishing households by assuming most occasional fishing is a wet season occupation in flood plain areas. It also highlights the possibility, particularly in Zone B, of many fish dependent households being involved in pond fisheries.

The overall conclusion is that an in-depth study of fishing household socio-economics is required, targeted on issues and locations that are likely to arise as a result of the proposed intervention. This also needs to include a catch assessment survey over a full yearly cycle in a "normal" flood year and include the adjacent areas external to the study boundary. Even without this data it seems possible to surmise that the most serious problem is likely to be the floodplain loss in Zone B, followed by Zone C, the eastern external area, Zone D and finally the Dakatia floodplain. The severity of this loss is likely to be greatest to occasional fishing households in Zone B (estimated to be a maximum of 9 800 households), and in Zone C (7 650 households). There may be some full time fishing household losses in zones B and C but the numbers are low and likely to be no more than 2 000. In Zone D the proportion and number of full time fishing dependent households is far higher than in other zones, however the degree to which they depend on the present flood plain is unknown. It is estimated that some 3 400 occasional fishing household will be effected in Zone D and perhaps a up to a similar number of professional fishing households. The situation in the external areas is even less certain as the numbers of fishing households are unknown and there are no catch assessment data split by fishing system.

In all some 20 000 occasional fishing households are estimated to be directly effected in Zones B, C and D, by that order of priority. The main outcome is likely to be declining levels of nutrition in these households. In addition an unknown number of fish dependent households will be negatively effected in the external areas and around 3 500 full and part time fishing households could be at socio-economic livelihood risk in Zone D. There

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are also likely to be losses to full time fishing households in Zones B and C, but these are likely to be small, in the order of 1 000 - 2 000 at the maximum.

c) **Socio-Economic and Livelihood Impacts**

A Social Impact Assessment (SIA) has been carried out as part of the socio-economic studies. The overall aim of the SIA is to ensure that no one group of people is dis-benefitted as a result of the intervention and benefits are spread in an equitable and non-divisive manner. In addition any constraints to achieving benefits were also considered so that the aims of the intervention are more likely to be realised. Investigations for the SIA were carried out as part of the public participation programme using group discussion techniques and raised a wide range of issues. The work identified likely disadvantaged groups and considered mitigation programmes to overcome these, including appropriate institutional structures for achieving these. Additional specific issues were raised by the SIA team that were of concern to them and had not been raised by local people. This is an important aspect of creating awareness of the specific localised issues that are likely to occur due to the highly site specific nature of the proposed intervention.

The two major causes of loss to socio-economic livelihood as a result of the intervention are likely to be amongst full time fishing households and those who lose land and fixed assets as a result of the need to acquire land for permanent works. The latter is likely to be a highly localised issue but in the case of a few households could be severe.

It has been estimated that as many as 3500 professional fishing households could be seriously effected in Zone D and up to a further 2000 in Zones B and C. In addition there are an unknown number in the adjacent external areas. A specifically targeted programme of replacement livelihood provision would need to be set up for these households. The development of a suitably owned and managed pond aquaculture programme would seem to be a strong possibility, especially as there appear to be such activities already happening in Zone B. In addition it could be the case that the extra labour required as a result of construction and development of irrigated agriculture would provide a suitable replacement livelihood. However the most serious problem lies in Zone D which is outside the intervention and irrigation area.

It has been calculated that the intervention programme will require 76 ha of land to be acquired for permanent works although this could in theory be offset to some extent by 19 ha gained from straightening the khals. A detailed cadastral mapping survey with full field verification and certification is required of the chosen deepened Khals so that accurate numbers can be given of the number of households effected and to what degree. This will require a socio-economic component that looks at each effected households asset portfolio and an assessment made as to the degree to which their livelihood is jeopardised. This will allow a suitable resettlement and compensation strategy to be developed which allows the greatest flexibility for the affected households. Overall such land and fixed asset acquisition must be done in a fair, equitable and timely manner or the construction programme could be seriously jeopardised. Recent difficult experiences on the Coastal Embankment Rehabilitation Project illustrate what can happen if these issues are not tackled in a timely and rational manner. The FAP 15 study review of land acquisition, resettlement and compensation issues raised serious questions as to the adequacy of the present implementation of these procedures. It is imperative that these issues are addressed and that there is close liaison with the effected people in avoiding and solving any potential disputes over land acquisition and compensation. It should be the case that all assets are full compensated for and resettlement satisfactorily completed before any works can commence on it. In addition there is a World Bank requirement for an agreed resettlement and compensation plan following the Operational Directive 4.30 to be agreed prior to funding. For the present study, estimates of compensation costs have been included in financial analysis of the intervention, based upon field reconnaissance and land values found in the area.

In addition land is required for storage/disposal of excavated soil. If this were to be for large permanent spoil tips it would require 457 ha of permanent land acquisition. However if the spoil were to be thinly spread this would affect 3633 ha but only temporarily during the construction period and for a period after spreading for any infertility to be redressed. These two alternatives have been costed and although the temporary acquisition option is slightly more expensive (overall the soil disposal costs are estimated to be some 5% of the total construction cost) it has considerable socio-economic benefits over permanent land acquisition. A flexible approach will be needed and in some areas affected people may for their own reasons favour permanent land acquisition, although the SIA work has indicated that very few people would object to temporary acquisition and soil spreading. Some people were actually keen to have the material and use it for house raising purposes.

Apart from these two direct socio-economic impacts there are also concerns that the benefits of the intervention, particularly those derived from agricultural intensification due to the provision of irrigation water, will only be fully realised by the richer farmers who have access to the inputs required to maximise returns to this type of operation. This can particularly be a problem in share cropped areas and could result in increased polarisation of income levels and widening of the equity gap. This requires specifically targeted assistance, particularly agricultural credit to poor farmers. In addition there appears to be conflicting views as to the likely pattern of increased demand for agricultural labour. It has been estimated that an additional 4.3 million person days per annum will be generated by the increase in agricultural activity. However in some areas of the country most additional labour requirements have been met by existing "surplus" labour available from within the landowning family (see the work of FAP 12). The situation in the study area looks to be different as many already hire in labour at certain times of the year which would indicate a shortage at some times and that any increased agricultural activity will generate significant wage paid labour from outside the household. This is important as it is considered a major way of overcoming the nutritional consequences of common good fisheries losses to occasional fishing households and generally spreading the benefits of the intervention to poorer households. This is also the case with the requirement for construction labour, which whilst temporary is estimated to provide employment for 10 000 people for three dry seasons. However this needs to be well managed if the benefits are to be passed to the most needy local people. It has been proposed that Labour Contracting Societies (LCS) be utilised so that this is more likely to happen. This is discussed in detail, with locals peoples views as to this proposal, in the SIA.

There would also seem to be some justification for broadening the scope of the intervention programme to tackle other related issues that are perceived by local people to be important in the area. These include items that would tackle mitigation measures and be central to an Environmental Management Plan (EMP) for the area which could be implemented with the help of NGO's. These would aim to increase socio-economic levels in the area, particularly to dis-beneficiaries. They include the promotion of fisheries management and aquaculture, replacement protein production programmes (poultry and vegetable production), social forestry, sanitation, water supply and health education. These would need to be designed in an appropriate manner as part of an integrated development programme.

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6.5.5 Impact Mitigation and Environment Management Plan

The aim of impact mitigation is to design the interventions to be as environmentally friendly as possible by minimising environmental dis-benefits and maximising benefits. In addition there should be targeted programmes to tackle specific negative impacts in defined places or amongst particular social groups. Another aspect of mitigation is to ensure that the construction phase is sensitive to environmental concerns and also the design of the operation of the intervention allows the identified environmental issues to be addressed. These mitigation measures need to be drawn-up to be sustainable in both environmental and economic terms. The costs of carrying out the measures should be included in the financial analysis of the intervention and be incorporated in the multi-criteria analysis. The environmental mitigation and management work should be formulated into an integrated programme within the framework of an Environmental Management Plan.

The main negative impacts are given in the residual impacts Table 6.4 with the major issues being shown, by decreasing order of importance, down the left-hand side. This is then followed by quantification and valuation where possible and also the additional data requirement. The possibilities for mitigation measures are shown in the in the next to last column. The mitigation measures are discussed in detail in the feasibility study.

They are briefly described below:

a) Fisheries Losses

It is envisaged that mitigation for the ecological consequences of floodplain reduction on fisheries (reduction bio-diversity and its knock on effects) will be very difficult, if not impossible to achieve. It would appear to be an inevitable cost of wishing to increase agricultural production using a drainage and irrigation intervention. The cash loss of the decline in commercial fisheries and the lost wages will be easily offset against the agricultural benefits in cash terms. A targeted fisheries management programme could however go some way to promoting sustainable fish use on the remaining floodplain. However the loss of socio-economic livelihood to professional fishing households could be severe locally and will require a targeted programme for re-training. The most appropriate role would appear to be as pond aquaculture fishermen, as this seems to be happening already in some parts of the study area. However this is a choice for individual household members and all that can be done is to assist in providing sustainable choices of options. It may be that many will chose to take up wage paid agricultural work for irrigated farming. The latter situation is likely to be the case for part-time fishermen. The nutritional consequences of fisheries losses to occasional fishing households could also be mitigated for by taking up the opportunities offered in increased agricultural wage paid labour. This would allow occasional fishing families to earn greater income and use this to purchase fish produced using pond aquaculture. However studies are required on the nature of likely income levels of such wage paid agricultural work and also work in the construction programme.

b) Livelihood loss due to asset loss under permanent works

The livelihood losses caused by the need for permanent and temporary land acquisition and loss of immovable assets should all be fairly and adequately mitigated for as part of a compensation and resettlement programme. This is a requirement of World Bank Operational Directives and is proposed to be fully addressed in the next phase once detailed enumeration surveys and assets inventories can be carried out. The aim of any resettlement and compensation programme should be to give the effected households the greatest choice in deciding an equivalent replacement alternative livelihood. The implementation of this work will require close liaison with the effected households. It is proposed to do much of this type of work through locally active NGO's.

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TABLE 6.4

Residual Negative Impacts

Principal Negative Impacts By Priority	Quantities	Valuation	Mitigation Possibilities	Residual Impacts	Residual Impact Rating
Fisheries Losses:					
- Ecological Consequences	Data needed - difficult	Not possible	Not possible	Yes(esp. in Zone B)	-2
- Lost Cash Resource (Financial)	3645 tons (internal) 737 tons (external)	Tk 51 million/Annum + External Value	Partly possible	Some (external areas)	-1
- Nutritional Consequences	25500 HH	Very difficult but possible	Partly possible	Some	-1
Socio-Economic Livelihoods:					
- Professional Fishermen	4660 HH	Possible - need more data Estimated 90% of Tk 51 million/Annum	Partly possible	Some likely (external areas)	-1
Direct Construction Impacts:					
- Permanent Land Loss	Estimate 76 ha	Tk 43.6 million	Possible	None	0
- Temporary land Loss	3633 ha	Estimate Tk 58 million	Possible	None	0
Fuel-wood and Grazing Decline	Detailed Data needed	Not yet possible and difficult	Possible	None	0
Waterborne Disease	Data needed	Not possible	Possible	Some in Zone B	0
Soil Fertility	Data needed	Not yet possible and difficult	Management needed	Very little if careful (monitoring)	0
Floodplain Flora and Fauna	Detailed data needed	Possible but difficult	Partly possible	Some	-0.5

c) **Fuelwood and Grazing**

The fuelwood issue is best resolved by instigating a social forestry programme on embankments and at homesteads. It is proposed to do this through an integrated rural development programme led by an NGO. The grazing issue is likely to resolve itself as greater volumes of rice straw are predicted to be produced as a result of agricultural intensification. However this will need a change from grazed animals to stall fed systems and extension services may need to assist in managing this. Provision of power tillers is also likely to help address this issue and overall it is considered that this can be fully mitigated for.

d) **Waterborne Diseases**

This is best addressed by continuing the increased provision of safe drinking water and also improving sanitation. However this needs to go hand in hand with a health education programme if it is to be effective. This could also be done as a component of an integrated rural development programme, and provided there were commitment to this any increased risk to waterborne disease attributable to the intervention could easily be mitigated for.

e) **Soil Fertility**

With regard to possible soil fertility issues the need is for an appropriate monitoring system with effective feed back responses from this so that any detected problems can be addressed by timely soil, water and agricultural management practices. If this mechanism is in place it should be possible to avoid or mitigate post-project soil fertility problems.

f) **Direct Construction Impacts**

The question of livelihood loss due to the requirements of land acquisition has been dealt with above. However other issues need to be addressed at appropriate stages of intervention design, construction and management. This is best done by having a permanent environmental perspective to the work and is not a "one off" process. The environmental considerations of a range of options were considered at the Regional Planning Stage and this report tackles the formulation of the proposed intervention. The detailed study and design phase follows, during which detailed engineering design considerations (e.g. fish friendly gate design and operation) can be addressed. The likely nature of detailed construction impacts cam also be addressed at this time and if necessary environmental safeguards built into the construction contracts along with appropriated enforcement procedures for these. If tacked with sufficient forethought most of the significant construction impact issues can be avoided and mitigated for at no great financial cost. If handled well and in a timely manner such an approach is likely to save time and money overall.

6.5.6 Environmental Management Plan

It is not possible at the moment to prepare a detailed Environmental Management Plan (EMP) for the proposed intervention. This requires more detailed data and information, particularly concerning accurate estimates of likely quantities of asset loss, compensation and resettlement. The data collection programme for such work is proposed to be covered in the next phase of the study and is described in Chapter 12 of the main feasibility study report.

6.5.7 Impact Timing

As explained previously a 6 year period has been used for assessment of the likely impacts of the interventions as indicated on the matrices. For the medium term (about 5 years) and longer term (over 10 years) impacts a baseline data collection and monitoring programme is needed. This would specifically need to address the issues of soil chemistry and structure change, medium and longer ecological impacts and also possible socio-economic issues due to agricultural intensification that may arise.

6.5.8 Residual Impacts

Table 6.4 gives a summary of the major negative environmental issues for the proposed intervention, quantification and valuation of these if possible and details of the proposed mitigation measures. The residual impacts that are thought to be impossible or very difficult to fully mitigate for are shown in the final column. The most significant residual impact would seem to be the ecological losses to the floodplain area. It is envisaged that all other major negative impacts can be mitigated for to a great degree.

6.6 Project Costs

6.6.1 Project Costs

Two summaries of the project costs for complete implementation including engineering surveys, design and construction are presented in tables 6.5 and 6.6.

These tables not only indicate the total costs for each item of works but also indicate the estimated breakdown of costs on a year by year basis. Table 6.5 assumes that all excavated spoil is to be placed in embankments or raised areas (2.5 m high) which are to be procured by land acquisition procedures in accordance with FAP 15 recommendations and government regulations.

The alternative costed proposal shown in Table 6.6 assumes that all excavated spoil will be spread over farm land and that appropriate compensation will be paid. Also allowance has been made for stripping topsoil and replacing after spoil spreading where this is needed.

TABLE : 6.5

Project Costs–Alternative I (Land Acquisition for Spoil Heaps)

Sl No	Description	Unit	Rate	Quantity	Amount (Tk. Mil.)	Year 1	2	3	4	5
1	Modification of Existing	No	L.S.	1	20.50	-	5.00	10.00	5.50	-
	14 Vent Rahmatkhali Regulator									
2	New 10 Vent Rahmatkhali Regulator	No	L.S.	1	69.20	-	15.00	35.00	19.20	-
3	New 4 Vent Noakhali regulator	No	L.S.	1	5.92	-	-	5.92		-
4	Modification of Existing Bridges									
	a) Modification of Structures	NO	L.S.	1	8.24	-	-	4.12	4.12	-
	on WAPDA/Rahmatkhali Khal									
	b) Scour Protection of Bridge Pires	NO	L.S.	1	3.63	-	-	1.81	1.82	-
	c) Modification/Reconstruction									
	of Bridges on Minor Khals	NO	L.S.	1	7.86	-	-	3.93	3.93	-
5	Dredging Rahmatkhali & WAPDA Khal	Cu.m	50.0	7460477	373.02	-	37.42	139.80	139.80	56.00
6	Manual Excavation Rahmatkhali	Cu.m	39.5	1693422	66.89	-	-	-	33.89	33.00
	& WAPDA Khal									
7	Khal Bank Protection	M	18000.0	1850	33.30	-	-	-	16.00	17.30
8	Manual Excavation of Minor Khals									
	(115 Km)									
	a) Noakhali Khal	Cu.m	31.0	229026	7.10	-	-	-	3.00	4.10
	b) Sonaimuri Khal	Cu.m	31.0	631608	19.58	-	-	-	10.00	9.58
	c) Mohandra Khal	Cu.m	31.0	509238	15.79	-	-	5.79	5.00	5.00
	d) Hornakhali Khal	Cu.m	31.0	195411	6.06	-	-	3.06	3.00	-
	e) Marameghna Khal	Cu.m	31.0	169795	5.26	-	-	2.00	3.26	-
	f) Khal No 28	Cu.m	31.0	99154	3.07	-	-	3.07	-	-
	g) Kamta Khal	Cu.m	31.0	406035	12.59	-	-	6.59	6.00	-
	h) Kabir Khal	Cu.m	31.0	210972	6.54	-	-	3.00	3.54	-
	i) Musar Khal	Cu.m	31.0	164614	5.10	-	-	5.10	-	-
9	a) Strip topsoil, Store,	ha	85000	19.01	1.62	-	-	1.14	1.14	-
	and Respread (Loop Cutting)									
	b) Strip topsoil, Store,	ha	85000	456.80	38.83					
	and Respread (Spoil Heaps)									
10	Buildings and Equipment									
	a) Refurbishment of BWDB offices at	No	L.S.	600000	0.60	-	0.60	-	-	-
	Lakshmipur, Noakhali and Feni									
	b) Computers, Generator									
	and Survey Equipment	No	L.S.	850000	0.85	-	0.85	-	-	-
11	Vehicles	No	L.S.	2100000	2.10	-	2.10	-	-	-
	(1 No Truck, 2 No pickup, 10 Motorcycle)									
12	Land Acquisition									
	a) Regulator Site	ha	500000.0	10.000	5.00	-	5.00	-	-	-
	b) WAPDA/Rahmatkhali Khal (Agricultural)	ha	500000.0	61.000	30.50	-	18.30	12.20	-	-
	c) WAPDA/Rahmatkhali Khal(Homestead)	ha	1620000.0	5.000	8.10		4.86	3.24	-	-
13	Land Acquisition for Spoil Heaps	ha	500000.0	456.800	228.40	-	114.20	114.20	-	-
	(Spoil Dump 2.5 m High)									
14	NGO's Cost	No	L.S.	28250000.0	28.25	3.53	7.06	7.06	7.06	3.54
	Sub-Total of Direct Construction Cost = A				1013.90	3.53	210.39	367.03	266.26	128.52
	Physical Contingencies 15% of (A) = B				152.08	0.53	31.56	55.05	39.94	19.28
	Sub-Total (A) + (B) = C				1165.98	4.06	241.95	422.08	306.20	147.80
	Engineering Service Cost 12% of C				139.92	28.00	28.00	32.00	32.00	20.18
	Total Project Cost (Tk. mil.)(A) + (B) + (C) =				1305.90	32.06	269.95	454.08	338.20	167.98

TABLE : 6.6

Project Costs–Alternative II (Land Compensation for Spoil Spreading)

Sl No	Description	Unit	Rate	Quantity	Amount (Tk. Mil.)	Year 1	2	3	4	5
1	Modification of Existing	No	L.S.	1	20.50	-	5.00	10.00	5.50	-
	14 Vent Rahmatkhali Regulator									
2	New 10 Vent Rahmatkhali Regulator	No	L.S.	1	69.20	-	15.00	35.00	19.20	-
3	New 4 Vent Noakhali regulator	No	L.S.	1	5.92	-	-	5.92		-
4	Modification of Existing Bridges									
	a) Modification of Structures	NO	L.S.	1	8.24	-	-	4.12	4.12	-
	on WAPDA/Rahmatkhali Khal									
	b) Scour Protection of Bridge Pires	NO	L.S.	1	3.63	-	-	1.81	1.82	-
	c) Modification/Reconstruction									
	of Bridges on Minor Khals	NO	L.S.	1	7.86	-	-	3.93	3.93	-
5	Dredging Rahmatkhali & WAPDA Khal	Cu.m	50	7460477	373.02	-	37.42	139.80	139.80	56.00
6	Manual Excavation Rahmatkhali	Cu.m	39.5	1693422	66.89	-	-	-	33.89	33.00
	& WAPDA Khal									
7	Khal Bank Protection	M	18000	1850	33.30	-	-	-	16.00	17.30
8	Manual Excavation of Minor Khals									
	(115 Km)									
	a) Noakhali Khal	Cu.m	31	229026	7.10	-	-	-	3.00	4.10
	b) Sonaimuri Khal	Cu.m	31	631608	19.58	-	-	-	10.00	9.58
	c) Mohandra Khal	Cu.m	31	509238	15.79	-	-	5.79	5.00	5.00
	d) Hornakhali Khal	Cu.m	31	195411	6.06	-	-	3.06	3.00	-
	e) Marameghna Khal	Cu.m	31	169795	5.26	-	-	2.00	3.26	-
	f) Khal No 28	Cu.m	31	99154	3.07	-	-	3.07	-	-
	g) Kamta Khal	Cu.m	31	406035	12.59	-	-	6.59	6.00	-
	h) Kabir Khal	Cu.m	31	210972	6.54	-	-	3.00	3.54	-
	i) Musar Khal	Cu.m	31	164614	5.10	-	-	5.10	-	-
9	Strip topsoil, Store, and Respread								1.14	-
	a)Loop Cuts	ha	85000	19.01	1.62	-	-	0.81	0.81	-
	b)Soil spreading areas	ha	85000	1816	154.36	-	15.44	51.20	51.20	36.52
10	Buildings and Equipment									
	a) Refurbishment of BWDB offices at	No	L.S.	600000	0.60	-	0.60	-	-	-
	Lakshmipur, Noakhali and Feni									
	b) Computers, Generator									
	and Survey Equipment	No	L.S.	850000	0.85	-	0.85	-	-	-
11	Vehicles	No	L.S.	2100000	2.10	-	2.10	-	-	-
	(1 No Truck, 2 No pickup, 10 Motorcycle)									
12	Land Aqusition									
	a) Regulator Site	ha	500000	10	5.00	-	5.00	-	-	-
	b) WAPDA/Rahmatkhali Khal(Agricultural)	ha	500000	61	30.50	-	18.30	12.20	-	-
	c) WAPDA/Rahmatkhali Khal(Homestead)		1620000	5	8.10		4.86	3.24	-	-
13	Land Compensation	ha	16000	3633	58.13	-	5.80	20.23	30.00	2.10
	(Soil Spreading, 0.3 m depth)									
14	NGO's Cost	No	L.S.	28250000	28.25	3.53	7.06	7.06	7.06	3.54
	Sub-Total of Direct Construction Cost = A				959.16	3.53	117.43	323.93	348.27	167.14
	Physical Contingencies 15% of (A) = B				143.87	0.53	17.61	48.59	52.24	25.07
	Sub-Total (A) + (B) = C				1103.03	4.06	135.04	372.52	400.51	192.21
	Engineering Service Cost 12% of C				132.36	26.50	26.50	30.00	30.00	19.36
	Total Project Cost (Tk. mil.)(A) + (B) + (C) =				1235.40	30.56	161.54	402.52	430.51	211.57

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The difference in capital costs in financial terms is less than 6 % and the difference in economic terms is also small. The consultants recommend the cheaper but less economic solution since it would seem less disruptive in the long tern. However it may be that in practice a mixture of the two approaches may prove to be the locally preferred solution with some areas opting for the one approach and others for the other.

The detailed breakdown of costs, quantities and rates are given in Annex 1 of the feasibility study and are based on 1992 prices.

6.6.2 Implementation Schedule

Figure 6.8 shows the provisional implementation schedule including all studies and designs as well as construction works. Each year is a calendar year starting in April.

Generally the principle for programming construction is to use the monsoon season for tendering and award procedures and the dry season for construction, particularly for manual works.

The progression of works has been assumed to start at the downstream end of the works so that as soon as an area is finished it can benefit from both improved drainage and irrigation potential. Thus it is estimated that the first irrigation benefits will be available in year 4 (second half) after completion of the main regulators and the first tranche of secondary Khals are completed. The first drainage benefits will be felt in the first half of year 5.

It has been assumed that the fisheries and environmental studies could be let as one package or separately with the results of the surveys available to the design team at least six months before the end of the design period so that any necessary physical mitigation measures can be incorporated in the designs.

The NGO design activities are scheduled to start six months after the design consultants start work. This allows the design team to review the proposals and produce a revised Khal alignment based on the results of the topographic and geotechnical engineering surveys.

6.7 Operation and Maintenance

There are a number of recently completed, ongoing and planned projects which have studied, are studying or will study various aspects of this current element of successful scheme development. These studies include FAP 13 (and the forthcoming FAP 13.1 and 13.2), Systems Rehabilitation Project, the National Minor Irrigation Development Project and the forthcoming FAP 26 which may affect institutional arrangements.

The consultants team have discussed aspects of O & M with both SRP and FAP 13 personnel and also with various BWDB officials. These consultations and the perceptions of local people have helped to frame the recommendations set out in this chapter.

There are many problems related to O & M but the two principal areas of concern for this particular project are firstly adequate provision of regular funding for maintenance and secondly the involvement of the local people to ensure their continued interest and support for the project and its objectives.

The following sections set out what needs to be done, how it could be arranged and how it could be funded.

6.7.1 Operation Requirements

At the design stage detailed O&M manuals should be prepared but the principal elements are set out in the following sub-sections:

The project as conceived is exceptionally simple in terms of operation but must nevertheless be staffed and equipped to fulfil the required tasks in an effective, efficient manner.

a) The Rahmatkhali Regulators.

These two regulator structures are the only control mechanism on the entire project and on their effective operation depend the whole of the benefits. The chosen design means that on a day to day basis no structure operations are required but seasonal operations and occasional emergency operations will be required.

The operating rules will be closely defined at the design stage but in outline they are as follows:-

i) Monsoon Season

As soon as water levels in the Meghna river rise such that levels at Pairapur reach + 3.00 m PWD the downstream (riverside) tidal flaps should be lowered into their operating positions.

These gates will then operate in a similar manner to the existing gates except that they will open wider under much lower heads and velocities allowing improved access for some fish species.

The gates will remain in their operating mode until the water levels in the Khal system are well below ground level at Piaiapur, Begumganj and Chandraganj so ensuring that drainage of the area is largely completed. It is suggested that a level at Chandraganj of + 2.3 m PWD would provide an effective measure to trigger the lifting of the flood protection gates. However an additional rule would include the maximum spring tide level of the Meghna at the regulator which should be below +3.00 m PWD.

When these two conditions are met the flood protection gates should be lifted clear of the water and fastened in the horizontal position (See figure 6.4). This is likely to occur during November but will vary from year to year.

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ii) Dry Irrigation Season

As soon as the flood gates have been raised the irrigation gates should be lowered into their operating positions so that when Meghna river levels are higher than those inside they will open to admit water for irrigation but when Meghna water levels fall (to those inside or lower) then the gates will close and will retain the water admitted during high tide. These gates will remain in the operating mode at least until the end of March. At this time the storage of water for irrigation become less important as the Meghna river level is already increasing and sufficient water should be available in the Khal system for the reduced irrigation requirement at this time without the need for gate regulation.

It is therefore proposed that the irrigation gates are lifted clear of the water at the beginning of April and fastened in their horizontal position.

For the months of April and May in most years it will be possible to keep the vents completely open providing unrestricted access for all spawn, fry and fish until the Meghna river achieves a level requiring flood protection as described in section i) above.

iii) Emergency Operation

This area is prone to cyclones and these most often occur in April on May and can sometimes produce a substantial tidal surge in the Meghna. This last occurred in 1991 and caused considerable damage to the existing hoisting mechanisms on the existing regulator and resulted in severe flooding in the areas upstream of the regulator. It is therefore recommended that the flood gates be lowered when a severe cyclone is forecast to hit this area so as to prevent flood damage to boro crops and flooding of homestead areas as occurred in 1991.

b) Irrigation Facilities

It is envisaged that the BWDB operating staff would spend much of their time, particularly during the dry season surveying and monitoring the status of the Khal system to ensure that its condition is satisfactory for irrigation purposes. Also it is at this time that effective monitoring and control of irrigation abstractions is required so as to ensure that all units are receiving water according to their established rights.

6.7.2 Maintenance

The requirements for maintenance of the project are again relatively simple to describe but implementation could be a problem unless proper preparations and organisations are put in place and these are described later in this chapter. The sub-sections below describe the maintenance activities required.

a) **The Rahamatkhali Regulators**

The gates will require regular painting and the gate seals will need adjustment and occasional repair or replacement. Also the hinge mechanisms will require regular greasing. Periodic monitoring and adjustments to the counterweights will be required to ensure their continued effective operation. This is most sensibly done during the seasons when each set of gates is not required for operation.

Regular monitoring of the upstream and downstream protection works and channels should be done and any remedial works required carried out as soon as operating conditions permit. The best period would be during April and May when neither drainage nor irrigation operations are necessary and flows through the structure should be at a minimum.

b) **Khal System**

The primary consideration here is likely to be the possibility of siltation or in places erosion. In both cases the prerequisite of good maintenance will be regular inspection and survey of the system to identify problems before they become severe.

The design at this stage has provided for the improvement of the Khai to reduce or eliminate erosion but the effectiveness of this will require frequent inspection and prompt remedial measures where problems occur whether at locations where protection is provided and is under attack or at locations where it was not anticipated.

Siltation of Khals could occur in two ways as follows:-

- collapse of embankment owing to instability, overloading of the embankment or pore pressures in the slopes.

- material washed into the Khals during the monsoon season.

The sediment studies carried out earlier by the Land Reclamation Project show low concentrations of sediment and the bed materials of the main khals show little evidence of sedimentation. However the tributary khals generally have bed levels substantially above those of the main khals and above the levels generally adopted by BWDB when deepening is presently carried out (+ O.91 m PWD). It is not entirely clear to what bed level the WAPDA khal was originally excavated since the drawings could not be obtained. However it appears that little maintenance work has been undertaken on the main khals and yet they are still substantial channels suggesting little siltation has occurred (indeed erosion is the main problem).

The provisions for earthworks maintenance contained in the FPCO guidelines require 6% of the capital cost to be provided for maintenance on an annual basis. This is equivalent to a volume of over 600,000 m^3/annum for the proposed project and this in turn is equivalent to an annual deposition of over 0.15 m of silt over the entire surface area of the khal system. siltation on this scale is most unlikely although the cost provisions (see

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section 14) do allow for this. The consultants would expect situation to occur at not more than a third of this rate bearing in mind that no Meghna water is involved and that all sediments from the Tripura hills are deposited in the (Little Feni catchment. It is suggested that the operation and maintenance staff of the project collect data annually to monitor performance of the system and adjust the O & M budget accordingly in agreement with the system beneficiaries.

6.7.3 O & M Costs

The costs have been prepared in accordance with the FPCO guidelines. As stated above in the case of earthworks these provisions may be excessive but the economic viability of the project is not affected by this factor and therefore for costing purposes the guidelines have been followed. In terms of financial viability and costs justification and recovery the monitoring and adjustment of maintenance budgets is recommended.

The costs are estimated to include:

- technical and administration staff
- labour and materials for minor works
- contracted maintenance works
- vehicles, survey and other equipment
- periodic painting and maintenance of gates, hoist mechanisms, hinges etc.
- monitoring of soil structure and chemistry in the principal I&D improvement areas
- supervision, monitoring and control of irrigation pump operators.
- Cooperation with water user associations to identify and remedy operational problems.

The operation and maintenance costs of the proposed works as described above are set out in Table 6.7

6.7.4 People's Participation in O & M.

The sustainability of projects like the Noakhali North Drainage and Irrigation Project is likely to substantially depend on the continued interest and support of the beneficiaries who are primarily the farming community. Additionally all the project works will directly benefit all those living and working near or adjacent to the enlarged khals both through irrigation and improved drainage.

It is important that these people understand and accept that the maintenance of the system is in their own interests and that as the principal beneficiaries they should contribute to maintenance.

Possible funding arrangements are discussed in section 6.7.5. But the method of involving the people in maintenance needs to be developed taking funding into account as they are inter-related.

SRP has pioneered new ways of involving people in maintenance activities and these initiatives should be incorporated in the proposed project.

TABLE 6.7

Annual Operation and Maintenance Costs

Sl No.	Description	Construction Cost (Tk. million)	Annual O&M %	O&M Cost (Tk. million)
1.	Modified Existing Regulator	20.50	3	0.615
2.	New 10 Vent Regulator	69.20	3	2.076
3.	New 4 Vent Regulator	5.92	3	0.178
4.	Modifications to Bridges	19.73	3	0.592
5.	Dredged Channels	373.02	6	22.381
6.	Manual Excavations	147.98	6	8.879
7.	Khal Bank Protection	33.30	10	3.330
8.	Buildings	0.60	6	0.036
9.	Equipment	0.85	4	0.034
10.	Vehicles (* 4% + 70,000x7)	2.10	*	0.574
	Total	-	-	38.695

Also the Muhuri irrigation project has also developed a system whereby there is dialogue with water users associations which implicity acknowledges an interdependence between the managers (BWDB) and the users.

a) Beneficiary Organisations and their Formation

As already identified by other projects the most obvious beneficiary groups are those concerned with irrigation facilities. There will be approximately 30000 ha of irrigation benefitting from the proposed project and it is recommended that the NGO which has developed relationships with the people along all the khals at the design stage incorporates in its messages that the project is a package requiring not only land at construction stage but also support at the O & M stage in return for which the project will provide irrigation benefits.

The message to farmers should be that the formation of WUAs would not only bring responsibilities in terms of costs but would also bring rights as follows:-

i) The right to an assured irrigation supply.

ii) Power to negotiate reasonable water rates with the pump operator

iii) The right to consultation and information concerning the O & M needs and costs.

The encouragement and formation of WUAs based on LLP command areas should be a primary function of the NGO activities. Also the formation of confederations of WUAs into larger units, could be promoted for representation on the PCC.

Once again at the O&M stage the PCC would be the coordinator bringing together the scheme managers, the users and the benefitting communities to arbitrate and resolve disputes and recommend improvements as necessary.

b) Participation and O & M Works.

Much of the maintenance work will involve the need for hand labour for desilting the secondary khals. It is recommended that this be undertaken by LCS groups comprising both male and female groups. This suggests that these works should in fact not be carried out by direct beneficiaries but by the less fortunate in society thus spreading the benefits. Rather the principal beneficiaries would be providing the means for this further dispersion of benefits to the disadvantaged.

It is recommended that Canal Maintenance Groups (CMG) are formed in a similar manner to those currently undertaking embankment maintenance under SRP. The groups must be recognised and registered by an organisation (eg BRDB or an NGO) which will both stand as guarantor and assist with processing of payments. These groups will require training and supervision. Since they will come from the same communities as those of the beneficiaries who are indirectly financing them there will be incentives for the work to be executed properly.

6.7.5 Funding of O & M

The issue of O & M cost recovery is always difficult but in this case as already stated the most obviously benefitting part of the community are those people who will benefit from irrigation. It is proposed therefore, that a substantial proportion of the O & M costs could be recovered from the WUAs through an irrigation fee arrangement. This could either be collected directly by BWDB from the WUA or through an operating licence fee for an LLP. If the latter were the case then the BWDB management could both monitor and control the operators through the licensing system and could also ensure through contact with the WUA that the operators are not overcharging. This is an example of how the rights and responsibilities of WUA's can be balanced through the negotiation of these levels of charges.

At the present time it appears that LLP operators are charging farmers a premium for water scarcity since charges are much higher in Noakhali than in Gumti according to the surveys undertaken in these areas. It is suggested that the existing levels of charges could still give operators a good return and could provide sufficient funds for O & M. If 30,000 ha of irrigation pay Tk1,000/ha/yr as an irrigation fee this would represent Tk 30 million for O & M and this would still leave the pump operator with Tk 5,700/ha/yr for operating the pump which is more than the total charge currently quoted in the Gumti area.

Another consideration is that the expected net benefit from a hectare of boro is about Tk 10,000/ha in financial prices after including family labour and Tk6,710 irrigation charges in the costs. Clearly this level of charges could not be considered excessive.

The above suggestions should not be regarded as firm recommendations since it is important that this project should not be radically different from others and therefore the recommendations and national policy which finally emerge from the initiatives and pilot projects of SRP and FAP 13.1 and 13.2 could be applied in an appropriate manner to the Noakhali North Project. However the above discussion serves to demonstrate that O & M cost recovery could be largely or completely achieved through irrigation charges.

The O & M costs may well be substantially lower than those quoted in Table 6.7 for reasons already explained and it is important that whatever system is implemented that it should be transparent and that most of the funds are retained at the local level, managed and accounted for by the local managers to the WUAs and their representatives. Accountability is an important requirement for the success of any charging system.

If national policy requires that part of the O & M costs are recovered from drainage beneficiaries on a wider scale then again the results of the SRP initiatives should be awaited. Options for such charges could include:

- tax on farm inputs.
- land drainage rates
- fuel tax
- local VAT

The most rational basis would be a land drainage rate but this is extremely difficult to arrange and administer since every land holder will benefit differently, some substantially and some not at all (eg those already having FO land and those remaining on F2 land), this aspect must be arranged through national policy.

Once all O & M costs can be recovered through such charges as those considered above consideration could be given to recovery of capital costs. This is also a question for national policy and SRP/NMIDP/FAP 13 will need to address such issues since all tertiary irrigation is now in the private sector.

6.7.6 O & M Management

BWDB are expected to be responsible for O & M of the completed scheme using a similar organisational structure as presently existing. The Executive engineer, O & M will remain the executive officer of the project and he and his staff would report regularly to the DCC on all matters relating to the scheme. The DCC will ensure that any disputes between BWDB, the LLP operators and or WUAs are resolved through discussion with WUA representatives. SRP has recommended units of 20 LLPs, in this case this would result in up to 75 such units who could ask to have matters discussed by the PCC. Thus for a scheme of this size it may be that sub-committees will need to be formed.

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6.8 Economics

The methodology used to evaluate project interventions is based on FPCO Guidelines for Project Appraisal. The economic analysis is based on 1991 constant prices whereas the financial analysis uses 1992 prices. Economic prices have been calculated by applying FPCO conversion factors to 1991 financial prices, which were either estimated from secondary data, market prices for example, or taken from previous reports (i.e. labour rates).

6.8.1 Benefits and Disbenefits

Benefits resulting from project interventions are described below but in general include the following:

- increased agricultural production resulting from either improved flooding regimes or from the provision of flood protection to crops

- avoidance of flood damage by the provision of protection to housing, livestock, fish ponds, and Government property.

Dis-benefits (or costs) to capture fisheries arise as a result of changed flooding regimes, where there is a direct conflict of interest between agriculture (which benefits from reduced flooding depths) and fisheries which suffer.

6.8.2 Results of the Economic Analysis

The economic analysis of the Noakhali North Project has been based on the assumptions presented in the previous chapters. The analysis assumes a project life of 30 years, with no residual values, and employs a discount rate of 12%. The principle economic indicator is the Internal Rate of Return (IRR).

The analysis is based on the cropping patterns presented in Table 6.10. Construction of the project should be completed in year 5 and the first incremental benefits obtained in year 6. Full benefits are assumed to be reached in year 10.

Fishery losses are included from year 6 onwards, as are crop protection and non-crop protection benefits. Flood protection benefits are only applicable to Zones B and C, or 40% of the project NCA.

The main analysis is carried out for the option in which land is purchased for disposal of spoil excavated from the khals, along the banks of the khals. An alternative is also presented which includes the cost of renting land next to the khal for one season and spreading the spoil over the (estimated) 3633 hectares required. Costs for removing the topsoil first and replacing it afterwards over 1800 hectares as well as an allowance of 150 kg of fertiliser per hectare are included. Yet another alternative, which is to transport the spoil and tip it in the River Meghna or otherwise dispose of it, has not been evaluated directly but can be assessed through the sensitivity analysis.

Tables 6.8 to 6.11 present a summary the results of the analysis and include the following:

- project cash flows
- summary of benefits in financial prices
- summary of cropping pattern changes
- summary of results and sensitivity analysis (for bath options)

The analysis of the main option (land acquisition for spoil disposal through the construction of embankments) produces an IRR of 18.4%. (See table 6.12)

Inspection of Table 6.8 shows that the major portion of benefit is incremental crop income. The percentage contributions to crop income of major crops are given below (after deducting irrigation costs)

	Present / Fwo	Future with
boro	45%	51%
LT aman	16%	16%
HYV aman	6%	10%
B aman	8%	5%

Flood damage benefits account for less than 10% of all benefits, whereas fishery losses are the equivalent of just over 3%, even though an annual loss of over 3600 tonnes is anticipated.

Inspection of Table 6.11 Summary of Results and Sensitivity Analyses gives the results of various tests of the project's sensitivity. These indicate that:

- the project is insensitive to increases in capital costs, O + M costs, fishery losses and reduced flood losses.
- the project is reasonably sensitive to reductions in crop benefits, delays in construction and delays in achieving full benefits

A number of additional sensitivity tests have been undertaken.

1) Fish losses increased by 50% (to 165 kg/ha of lost flood plain) : IRR = 17.0%.
2) In addition to the above, no infrastructural damage benefits are included : IRR = 16.1%.
3) In addition to 1) and 2) above, no crop damage protection benefits are included : IRR = 15.3%.

These tests show that the relative importance of the above items within the analysis is not great.

If no increase in HYV aman is included in the "future with" cropping patterns and that all increases in T. aman are the local variety, the IRR falls to 16.3%.

If on the other hand, the full area of HYV aman is planted in both the "future without" and "future with" project situations, the IRR increases to 22.3% which can be regarded as the highest possible rate of return.

If the incremental area of boro is halved the IRR falls to 11.4%, clearly demonstrating where the project could be vulnerable.

TABLE 6.8

Project Cash Flows (1991 Economic Prices)

Year	Net Crop Income FWO	Net Crop Income FWO	Benefits Incremental Crop Income	Flood Damage		Total Benefits	Costs Capture Fisheries Losses	Capital Costs	O&M Costs	Total Costs	Net Incremental Benefits
				non-agr.	crop						
1	1518	1518	0	0.0	0.0	0.0	0.0	29.4	0.0	29.4	-29.4
2	1518	1518	0	0.0	0.0	0.0	0.0	185.0	0.0	185.0	-185.0
3	1518	1518	0	0.0	0.0	0.0	0.0	290.3	0.0	290.3	-290.3
4	1518	1518	0	0.0	0.0	0.0	0.0	215.2	0.0	215.2	-215.2
5	1518	1518	0	0.0	0.0	0.0	0.0	110.0	0.0	110.0	-110.0
6	1518	1589	70	13.3	12.4	96.0	47.5	0.0	26.0	73.5	22.5
7	1518	1660	141	13.7	12.4	167.5	47.5	0.0	26.0	73.5	94.0
8	1518	1731	213	14.1	12.4	239.7	47.5	0.0	26.0	73.5	166.2
9	1518	1804	286	14.5	12.4	312.5	47.5	0.0	26.0	73.5	239.0
10	1518	1870	351	14.9	12.4	378.9	47.5	0.0	26.0	73.5	305.3
11	1518	1870	351	15.4	12.4	379.3	47.5		26.0	73.5	305.8
12	1518	1870	351	15.8	12.4	379.8	47.5		26.0	73.5	306.2
13	1518	1870	351	16.3	12.4	380.2	47.5		26.0	73.5	306.7
14	1518	1870	351	16.8	12.4	380.7	47.5		26.0	73.5	307.2
15	1518	1870	351	17.3	12.4	381.2	47.5		26.0	73.5	307.7
16	1518	1870	351	17.8	12.4	381.8	47.5		26.0	73.5	308.2
17	1518	1870	351	18.4	12.4	382.3	47.5		26.0	73.5	308.8
18	1518	1870	351	18.9	12.4	382.8	47.5		26.0	73.5	309.3
19	1518	1870	351	19.5	12.4	383.4	47.5		26.0	73.5	309.9
20	1518	1870	351	20.1	12.5	384.0	47.5		26.0	73.5	310.5
21	1518	1870	351	20.7	12.4	384.6	47.5		26.0	73.5	311.1
22	1518	1870	351	21.3	12.4	385.2	47.5		26.0	73.5	311.7
23	1518	1870	351	21.9	12.4	385.9	47.5		26.0	73.5	313.3
24	1518	1870	351	22.6	12.4	386.5	47.5		26.0	73.5	313.0
25	1518	1870	351	23.3	12.4	387.2	47.5		26.0	73.5	313.7
26	1518	1870	351	24.0	12.4	387.9	47.5		26.0	73.5	314.4
27	1518	1870	351	24.7	12.4	388.6	47.5		26.0	73.5	315.1
28	1518	1870	351	25.4	12.4	389.3	47.5		26.0	73.5	315.8
29	1518	1870	351	26.2	12.4	390.1	47.5		26.0	73.5	316.6
30	1518	1870	351	27.0	12.4	390.9	47.5		26.0	73.5	317.4
Present Value (a) 12%		1377	1247	73.4	55.3	1375.9	211.5	579.5	115.7	906.8 EIRR (%)	469.1 18.38

TABLE 6.9

Summary of Benefits

ZONES A & B	Unit	Project Year 1	Future Without (1)	Future Without (2)	Future With (1)	Future with (2)	% increment (1)	% increment (2)
Net Cultivated Area	'000 hectares	108.6	108.6	108.6	108.6	108.6	0	0
Irrigated Area	'000 hectares	50.0	50.0	50.0	68.4	68.4	37	37
Labour Requirement (ag & fish)	million man days	30.5	30.3	30.3	33.7	33.7	11	11
Paddy Production	'000 tonnes	491	491	491	603	603	23	23
Cropping Intensity (excl. orchard) %	NCA	166%	166%	166%	184%	184%	10	10
Irrigated area	% NCA	46%	46%	46%	63%	65%	37	37
Net Crop Income	million Taka	1.307	1307	1.307	1.604	1.604	23	23
Crop fishery income	million Taka	91	84	84	33	33		
Crop Flood loss reduction	million Taka				14	14		
Non-agric. flood loss reduction	million Taka				18	32		

Notes:
Project Year 1 : assumed 1994/95
Future Without (1) : Future Without Project Conditions, 5 years after project would have been completed
Future Without(2) : Future Without Project Conditions, year 30
Future With(1) : Future With Project Conditions, 5 years after project completion
Future With(2) : Future With Project Conditions, Year 30
% Increment(1) : % difference FW(1) over FWO(1)
% Increment(2) : % difference FW(2) over FWO(2)

Flood losses refer to average annual losses that will be eliminated by the project.
Values in 1992 financial prices

TABLE 6.10

Summary of Cropping Pattern Changes

					(% of NCA)
	Year 1	Future without(1)	Future Without(2)	Future Without(1)	Future With(2)
B Aus, local	10.8%	10.8%	10.8%	8.0%	8.0%
B Aus, HYV	4.6%	4.6%	4.6%	4.6%	4.6%
T Aus, local	3.6%	3.6%	3.6%	3.2%	3.2%
T Aus, HYV irri	0.3%	0.3%	0.3%	0.4%	0.4%
T Aus, HYV n-r	8.4%	8.4%	8.4%	8.2%	8.2%
Mixed aus/aman	7.6%	7.6%	7.6%	5.6%	5.6%
B Aman local dw	26.3%	26.3%	26.3%	19.6%	19.6%
T Aman local dw	4.5%	4.5%	4.5%	4.0%	4.0%
T Aman, local	32.2%	32.2%	32.2%	39.6%	39.6%
T Aman HYV irri	0.0%	0.0%	0.0%	0.0%	0.0%
T Aman HYV n-ir	5.7%	5.7%	5.7%	12.7%	12.7%
Boro, local	0.0%	0.0%	0.0%	0.0%	0.0%
Boro, HYV irrig	46.0%	46.0%	46.0%	63.0%	63.0%
Boro HYV n-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	0.0%	0.0%	0.0%	0.0%	0.0
Wheat unirrig	0.1%	0.1%	0.1%	0.1%	0.1%
Potato irrig.	0.1%	0.1%	0.1%	0.1%	0.1%
Potato unirrig	0.2%	0.2%	0.2%	0.2%	0.2%
Jute	0.7%	0.7%	0.7%	0.0%	0.0%
Pulses : ave.	8.9%	8.9%	8.9%	8.5%	8.5%
Mustard	2.1%	2.1%	2.1%	1.7%	1.7%
Spices (chilli)	3.2%	3.2%	3.2%	3.2%	3.2%
Veg. (brinjal)	0.8%	0.8%	0.8%	0.8%	0.8%
Total	166.3%	166.3%	166.3%	183.5%	183.5%

TABLE 6.11

Summary of Results and Sensitivity Analysis

	ZONES A & B		
Capital Cost	829.9 Tk.m.	construction	4 years
Annual O&M Cost	26.0 Tk.m.		
Net Present Value @12%	469.1 Tk. m.	(economic prices)	
Economic Internal Rate of Return	18.4%		

Sensitivity Analyses

Variable	Base Case	Economic IRR(%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	18.4	17.3	15.8	13.9	19.7	22.0	27.7	80.94
O&M Costs	18.4	18.2	18.0	17.6	15.5	18.7	19.1	405.38
Fisheries Losses	18.4	18.1	17.7	17.0	18.6	19.0	19.7	221.73
Reduced flood losses	18.4	18.5	18.8	19.2	18.2	18.0	17.6	164.47
Total Benefits	18.4	19.9	22.1	25.2	16.7	13.9	8.0	34.09
Incremental Net Crop Income	18.4	19.8	21.7	24.6	16.9	14.4	9.2	37.61
Delay in full benefits								
2 years	16.2							
4 years	14.8							
Delays in Completion								
2 years	15.8							
4 years	14.1							

TABLE 6.12

Summary of Results and Sensitivity Analysis
Land Renting Option for Spoil Disposal

Capital Cost	851.0 Tk.m.	Construction period	5 years
Annual O&M Cost	26.0 Tk.m.	(economic prices)	
Net Present Value @12%	460.0 Taka million (economic prices)		
Economic Internal Rate of Return 18.1%			

Sensitivity Analyses

	Base	Change in Variable						Switching
Variable	Case	+10%	+25%	+50%	-10%	-25%	-50%	Value
Capital Costs	18.1	17.0	15.6	13.7	19.4	21.7	27.4	77.41
O&M Costs	18.1	18.0	17.8	17.4	18.3	18.5	18.9	397.57
Fisheries Losses	18.1	17.9	17.5	16.8	18.4	18.8	19.4	217.46
Reduced flood losses	18.1	18.3	18.5	18.9	18.0	17.8	17.4	157.44
Total Benefits	18.1	19.7	21.8	24.9	16.5	13.7	7.8	33.30
Incremental Net Crop Income	18.1	19.5	21.4	24.3	16.7	14.2	9.1	36.72
Delay in full benefits								
2 years	16.1							
4 years	14.6							
Delays in completion								
2 years	15.6							
4 years	14.0							

CHAPTER 7

DEVELOPMENT OPTIONS - MID SUB-REGION

7.1 Introduction

This sub-region comprises planning units 3 to 9 inclusive. However planning units 3 and 4 have already been described in some detail in chapter 6 and in the Noakhali North Drainage and Irrigation Project feasibility study reports and therefore planning unit 3 is not discussed in this chapter.

The chapter is divided into several sections as follows:

- 7.2 Sonaichari (Planning Unit 9)
- 7.3 Dakatia - Little Feni Transfer (Planning Units 4 end 5)
- 7.4 Chandpur Irrigation Project (Planning Unit 6)
- 7.5 Dhonagoda (Planning Unit 8)
- 7.6 Meghna Dhonagoda Irrigation Project (Planning Unit 7)

At the review of the draft Regional Plan Report it was agreed that the consultants would completely review their proposals for the Dakatia - Little Feni Transfer scheme and would consider the overall drainage problems of the sub-region comprising planning units 4, 5 and 9. It is for this reason that the chapter now starts with examination of the problems of the Sonaichari Planning Unit which is in the headwaters of the Dakatia - Little Feni drainage system.

7.2 Sonaichari-Planning Unit 9

7.2.1 General Description

The planning unit comprises a gross area of 19165 ha. The unit is bounded by the Indian border to the east, where the ground levels are comparatively high, by the Gumti river to the north, by the Lalmai hills to the west and by the Pagli and New Dakatia rivers to the south.

The area is protected from flooding from the Gumti river by it's southern (left bank) embankment. Development in the planning unit is dominated by Comilla town which is the district headquarters and the Sonaichari Irrigation Project which lies in the centre of the planning unit immediately south of Comilla town and west of the main Chittagong - Comilla road.

The Sonaichari Irrigation Project is run by the Comilla based Kotwali Thana Central Co-operative Association Ltd. (KTCCA). The scheme has a net cultivable area of 4321 ha. The gross area is 5603 ha, comprising 980 ha in the eastern block, and 4623 ha in the western block.

The scheme was first constructed in the early 1960s when the diversion from the Gumti river was built to supply surface water to Sonaichari Khal which was then low lift pumped to the fields. Later in the mid 1980s regulators were built on the Sonaichari khal and the New Dakatia river to permit gravity supply to large parts of the scheme. These regulators also required the construction of embankments to prevent flooding of the area by flash floods.

The scheme now suffers from drainage problems which affect crop production in both the pre-monsoon and main monsoon periods. The drainage problems are thought to relate in part to siltation of the river system, caused by heavy sediment loads in the rivers draining through the area from the Tripura Hills, and also to the low lying nature of the area and to general drainage congestion. A report on the drainage of the area was prepared by Northwest Hydraulic Consultants in 1989. In 1984, apparently as much as 60% of the boro crop was lost in pre-monsoon flooding, while in 1987 and 1988, slow drainage resulted in delayed planting of the post monsoon aman crop. In May 1993 exceptionally heavy rainfall again caused widespread damage to the boro crop.

A map showing the planning unit and the principal features of the Sonaichari Irrigation Project is shown in Figure 7.2.1. Irrigation water supply is obtained from both surface and groundwater sources. The surface water supply is from a 4.25 m^3/s (150 cusecs) gravity intake on the Gumti River close to the Indian border. This intake was completed in 1964. The canal runs due south from the Gumti, and discharges into the Sonaichari River upstream of the Chauara headworks. There are two further regulators on the Sonaichari khal at Bhubanpur, and on the New Dakatia River at Tungirpar. These regulators feed canals on both banks. The regulators are used on a rotational basis to back up water which is then gravitated as far as possible through the irrigation area.

In addition to the surface water irrigation, it is estimated that 2500 ha are irrigated from groundwater. Groundwater was developed during the 1960's and 1970's. It would appear therefore that there is no shortage of water in the project area. The extent of the irrigated area is shown in Figure 7.2.1. Groundwater potential in the area is such that more land could be irrigated from groundwater, although this could involve changing pumping technologies. Cropping intensity in the area is estimated to be 181% although KTCCA have recently claimed up to 250% for parts of the scheme.

Almost the entire area is affected by drainage problems, and the eastern block can be affected by flash flooding from rivers draining from the Tripura Hills. The area to the west of the scheme and east of the Lalmai hills also suffers from drainage congestion.

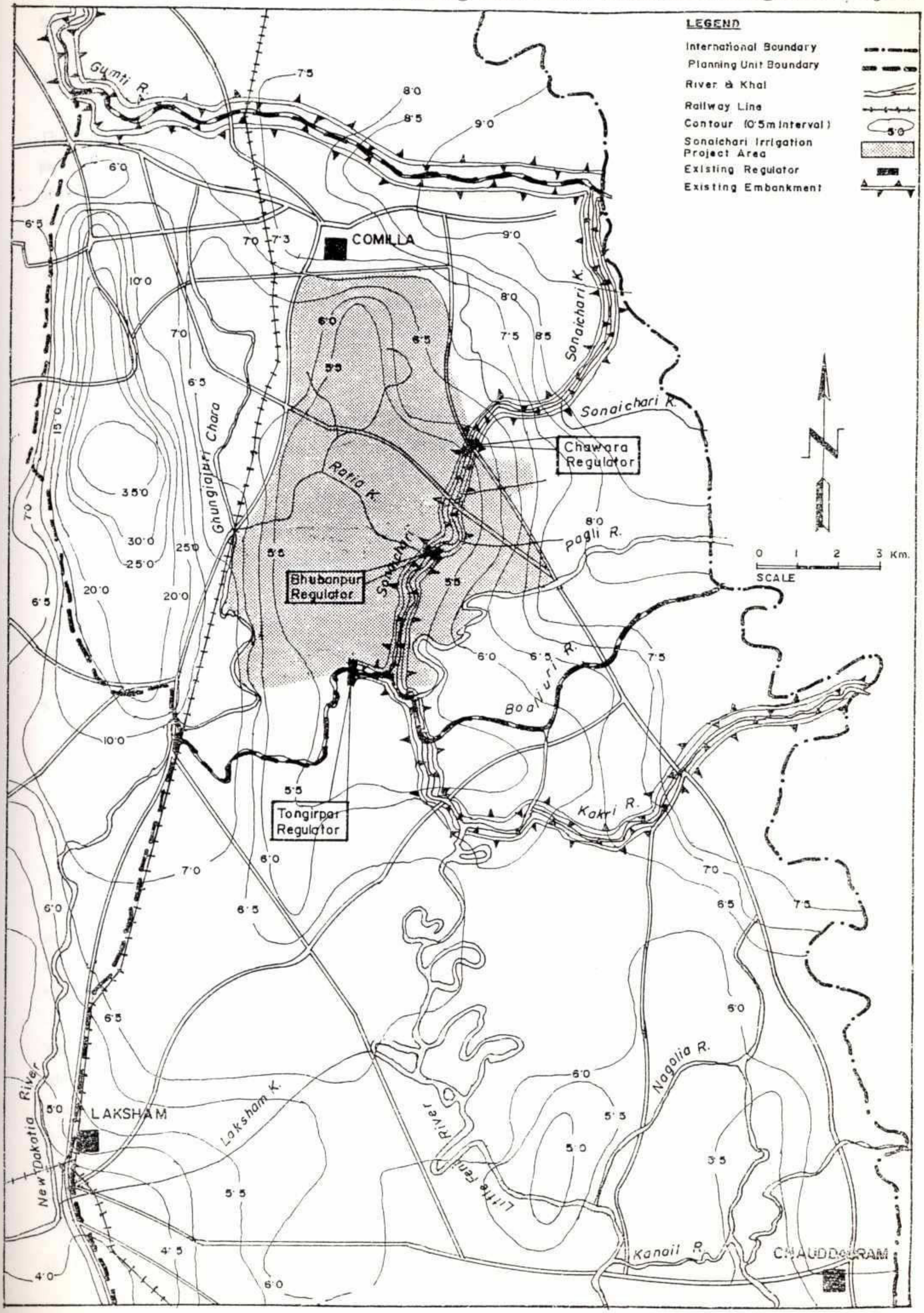
7.2.2 The River Systems

The primary river systems draining through the project area are the New Dakatia River and the Old Dakatia River/Little Feni river. The New Dakatia River is presently the main drainage route, collecting flood runoff from the Sonaichari, Pagli and Kakri rivers although the Kakri river flows in fact drain to both main channels. These rivers drain from the Tripura Hills and have most of their catchment areas in India. (See section 7.2.4.c) There are three smaller khals - the Lakhipur Khal, the Kamlapur Khal, and the Boaljuri Khal, which drain smaller areas through the eastern block to the Sonaichari and Old Dakatia rivers and then discharge to the New Dakatia.

The New Dakatia River also receives drainage from the Lalmai Hills through the Gungiajuri, and from the Kulai Khal which drains part of Comilla. As a result of flood discharges from the Lalmai Hills, flow reversals can

Figure 7.2.1

Planning Unit 9 and Sonaichari Irrigation Project



occur through the Rotia Khal which connects the Gungiajuri khal and the Sonaichari khal through part of Sonaichari scheme west cell.

a) **Structures and Embankments**

There are three significant water control structures on the river system. These are the Chauara, the Bhubanpur and Tungirpar regulators. Their locations are shown in Figure 7.2.1. These structures were completed as part of the Sonaichari Irrigation project since 1984. They provide a means of gravity irrigation through much of the area, and reduce lifts to those areas that cannot be fed by gravity.

At Chauara the offtakes are now completely disused, and much of the irrigation seems to be by DTW. There are a number of small uncontrolled offtakes upstream of the regulator (pipes through embankments), but head created from Bhubanpur seems to be adequate to permit these to operate. The Chauara regulator is apparently now redundant.

The Bhubanpur regulator has vertical lift gates, and a maximum open area of only 19.5 m^2. This is only 60% of the maximum open area at Chauara upstream with gates fully open and water levels within the flood banks. The river is embanked throughout this reach, and apparently these have never overtopped. Embankments were rehabilitated under FFW in 1989, although in some areas there have apparently been inadequate drainage provisions through embankments. Embankments have been cut in some places to provide irrigation, and at times apparently to improve drainage also.

At the Bhubanpur regulator head losses of up to 900 mm have been observed by local farmers during the monsoon when water levels are generally high. In the reach upstream of the regulator there are no gated offtakes other than the diversion to the Rotia Khal. This is a new structure, and has a maximum open area of 5.8 m^2. It restricts what can be discharged to the Rotia Khal.

Irrigation tends to be from either cuts in the embankments or uncontrolled pipe offtakes going through the embankments (which are presumably blocked off during the monsoon). With the regulator closed, water is backed up and much of the area commanded by gravity.

A number of village roads, particularly on the left bank of the Sonaichari khal, now compartmentalise the flood plain. Local people say that these have improved their flood situation by keeping out some of the water which used to originate from the Kamlapur Khal. Northwest Hydraulics Consultants also noted the lack of drainage structures through the embankments upstream of Bhubanpur, and recommended that a number of new structures be provided.

The Tungirpar regulator has a maximum open area of 37 m^2 with a flood level of 6.5 m. Unlike Bhubanpur, which has gated culverts, the gates at Tungirpur can be lifted completely free of the water surface. There are structural problems - the support beam carrying the gate lifting gear appears to have moved on the abutments. With the gates fully open, there is said to be a 300 mm head loss, at times, through the structure in the monsoon season. In the vicinity of the regulator many of the irrigation offtakes have no gates. These are quite large structures and farmers are unable to block them off in the wet season. These therefore allow floodwater into the irrigation area. They are reportedly adequate for drainage purposes when river levels eventually fall.

From the foregoing, it would appear that the Bhubanpur regulator may be causing a significant head loss in the system. Head losses at the Tungirpar regulator may also be significant. The indication is that these structures between them may be resulting in a head loss of upto 1.2 m. This must be verified, but from considerations of their relative open areas, it is not entirely surprising.

Sedimentation in the system is thought by farmers to be a relatively recent problem, having got worse since the construction of the regulators.

b) River Profiles and Cross Sections

The river system through the Sonaichari area is represented in the South East Regional Model (SERM). The representation is coarse, but the data base does give an indication of the characteristics of the system. Using the cross sectional data base of the model, three longitudinal profiles have been prepared. The river reaches to which these relate are indicated in Figure 7.2.2, and the profiles are presented in Figure 7.2.3. The river bed gradients are significantly steeper upstream of the confluence at Bagmara (profiles 1 and 2). These are the reaches probably most affected by siltation. From the profiles shown, it appears that there may be scope for reducing gradients in the upper reaches. The sections and longitudinal profiles are based on survey carried out in 1986. This precedes the excavation work done under FFW to rehabilitate the embankments, and they may no longer be representative. General bed slopes through the area are of the order of 0.00025.

The longitudinal profile for the Little Feni and Old Dakatia rivers are particularly interesting. It appears that a bar has formed in the bed of the Little Feni River, which is of course an impediment to southward drainage from the Kakri. It is understood that formerly the principal drainage of the Kakri was to the south, and that in recent years with the formation of the sand bar, more Kakri drainage has been going north to the New Dakatia through the Tungirpar regulator.

c) Sediment Loads

Sedimentation is perceived to be a contributory factor to drainage congestion in the Sonaichari area. The Kakri River in particular carries very high sediment loads. There are, however, very few data on sediment discharge for rivers issuing from the Tripura Hills.

Data were collected for the Gumti River as part of hydrological and morphological studies in 1989 (Ref. 2). These data indicated annual sediment yields from the Gumti catchment of the order of 770 tonnes/km^2/year, of which 10% was sand (77 tons/km^2/year), and 70% was silt.

Discussions with the contractor who has the concession for sand removal on the Kakri River suggest that annual sand extraction is about 54,000 tonnes. This indicates an annual sand yield from the Kakri in excess of 490 tonnes/km^2/year, more than six times that of the Gumti. It is unclear at this time why the Kakri should yield so much more sand than the Gumti. It could be that soil cover is different, or that there has been severe land use change. There are no data on total sediment load, and it is also unclear as to whether there are any particular problems in the Pagli or other neighbouring rivers.

On the Kakri, commercial sand extraction takes place at three locations, one of which is at its confluence with the Little Feni. It is quite certain that the efficiency of sand extraction will not be particularly high in the

Figure 7.2.2

Locations of River Profiles Shown in Figure 7.2.3

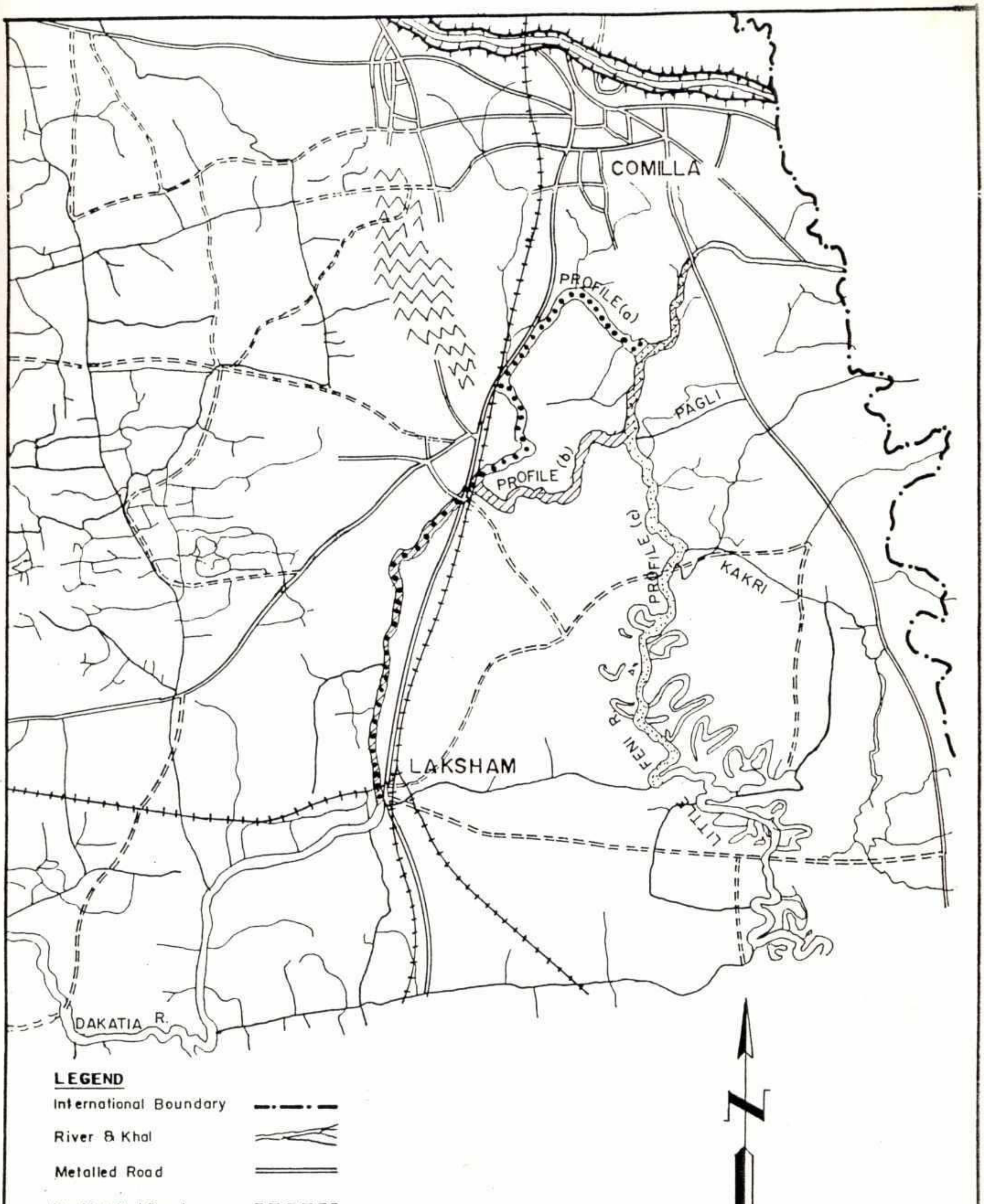
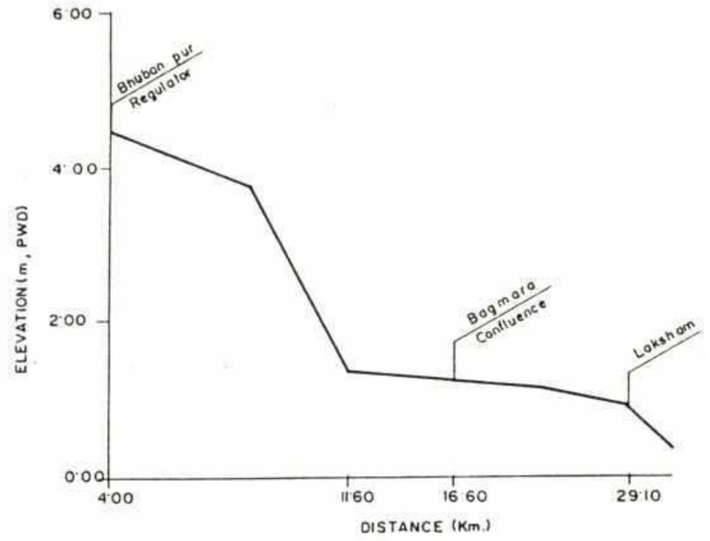
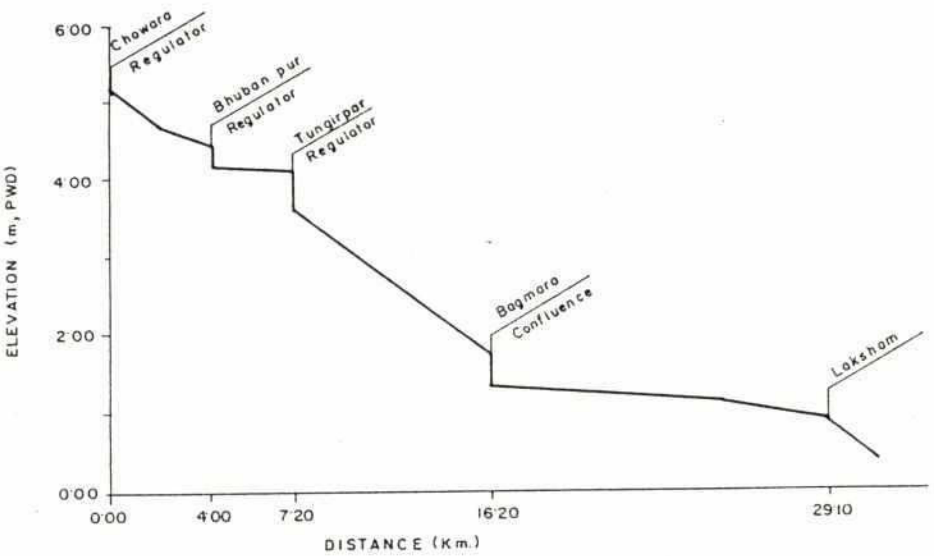


Figure 7.2.3
River Bed Profiles

a) Bed Profile of Rotia Khal/Ghungiajuri/New Dakatia River to Laksham.



b) Bed Profile of Sonaichari Khal/New Dakatia River to Laksham.



c) Bed Profile of Sonaichari/Old Dakatia/Little Feni Down to Gunabati Rly Bridge.

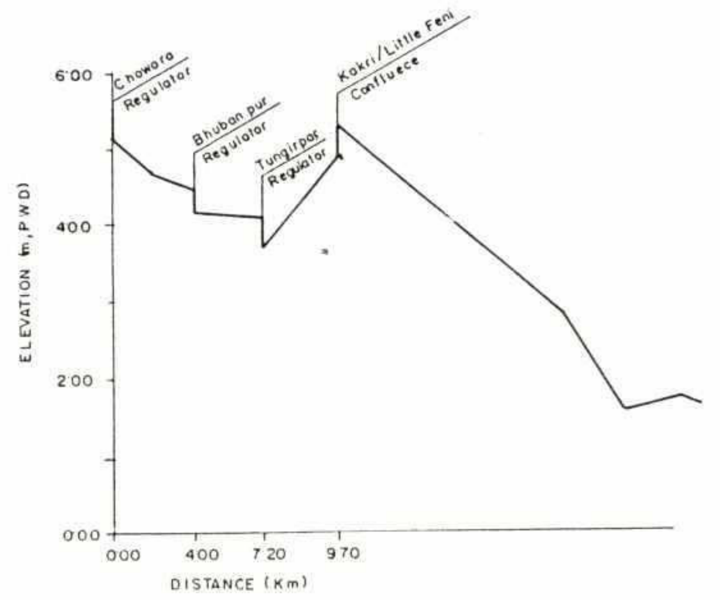
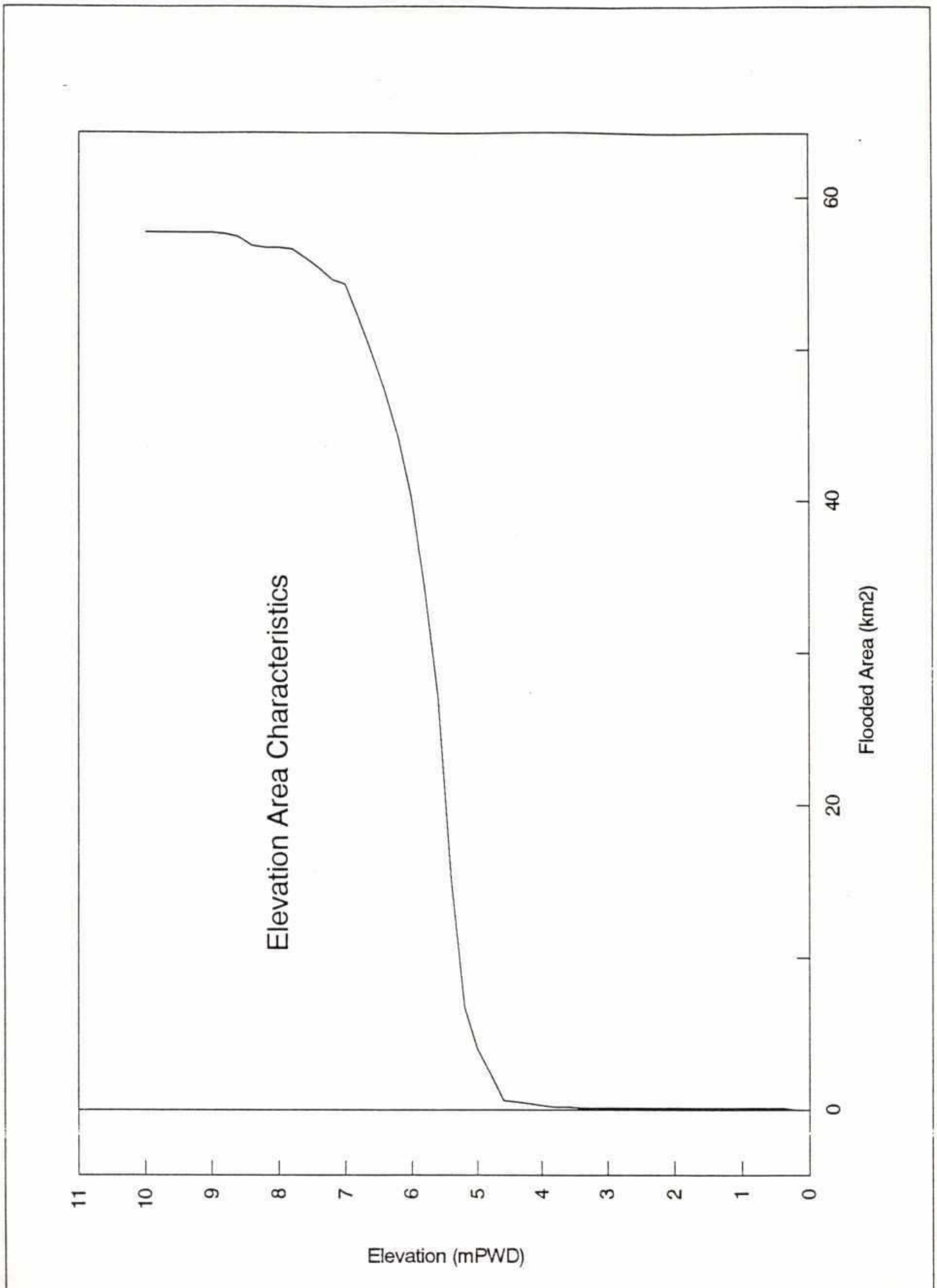


Figure 7.2.4

Elevation Area Characteristics - Sonaichari Planning Unit



monsoon season, and that significant quantities of sand are entering the Little Feni River, and possibly the New Dakatia River. In June 1993 at Bagmara at the confluence of the New Dakatia and the Gungiajuri the colour of the New Dakatia water indicated that it was carrying a much higher sediment load than the Gungiajuri water.

7.2.3 Perceptions of the Drainage Problem

Visits have been made to the Sonaichari project area, and discussions held with local people in order to build up an understanding of the current problems. These seem to be associated mainly with the New Dakatia and Sonaichari rivers.

Upstream of Chauara, there are flood problems on the left bank of the river, which is not embanked. Flood durations are reportedly of the order of two or three days and this is thought to occur mainly in the monsoon season when there are backwater influences from downstream.

In the reach upstream of Bhubanpur Regulator, the problems are of high river levels in the monsoon, against which local drainage cannot be discharged. The Lakhipur Khal and the Kamlapur Khal have small catchments in India, and are also unable to discharge into the Sonaichari / New Dakatia. The Kamlapur Khal has been embanked, and has a regulator, presumably to help with irrigation in the dry season. This is said to lack capacity during the monsoon, however, and the drainage problems are aggravated by it. There is also a lack of provision of drainage structures through the river embankments, and when river levels do begin to fall, drainage from the areas behind the embankments is at too slow a rate.

A large head loss reportedly occurs through the Bhubanpur regulator. There can be no doubt that this significantly aggravates the problems upstream, although surprisingly it was not recognised by the local people as a problem. Confirmatory observation and measurement are required.

In the vicinity of Tungirpar regulator there are similar problems of high river levels against which local drainage cannot be discharged. The flow of river water into the floodplain through ungated irrigation offtakes aggravates the problem, as does the head loss through the regulator. The Kakri is said to contribute significantly to severe flooding, and contributes much more to flow than the Sonaichari. The proportion of flows brought in from the Kakri is thought to have increased in recent years as a result of siltation in the Little Feni River.

The river bed profile in the Gungiajuri and New Dakatia Rivers are much steeper than those of the Dakatia River downstream of their confluence. Also this is reflected in water surface profiles. Were water surface slopes to be reduced, then an improvement in the floodplain drainage might be achieved. However much of the project area is very low lying; the elevation area characteristics for the scheme are shown in Figure 7.2.4. Typically outfall water levels in the Dakatia River at the confluence of the Gungiajuri and New Dakatia Rivers are of the order of 5.5 m, and levels in excess of 5.0 m are exceeded for long periods. As much of the project area lies at levels below 5.5 m, some inundation during the monsoon season is unavoidable without pumped drainage.

It has been noted that the construction of village roads is significantly modifying floodplain flow paths and creating compartments. Often, very little drainage is provided through these, and drainage conditions locally may be quite different from those represented in the SERM.

7.2.4 Flood Hydrology

a) General

Flooding and flood evaluation in the Sonaichari area is no less problematical than for anywhere else in Bangladesh, although being close to the Tripura Hills, flash floods have a more dominant influence in the production of extreme events. The principal rivers affecting the project area are the Sonaichari, the Pagli and the Kakri. Flash floods are common in each of these rivers.

The only relevant long term discharge data for the area are for the Gumti at Comilla. These are mean daily discharge data, however, and there is no information on instantaneous flood peaks or on hydrograph shapes. The SWMC have established flow monitoring stations on the Kakri and Pagli rivers, for which data are available from 1987. The available record period is obviously rather short for any meaningful flood frequency analysis, although they can assist in giving an indication of likely flood responses. In addition to consideration of these data, flood hydrograph synthesis from rainfall has been carried out. The objective has been to put the potential problems of flash flooding into some form of perspective.

b) Rainfall Extremes

The catchments draining the Tripura Hills are all relatively small and will have short times of concentration. One day rainfall extremes are therefore most appropriate with regard to the generation of flood peaks. Rainfall frequency analysis was carried out for a large number of stations as part of the South East Regional Study. The record for Comilla is of most interest to the Sonaichari area. Estimates of annual maximum 1 day rainfalls at Comilla are presented in Table 7.2.1. For agricultural drainage design, it is more common to work in terms of 3 or 5 day rainfalls, and these are included in Table 7.2.1 also.

c) Catchment Characteristics

The catchment characteristics of most interest in flood synthesis are:

- catchment area
- vegetation cover
- soil type and characteristics
- overland flow slope
- main stream length and slope.

Almost no information is available for those parts of the catchments lying in India, particularly with regard to soil characteristics, and gradients. It has therefore been necessary to make some estimate of characteristics from satellite imagery and visual inspection from Bangladesh. The estimated characteristics are presented in Table 7.2.2. The curve number CN, refers to hydrological response, and is discussed in section d) below. Main stream slopes represent nothing other than a conservative guess.

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Table 7.2.1

Annual Maximum Daily Rainfall at Comilla

Return Period (years)	1 Day Rainfall (mm)	3 Day Rainfall (mm)	5 Day Rainfall (mm)
2	125	211	263
5	164	269	326
10	189	306	368
20	213	343	408

TABLE 7.2.2

Catchment Characteristics

Catchment	Area (km^2)	Stream Length (km)	Slope	Curve No.
Sonaichari	64	4	0.005	75
Pagli	56	4	0.005	75
Kakri	111	8	0.005	75

d) Flood Synthesis

The US Soil Conservation Service Method has been adopted for the synthesis of floods in the Tripura Hill catchments. The method provides a means of assessing runoff from small catchments where limited data are available, i.e. no streamflow. The basic rainfall - runoff relationship used in the method is as follows:

$$Q=(P-Ia)^2/\{(P-Ia)+S\}$$

where, Q = runoff
P = precipitation
Ia = initial abstraction
S = potential maximum retention

Commonly Ia is expressed in terms of S, which is variable and related to antecedent soil moisture conditions, land use and treatment and soil class. These characteristics are defined through a curve number CN, which is related to S as follows.

Curve numbers, which cannot exceed 100, have been derived by the Soil Conservation Service for a large number of catchments. Curve numbers for typical land uses are summarised in Table 7.2.3. The hydrological soil groups are:

A high infiltration even when wet

B moderate infiltration when thoroughly wet

C slow infiltration when thoroughly wet

D very slow infiltration when thoroughly wet

For the purposes of the present investigations, it has been assumed that the soils in the Tripura Hill catchments will be in Group B or C, and that the slopes are only partially wooded. A curve number of 75 has been adopted, which may be conservatively high.

The daily rainfall total is distributed according to a storm profile. It is possible to derive a profile from available rainfall intensity data, but for the purposes of the present investigations, a standard profile for a frontal storm has been adopted, in which 42% of the storm total occurs in a single hour. This is likely to be too extreme for very large long return period rainfall events, but is consistent with derived profiles for other tropical regions.

The USSCS method incorporates a synthetic unit hydrograph to translate rainfall excess into a runoff response. Unit hydrographs from successive time increments are convoluted to produce the overall flood hydrograph. A number of approaches are built into the method for lag time computation. These include Kirpich for large catchments, and the overland flow estimates for smaller catchments.

e) **Design Flood Estimates**

Flood hydrographs have been synthesised for each catchment, and are presented in Figure 7.2.5. The flood peaks are summarised in Table 7.2.4. It should be noted that there is considerable uncertainty about catchment parameters. For this reason, sensitivity analysis has been carried out, particularly with regard to main stream slope. Two methods of calculating lag time have been adopted. The first is the SCS lag equation which is primarily meant for overland flow, and for which general catchment slope is used. The second was the Kirpich equation which is intended for large catchments, and uses stream parameters. The general catchment slope was taken to be 0.005 for use with the SCS approach. The stream slope was taken as 0.00025 for use with the Kirpich equation, this being the slope of the Old Dakatia and New Dakatia rivers. There is a fairly wide range in flood peak estimates derived by the different methods, reflecting the level of uncertainty that exists in this type of exercise. Flood volume is not sensitive to assumptions related to the time of concentration. Synthesised Flood volumes are given in Table 7.2.5.

It is likely that in any of the above river systems, a two year flood would go out of bank before reaching Bangladesh. There would therefore be some attenuation of the flood hydrograph. Although the synthesis of flood peaks for these rivers is extremely uncertain, the analysis has demonstrated the flashy nature of the rivers.

A great deal of uncertainty also exists in the lag time computation. Different methods can give considerably different assessments.

Figure 7.2.5

Synthesised Flood Hydrographs

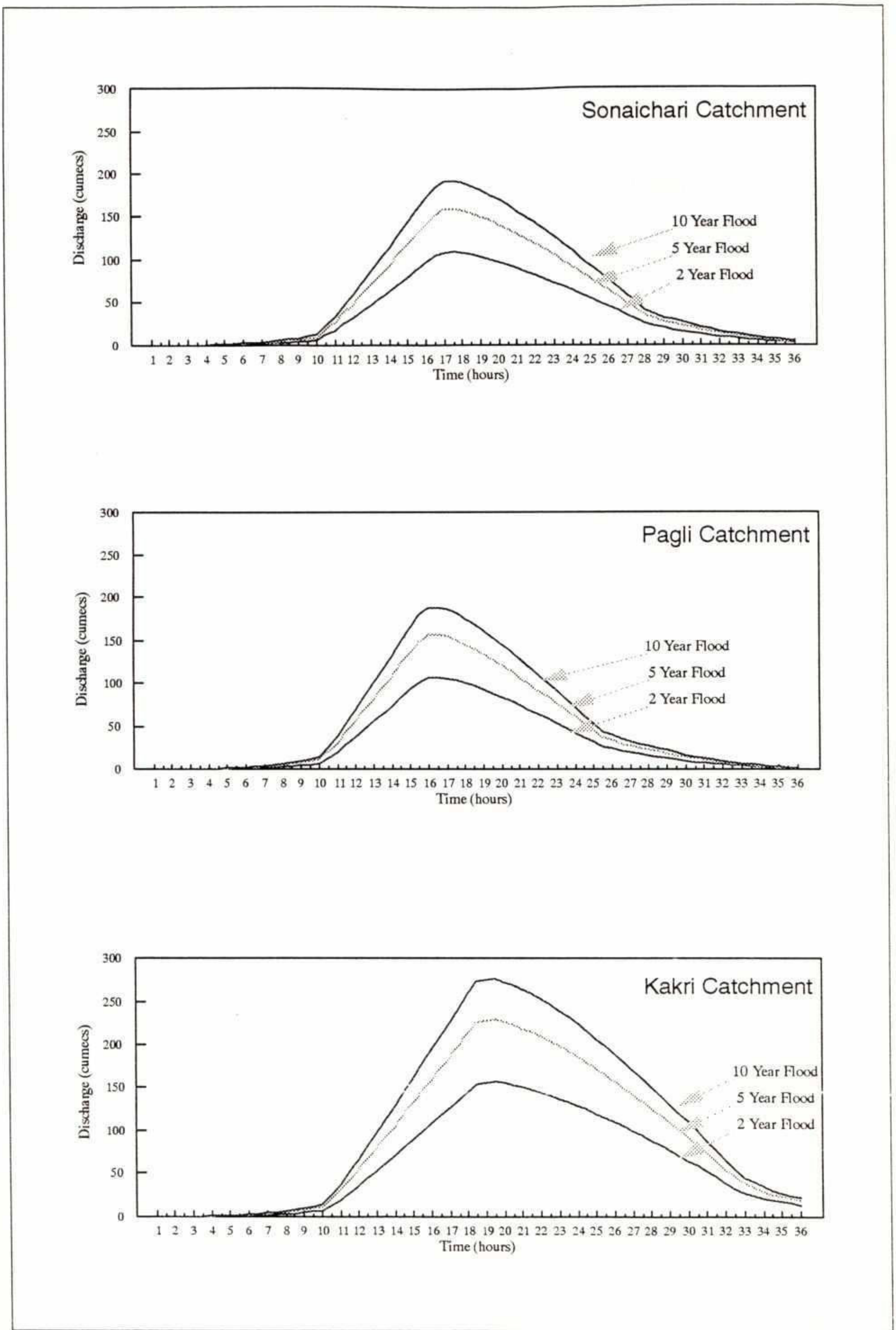

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TABLE 7.2.3

USSCS Runoff Curve Numbers

Runoff curve numbers for hydrologic soil-cover complexes (Antecedent moisture condition II, and Ia = 0.2 S)

Land Use and Treatment or Practice	Hydrologic Condition	Hydrologic Soil Group A	B	C	D
Fallow					
Straight row	-----	77	86	91	94
Row Crops					
Straight row	Poor	72	81	88	91
Straight row	Good	67	78	85	89
Countoured	Poor	70	79	84	88
Countoured	Good	65	75	82	86
Countoured and terraced	Poor	66	74	80	82
Countoured and terraced	Good	62	71	78	81
Small Grain					
Straight row	Poor	65	76	84	88
Straight row	Good	63	75	83	87
Countoured	Poor	63	74	82	85
Countoured	Good	61	73	81	84
Countoured and terraced	Poor	61	72	79	82
Countoured and terraced	Good	59	70	78	81
Close-seeded legumes or rotation meadow					
Straight row	Poor	66	77	85	89
Straight row	Good	58	72	81	85
Countoured	Poor	64	75	83	85
Countoured	Good	55	69	78	83
Countoured and terraced	Poor	63	73	80	83
Countoured and terraced	Good	51	67	76	80
Pasture or range					
No mechanical treatment	Poor	68	79	86	89
No mechanical treatment	Fair	49	69	79	84
No mechanical treatment	Good	39	61	74	80
Countoured	Poor	47	67	81	88
Countoured	Fair	25	59	75	83
Countoured	Good	6	35	70	79
Meadow	Good	30	58	71	78
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	25	55	70	77
Farmsteads	----	59	74	82	86
Roads 1/					
Dirt	----	72	82	87	89
Hard surface	----	74	84	90	92

TABLE 7.2.4

Synthesised Peak Flood Discharges

Catchment	SCS Lag Return Period 2	5	10	Kirpich Lag Return Period 2	5	10
Sonaichari	108	158	192	130	190	230
Pagli	106	156	188	127	185	224
Kakri	156	228	276	191	278	337

TABLE 7.2.5

Synthesised Flood Volumes (Mm^3)

Catchment	Return Period 2	5	10
Sonaichari	4.77	6.92	8.35
Pagli	4.17	6.06	7.31
Kakri	8.27	12.01	14.49

f) Observed Flood Hydrographs

Figure 7.2.6 shows an observed flood hydrograph for the Kakri river for a storm in May 1990. The peak discharge is shown as 230 m^3/s which approximates to a 1 in 5 year event according to Table 7.4 above (SCS lag). This confirms the analysis in section e) above and the need for additional data.

7.2.5 Hydraulic Evaluation

a) General

The Sonaichari area is headed in the South East Regional Model. The resolution is, however, extremely coarse. and not all structures are included. The Mike11 network is shown in Figure 7.2.7. Reach lengths are of the order of 5 km.

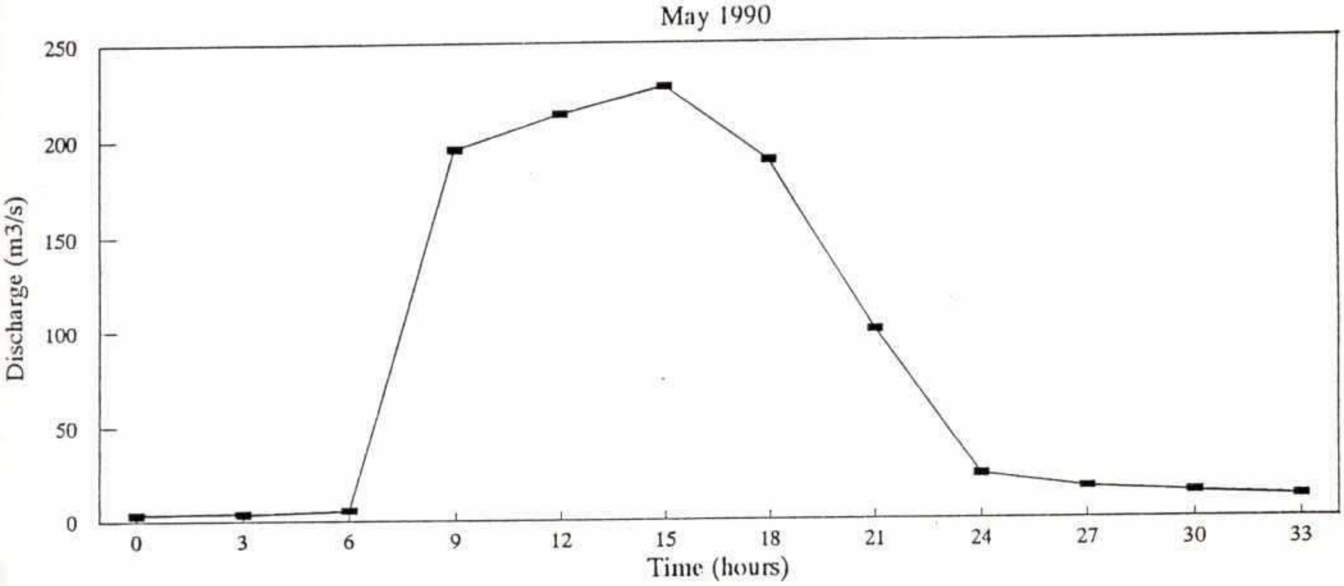
River cross sections were surveyed in 1986. The model may not therefore be particularly representative of present conditions. It can, however, give a general indication of the flood problems.

b) Flood Profiles

The SERM has been used to generate flood profiles in the Sonaichari/Dakatia River system. The envelopes of 2 day and 20 day duration water levels for 1983 are presented in Figure 7.2.8. It is apparent that a significant water surface slope exists through the planning unit but it is also apparent that there are other controls on water levels outside the Sonaichari area.

Figure 7.2.6

Kakri River Observed Flood



211 **Figure 7.2.7**

Mike11 Model Network

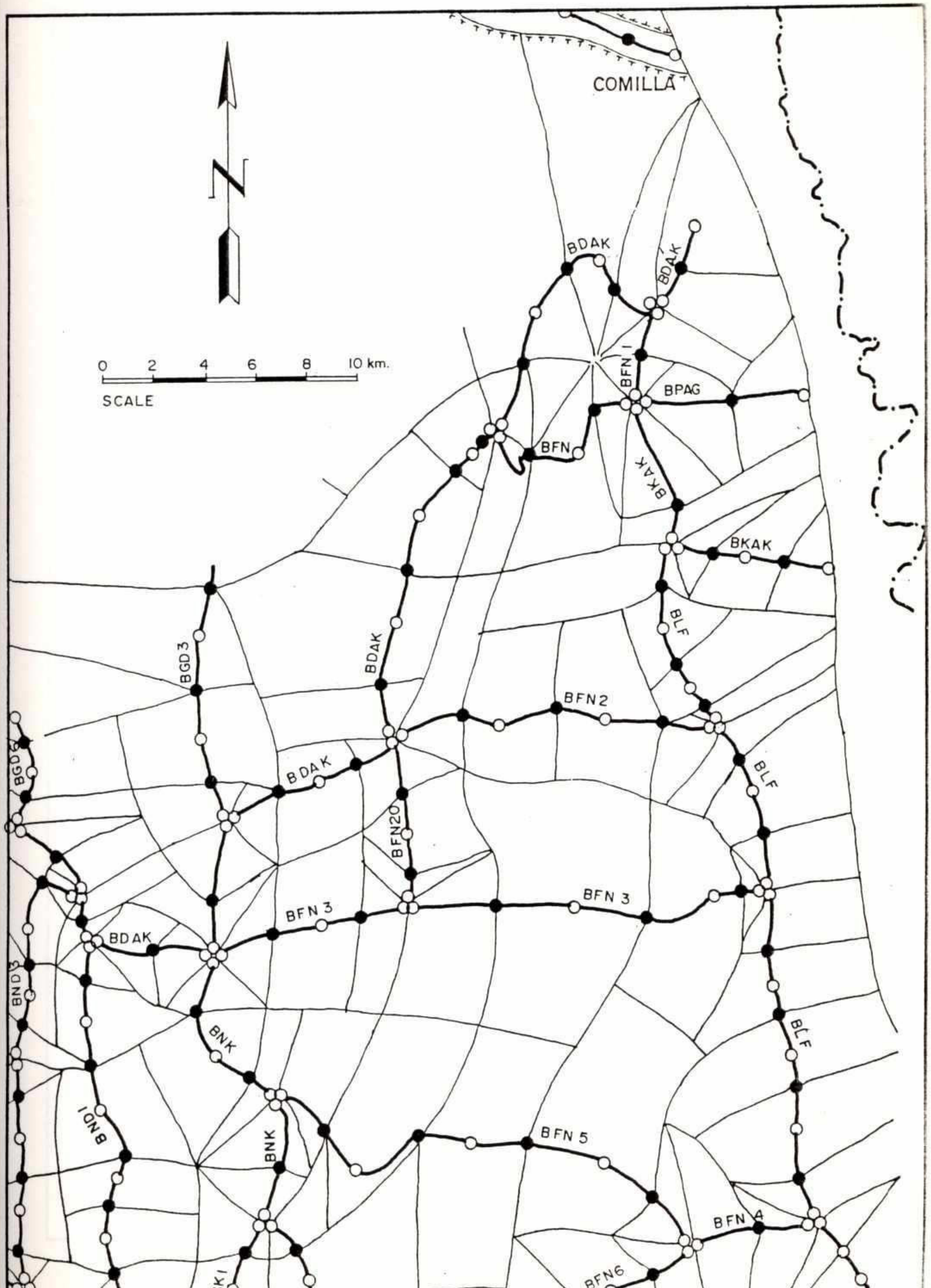
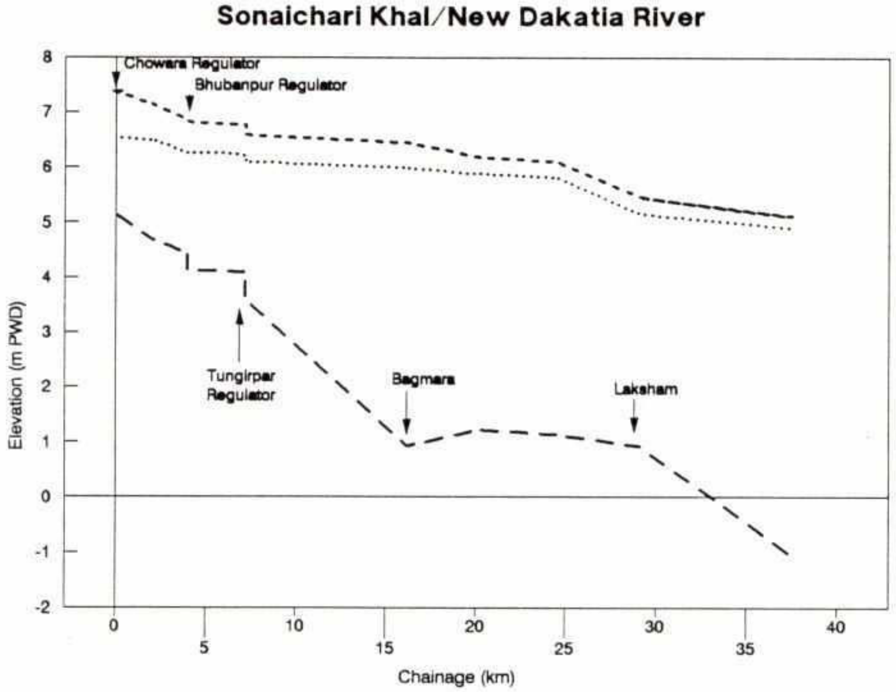
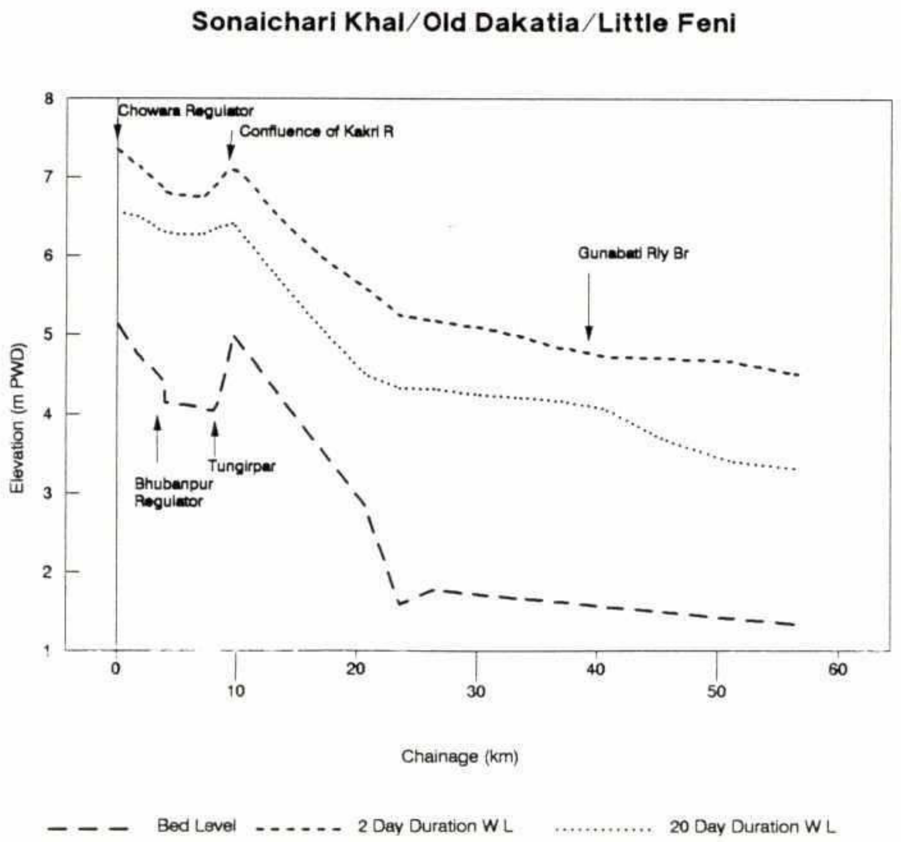


Figure 7.2.8
River Flood Profiles





7.2.6 Potential Mitigation Measures

a) General

On the basis of the preceding discussions, it is clear that there are a number of potential flood mitigation measures which could be adopted either singly or in combination. The possible measures are:

- reduction of head losses through regulators
- reduction of channel losses and of water surface slope through dredging
- provision of more drainage structures into the river system upstream of Tungirpur and Bhubanpur
- provision of pumped drainage
- redirection of greater part of Kakri flows to the Little Feni
- redirection of greater part of Sonaichari flow to the Gungiajuri.

The maintenance of larger dredged channel sections, or of a redirection of greater Kakri flows down the Little Feni River, would be best achieved with some form of sand and silt trapping in controlled reaches. The annual sediment load entering the system is possibly of the order of 250,000 tonnes. Much of this may wash through, but clearly maintenance of dredged channels could be a significant consideration. Each of the above options are discussed in more detail below.

b) Reduction of Afflux Through Regulators

A large head loss apparently exists at the Bhubanpur regulator. If head losses through the structure are indeed 900 mm as reported, then there must be a very strong case for constructing a new regulator and demolishing the existing one.

Similarly at Tungirpar, if there is a 300 mm head loss through the existing structure, then the provision of an additional bypass channel, or replacement or enlargement of the existing structure could be worth while.

There are also cumulative losses through existing bridge structures which must be investigated.

c) Reduction of Channel Losses

Water surface slopes could be reduced by lowering the channel bed gradients in both the Gungiajuri and New Dakatia Rivers, upstream of their confluence. At Chauara, bed levels could be reduced by up to 3 m, thereby increasing conveyance. This would result in problems for the existing structures, and channel remodelling would have to be accompanied by structure modifications, (effectively by reconstruction) as suggested in b) above. Existing invert levels would be too high. Selected loop cutting could also be carried out in the lower reaches of the New Dakatia.

Material removed from the river bed could be used in raising homestead areas, infilling old meanders of the river, or could be spread on fields. There would be an ongoing maintenance commitment, however, and serious thought would have to be given to whether silt trapping or dredging would be the most effective means of control. Silt trapping on tributaries may reduce and focus maintenance. Increased commercial exploitation of sand extraction may also be possible.

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d) Provision of Additional Drainage Structures

The provision of additional drainage structures was suggested by Northwest Hydraulic Consultants. This would certainly improve the situation with regard to clearing floodwater once river levels start to fall. The proposals need to be considered in conjunction with river improvement proposals, and related to new rural road construction in the area.

e) Provision of Pumped Drainage

It may be that in view of high tail water levels in the Dakatia River, and the very low gradients that exist in the Dakatia River through the main monsoon period, that gravity drainage from the Sonaichari area cannot be substantially improved. Pumping may be the only realistic alternative, and should be investigated. However it may be possible to achieve some improvement in the pre-monsoon period (April/May).

f) Redirection of Kakri Flows

By removal of the sand bar on the Little Feni downstream of the Kakri confluence, it would be possible to direct more of the Kakri flow down the Little Feni, thereby relieving the Dakatia system. There would be an ongoing maintenance requirement, and it would of course be necessary to evaluate regional impacts. There could be negative impacts in the Little Feni catchment. (See section 7.3).

g) Increased Diversions Through the Rotia Khal/Gungiajuri

It would be possible to increase the capacity of the link at Bhubanpur through Rotia Khal, by providing a larger structure. Without modelling, it is unclear what the impact might be.

h) Likely Benefits and Costs

On the basis of the work carried out by Northwest Hydraulic Consultants, the potential annual benefit from drainage improvement in the Sonaichari area might be of the order of Tk 3.5 million. Providing the removal of say 250,000 m^3 of material from the river beds every five years would have an annual cost of about Tk 2.0 million, and the provision of new regulators could be of the order of Tk 15 million each. More minor works recommended by Northwest Hydraulic Consultants amounted to about Tk 13 million. The economics of improved drainage will thus require careful consideration, although potentially significant benefits may be achieved.

7.2.7 Investigations Required

a) General

From the review reported in the preceding sections, it is clear that a detailed investigation is required if a cost effective and permanent solution to the drainage problems in the Sonaichari area is to be found. The drainage of the area is complex and cannot be viewed in isolation from that of the entire Dakatia and Little Feni river basins. Available hydraulic gradients are very low, and it must be recognised that there may not be any effective means of substantially improving gravity drainage from the area. The evaluation of alternative measures requires that the existing hydrodynamic model of the area be refined, and that observations be made of drainage conditions and sediment discharges throughout the forth coming monsoon season. The present data base is considered to be inadequate for assessing any of the alternatives put forward in the preceding sections.

Perceptions of the drainage problem are based on discussions with local farmers, and are therefore subjective. It is essential that the evaluation be put onto an objective basis, and this cannot be achieved without an intensive field measurement programme and rigorous analysis.

The further investigations required may be considered under the headings of:

- hydrological survey;
- topographic survey;
- hydrodynamic modelling;
- engineering;
- appraisals.

Each are interlinked of course, and are discussed in the following section.

b) Hydrological Survey

It is necessary to monitor water levels in the drainage system between Laksham and Chauara, throughout the next monsoon season. Water level gauges should be established immediately up and downstream of each of the main river structures, including bridges. These could be manually read, at maximum time intervals of 12 hours. During floods the frequency of observation should be increased such that it is adequate to permit hydrograph construction for flash floods entering and passing through the system. These data will be required for hydraulic model calibration, and for a rigorous assessment of system constraints.

A discharge measurement station will have to be established on the Sonaichari. Stations already exist on the Pagli and Kakri rivers which are run by the SWMC. It will be necessary to liaise closely with the SWMC in order to ensure access to data from their stations as it becomes available.

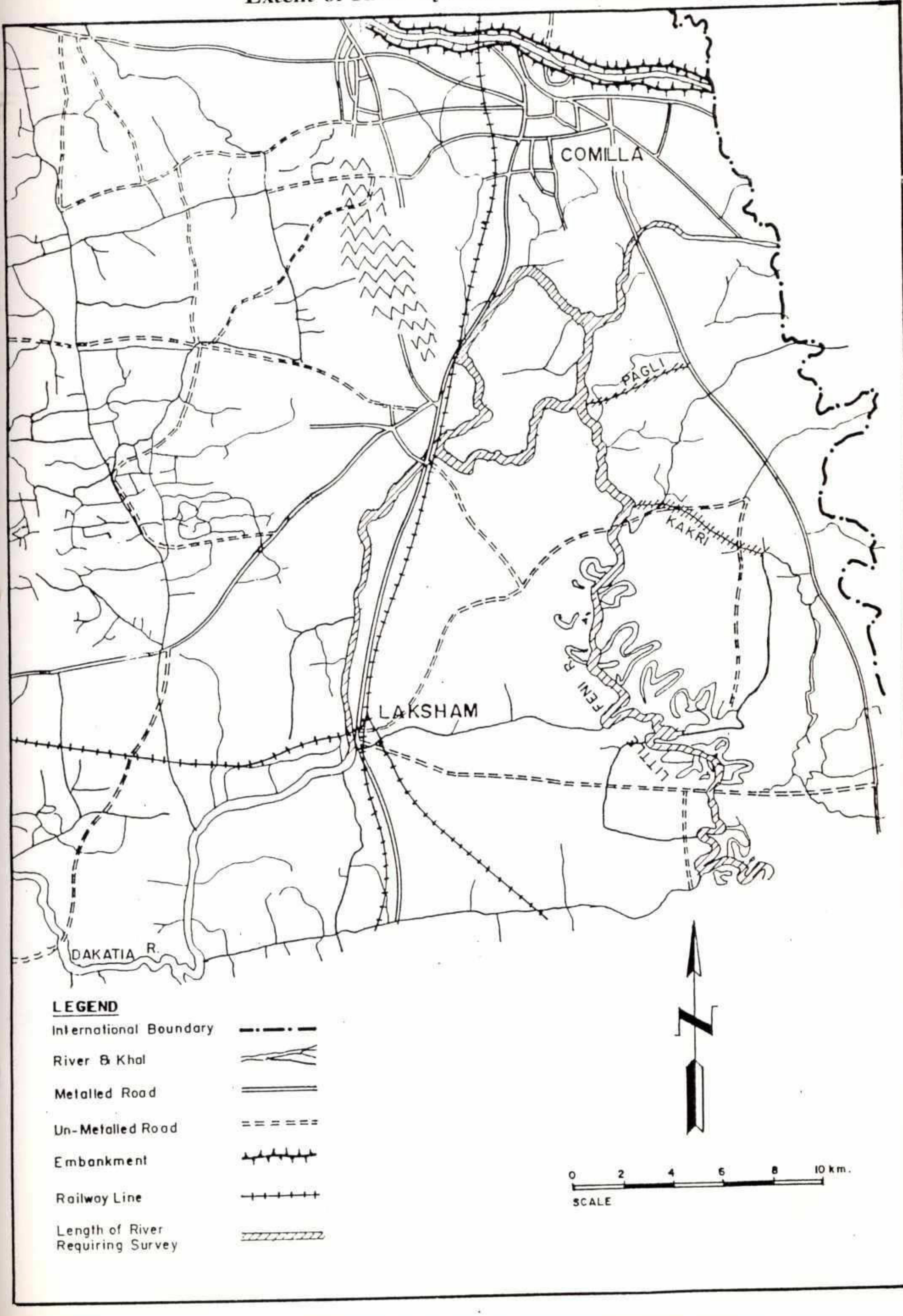
Sediment discharge data are required for the Sonaichari, Pagli and Kakri rivers and also on the Little Feni river, downstream of the Kakri confluence. The ideal would be to prepare sufficient data from which to construct sediment ratings. Sites should be at the same locations as the flow gauging sites, and river flows measured at the same time as samples are taken. Each site should be equipped with a water level gauge also. Samples should be analysed to give suspended sediment load as well as particle size distribution. Bed material should be sampled at each site also, and graded.

c) Topographic Survey

Infill survey is required of river cross sections between the confluence of the Gungiajuri and New Dakatia Rivers and Chauara, including the upper reaches of the Little Feni River. The extent of survey required is shown in Figure 7.2.9. Cross sections should be surveyed at approximately 500 m intervals, and more closely in areas of rapid section change. All structures on or over the river system must be fully surveyed. The survey must also identify, map and level, all impediments to floodplain flow in the area, such as road or flood embankments. These must be levelled in and open areas measured.

Figure 7.2.9

Extent of River System for Which Detailed Survey Required



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d) **Hydrodynamic Modelling**

It is necessary to construct a refined hydrodynamic model of the area. The additional survey will permit more reaches to be introduced to the model, and the floodplain survey will permit better definition of flood cells within the model. These should use spot heights from the most recent topographic mapping. With the new model definition, some reappraisal of the NAM catchment boundaries may be required also a restructuring of floodplain representation.

The additional water level records will permit model calibration, although there may be some difficulties in defining inflows to the system.

For calibration purposes it will be possible to run the model as a separate unit in isolation from the SERM. For production runs it can either be used as part of the SERM, or the SERM used to define the downstream boundary conditions for it. It will be possible to do some options testing on a shortened version of the model, but sub-regional model runs will be required to assess overall impacts, including those on areas outside of the Sonaichari Project in planning units 4 and 5.

Alternative mitigation options may be judged by their affect on flood level duration frequency relationships for the floodplains.

Morphological modelling of the Sonaichari, New Dakatia and Kakri rivers should also be carried out subject to the availability of functional models at SWMC. This will give an indication of likely maintenance requirements were the channels to be deepened. Assistance may be required from the SWMC to set up and run the morphological models.

e) **Engineering**

Although an outline of potential flood mitigation options for the area have been given above, these and other identified options will have to be worked up into alternative schemes, and outline designs and costs prepared. Particular attention must be given to operation and maintenance considerations.

f) **Appraisals**

The nature of the identified mitigation measures is such that full financial and economic appraisal will be required. The appraisals could be based on the methodologies adopted on the recent feasibility studies of the Gumti II and Noakhali North projects. In addition it would be necessary to taka account of environmental considerations. (In particular any negative impacts outside the unit receiving additional flood waters as a result of proposed improvements). Whilst it is considered that the volumes involved are relatively small in comparison to the downstream areas it must nevertheless be considered. Impacts on capture fisheries in this area are likely to be minimal but should also be evaluated.

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e) **Programme**

A programme for the proposed activities is presented in Table 7.2.6. It is anticipated that the study will require a minimum investigation period of 18 months and if it is combined with the study of the proposals in section 7.3, as would be preferred, two years would be required. this might also allow more than one monsoon season's data to be collected and analysed.

The programme is largely self explanatory. Hydrometric field data collection would be required throughout the next monsoon season. It would, however, be possible to begin mathematical model building as soon as the river cross sectional survey was complete. It is anticipated that the floodplain configuration of the current SERM would be completely reconfigured in the Sonaichari area. An overall period of 8 months should be allowed for mathematical modelling activities. This will include results, post processing and evaluation. Six months have been allowed for engineering investigations, which should include consideration of the sedimentation issues, and maintenance costs.

The data collection should be undertaken over an entire flood season, and will be labour intensive.

7.2.8 Water Resources Development

It has already been described in section 7.2.1 that the Sonaichari Irrigation Project is well supplied with alternative water supplies (surface water and groundwater). At the present time the groundwater sources are not fully utilised.

There have been recent requests from farmers in the eastern part of the planning unit, between the Dhaka-Chittagong highway and the Indian border, for the construction of additional structures to allow diversion of the surface water back up the Sonaichari khal. Any structure designed to achieve this must be designed to allow both small and large floods to pass without afflux.

It would seem sensible that areas adjacent to the existing diversion channel be allowed to pump directly from the channel using LLPs and that the water lost to the Sonaichari scheme be replaced by extending the use of the presently utilised tubewells.

The areas more remote from the existing canal are generally on higher ground and in this case either DSSTWs 1 cusec DTWs or possibly SFMTWs would be the most appropriate form of development for the area.

7.2.9 Recommendations

Successive past interventions have concentrated on a combination of channel excavations loop-cutting, regulators and embankments based on the urgent demands of local pressure groups.

None of these measures has proved successful in the long term and several have caused as many or more problems than they have solved. The consultants believe that it is necessary to develop a comprehensive database as set out in section 7.2.7 so that the various alternative mitigation measures described in section 7.2.6, can be properly evaluated. It is possible that there is no economically viable solution but without the database there is no way of preparing a meaningful analysis.

The consultants principal recommendations are therefore as follows:

a) Undertake a detailed study as described in section 7.2.6.

b) Do not construct further structures or embankments in the area until the results of the analyses are available.

c) Maximise the utilisation of the available water resources infrastructure by extending surface irrigation adjacent to the Sonaichari diversion canal by low lift pump.

d) Replace supplies lost to Sonaichari Irrigation Project by increased pumping from existing wells if necessary.

e) Limited extension of groundwater development in the east of the unit by means of DSSTW, DTWs and SFMTW as appropriate considering the depth of the aquifer below ground level and the productivity of the aquifer as the critical parameters.

   The introduction of SFMTWs could affect existing STWs and DSSTWs but could allow greater overall development since they allow greater depths of aquifer to be exploited up to the recharge limit and they should be reliable throughout the duration of the dry season.

TABLE 7.2.6

Sonaichari Project – Work Programme

Activity	Feb.	Mar.	Apr.	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July
Data Collection and Review	■	■	■															
Procurement of Equipment		■	■															
Install Water Level Recorders				■														
Discharge Measurements				■	■	■		■										
Sediment Measurements				■	■	■		■										
Water Level Observations			■	■	■	■	■	■	■									
River Cross Section Survey					■	■												
Evironmental Surveys			■	■	■	■	■	■	■	■	■	■	■					
Hydrodynamic Model Set Up						■	■	■										
Revised Hydrological Boundaries							■											
Model Calibration								■	■	■	■							
Model Verification									■	■	■							
Options Testing and Evaluation											■	■	■					
Outline Engineering Design												■	■					
Engineering Costs													■	■				
O & M Assessments														■	■			
Environmental Analysis and Reporting										■	■	■	■	■	■	■		
Benefits Assessment														■	■	■		
Project Formulation and Reporting															■	■	■	■

7.3 Dakatia/Little Feni Transfer Scheme.

7.3.1 Introduction

This scheme was presented in the draft regional plan report in various ways (Dakatia option 4, Little Feni options 1,2 and 3 and Muhuri options 1 and 2). The review of the draft plan directed that the consultants revise and upgrade these proposals to include consideration of the drainage problems of the upstream areas, (Sonaichari) and within the planning units.

The previous section has described in detail the situation in the Sonaichari area and has identified the interdependence of drainage considerations with the Dakatia and Little Feni planning units. It has identified the paucity of the existing data base and made recommendations for studies to remedy this. In this section the objective is to identify how this affects the lower catchments and also to examine other water resources development options for these areas. These aspects are then drawn together to produce recommendations for a comprehensive study of planning units 4, 5 and 9 as a package not forgetting the possibility of augmenting flows to the Muhuri area which lies outside the designated South East Region.

7.3.2 General Description and Constraints

The Dakatia planning unit extends from the Chandpur-Comilla road in the north to the Ramgati-Chatkhil-Senbag road in the south, and from the Chandpur Irrigation Project in the west to the Comilla-Chittagong railway line in the east. The drainage and flood control aspects of this unit have been studied as part of the Noakhali North Drainage and Irrigation Project (NNDIP) (See Chapter 6). However the irrigation possibilities for this unit are discussed in this chapter and an overall plan to further study the inter-relationship of this unit with the Sonaichari planning unit together with the Little Feni planning unit, but for both improved drainage and irrigation are examined.

Thanas included, in whole or in part, are Hajiganj, Shahrasti and Kachua in Chandpur District; Laksham, Barura and Nangalkot in Comilla District; and Begumganj and Senbag in Noakhali District. The Dakatia river is the arterial drain for this planning unit.

The Little Feni River planning unit lies in the south-east of the study area. It is bounded on the east by the Tripura Hills of India; the south-east by the Muhuri Irrigation Project; the south by the Bay of Bengal; the west by a low ridge separating it hydrologically from much of the remainder of the study area, (Noakhali North and Dakatia planning units) and on the north by higher ground approaching the Lalmai Hills (Sonaichari-planning unit 9). It includes the thanas of Kotwali, Laksham, Chauddagram and Nangalkot in Comilla District; Daganbhuiyan, Feni and Sonagazi in Feni District, and Senbag, Sudharam and Companiganj in Noakhali District.

The Little Feni River is the main drainage channel of the area, flowing from north to south. Upstream of Gunabati railway bridge it is known as the Old Dakatia River, but for present purposes the name Little Feni River will be used for its whole length within the planning unit south of the outfall of the Kakri river. The ground slopes up gently from the Little Feni River towards the eastern and western boundaries of the planning unit, except in the south, where the land is practically flat.

The Little Feni River itself has developed a flat slope for the major portion of its length. Some flashy tributaries from the Tripura Hills, such as the Kakri River, bring in a large amount of coarse sediment from India which is deposited in the upper part of the Little Feni River, causing drainage congestion. Some of this imported material is currently excavated on a commercial basis, normally during the recession of the monsoon.

Flooding in the Little Feni basin was alleviated by the construction of Kazirhat Regulator in 1967/68, and loop cutting and re-excavation of the Little Feni River during the late fifties. Embankments have also been constructed along the Kakri River, but drainage congestion is still a problem, partly due to heavy siltation at the outfall of the flashy rivers and partly due to tidal deposition downstream of Kazirhat Regulator, which blocks the flap gates. Silt was cleared from the upstream reaches of the Little Feni River under the Food For Work programme during the years 1976/77 to 1981/82 and in 1984/85. It is reported that the channel is again silted up in places. The Kazirhat Regulator outfall channel is partially cleared every year, before the onset of the monsoon, for a distance of about four kilometres downstream. It takes about two months from the start of the monsoon for the channel to clear itself sufficiently to lower the water level upstream of the regulator by about two metres.

7.3.3 Previous Studies

(i) Master Plan (International Engineering Company Inc, December 1964)

The Master Plan envisaged a Little Feni Drainage Project broadly corresponding with the present planning unit, but extending as far north as Comilla and the Gumti River. A regulator corresponding with the now existing Kazirhat Regulator was proposed. No water transfer from the Meghna River was anticipated, but an area of surface water irrigation in the north of the planning unit (corresponding with the now existing Sonaichari Irrigation Project) was identified under the separate Gumti River Project.

The Master Plan also envisaged a single Comilla-Noakhali Project of 336 000 ha gross covering the whole of the Noakhali North, Dakatia, Dhonagoda and Gumti Phase I planning units, with the exception of the south-west portion of the Dhonagoda planning unit; this was treated as the North Unit of the Chandpur Project which like the Meghna-Dhonagoda Project, was treated as a separate project. The Dakatia planning unit (as defined in the Interim Report) more or less corresponds with the southern portion of the Central Area designated in the Master Plan. It was proposed to provide full flood protection with pumped drainage initially, followed by surface water irrigation from the Lower Meghna River.

(ii) Meghna-Muhuri Water Transfer Scheme (MMWTS). Draft Planning Report (International Engineering Co/Rahman & Associates, September 1972)

The planning unit (in its Interim Report form) constituted a component of Phase I of the proposals for the transfer of irrigation water eastward from the Lower Meghna River. Development was anticipated two stages:

Stage I

Dry season flows in the Dakatia River were to be reversed by means of Kamta Khal Pump Station (corresponding to Dakatia Pump Station in the present proposals) in conjunction with a regulator. A relift pump station at Disaganj (as per the present proposals) would raise the water into Mellar Khal for the higher eastern areas, and thence to the Little Feni Project area. Final delivery in all areas was to be by low lift pump (LLP), except in the far north and east, where additional pump stations would feed a gravity distribution system. The Dakatia River east of Kamta Khal Pump Station was to have low embankments retaining irrigation water at above ground level, with distribution and drainage via simple flashboard structures.

Stage II

Flood control would be achieved by raising the Hajiganj-Comilla road embankment as necessary and closing culverts, and embanking the north bank of the Dakatia River between Hajiganj and Kamta Khal Pump Station. Drainage would be improved by further excavation of the Dakatia River and other channels and operation of Kamta Khal pump station in reverse (drainage) mode.

(iii) Feasibility Report on Comilla and Noakhali Project - Phase I (Dakatia Unit) (BWDB/Netherlands Engineering Consultants, February 1980)

This report (based upon an Interim Project Feasibility Report of May 1974, prepared by International Engineering Co/Rahman & Associates) considers the provision of full irrigation and flood control to that portion of the Dakatia Project (as defined in the Meghna-Muhuri Water Transfer proposals in (ii) above) bounded by the Dakatia River in the north-east, the Chandpur Irrigation Project in the west and the Ramganj-Chitoshi road in the south-east. The area covered thus now lies fully within the extended Noakhali North planning unit, as redefined for the Regional plan.

It was concluded that the provision of irrigation alone was not economically viable, but became so with the addition of full flood protection and drainage. Irrigation water supply was to be via three pump stations on the Dakatia River, with no regulation of the river itself.

The report acknowledges that the proposals are not directly compatible with the Meghna-Muhuri Water Transfer Scheme (MMWTS) proposals, but reaches the conclusion that the latter is unlikely to come into operation within the next 25 years, and therefore, in evaluating the proposals for the Dakatia Unit "with discount factors approaching zero for periods longer than 25 years, it becomes superfluous, from the economic point of view, to take the MMWTS into consideration".

(iv) Draft Feasibility Report - Rehabilitation of Old Dakatia and Little Feni River (Sub Project Nr 19, Rehabilitation of Water Development Project, EPC/Harza/MacDonald April 1988).

This report describes the existing problems of the Little Feni basin, associated with the sedimentation of the upper reaches and the siltation of Kazirhat Regulator. The construction of a new regulator 15 km downstream of the existing Kazirhat Regulator was considered, but not recommended for immediate implementation because:

- the new regulator might face a similar problem of downstream accretion within a few years. This could be increased by construction of the proposed Sandwip cross-dam.

- the proposal needs to be examined in the context of drainage planning for the whole of the area to the south of the Chandpur-Comilla highway, under the South-East Regional Study.

However, a tentative analysis using the South East Region Surface Water Simulation Model (SERM) was reported to indicate substantial benefit from a new regulator.

Recommendations were thus substantially confined to silt clearance in the upper channel reaches, and annual excavation of a pilot channel for about 4.5 km downstream of Kazirhat Regulator at an estimated annual cost of Tk 3 592 000 (the latter more or less along the lines of current practice).

(v) Feasibility Report - Structures for Little Feni River Sub-Project (Second Small Scale Flood Control, Drainage and Irrigation Project, North-west Hydraulic Consultants Ltd., 1988).

This Sub-Project is located on the right bank of the Little Feni River immediately adjacent to Kazirhat Regulator. It aims to protect a gross area of about 536 ha from early floods (caused by the delayed opening of the Regulator), through the provision of a sluice. The same sluice also would admit irrigation water. A further area of 103 ha gross downstream of the regulator would be protected from sea-water intrusion through embankment resectioning and provision of a sluice. It is understood that a contract was awarded for construction, but the first contractor failed to perform.

(vi) Little Feni and Noakhali Regulators (International Engineering Company Inc, October 1961)

This report presents the results of preliminary investigations, detailed designs and cost estimates for proposed regulators on Noakhali Khal and the Little Feni River. The purpose of both regulators, in conjunction with the coastal embankments then under construction under the Coastal Embankment Project, was to prevent the inflow of sea water and resultant salination, whilst permitting floodwater to be evacuated through flap gates at low tide. Improved internal drainage channels and peripheral embankments were also to be provided. The design selected for the Little Feni (Kazirhat) Regulator consisted of 30 Nr 12 foot (3.66 m) diameter corrugated steel culvert barrels with dished-head flap gates at each end, with three wagon mounted gate hoists provided. The regulator as constructed consists of only 20 Nr barrels. An area of 28 700 ha was assumed to benefit, including gravity irrigation for 3 650 ha of boro.

7.3.4 Groundwater Development Potential

a) Dakatia (Planning Unit 5)

As described in the Noakhali North Drainage and Irrigation Project feasibility study there is very little shallow groundwater potential in the planning unit 5 area owing to the salinity problems in this area. However there is some deep tubewell development potential in the north east of the unit particularly north of the Chandpur-

Laksham road. Further south the deep tubewell potential requires very deep wells with screens below 130 m (see Annex V) and it has already been recommended that their potential is further investigated with a possible zoning restriction to allow any potential to be used in the southern coastal polder areas if possible. (Chapter 5).

On the basis of the studies described in Annex V, the total potential for groundwater irrigation within the planning unit, allowing for the salinity constraint, assuming a net irrigation requirement of 625 mm for a boro crop, is as follows together with the existing area irrigated.

	Potential (ha)	**Existing (ha)**
STW/DSSTW	5 100	2 707
FMTW	8 653	5 196

b) Little Feni (Planning Unit 6)

Although the southern areas are affected by coastal salinity, there is significant growth potential for force mode tubewell in the northern part of the planning unit. On the basis of the studies described in Annex V, the total potential for groundwater irrigation within the planning unit allowing for the salinity constraint, assuming a net irrigation requirement of 625 mm for a boro crop, is given below together with the existing area irrigated.

There have however been reports that one on two DTW have failed in Chauddagram and Feni thana which may indicate some local difficulties in full exploitation of the potential. This would need to be investigated at the feasibility stage.

Also, as explained in Chapter 2, even where most of the potential is best exploited by force mode tubewells the private sector development will tend to favour the less expensive STW and DSSTW technologies. This will again tend to reduce the actual development below the full potential.

Therefore to allow for these factors the Consultants have assumed that no more than about 75% of force mode tubewell potential is likely to be exploited within the plan period; as shown below.

Little Feni River - Groundwater Development

	Annex V Potential (ha)	Planned Development	
		Existing (ha)	Limit (ha)
STW/DSSTW	2 586	2 856	2 856
FMTW	23 297	6 553	17 573

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7.3.5 Surface Water Potential and Proposals

The draft regional plain identified that there was a limited potential for diverting flows back up the Dakatia river for irrigation in various planning units. The limit on the potential is the substantial length of the Dakatia river at its eastern (downstream) end which has a shallow bed. This condition is probably caused by both deposition of silt laden flood flows coming down the Dakatia and even more seriously by deposition of Meghna sediments in this tidal reach of the Dakatia. Dredging of this 8 Km stretch of river has not been considered a viable and sustainable option owing to the probable rapid resedimatation which would be likely to occur. The ability to divert water back up the Dakatia is therefore limited by the amount which can be drawn through the shallow section of the river described above in addition to that already being abstracted by the Chandpur Irrigation Project.

The NNDIP study has already identified that it is not possible to supply significant additional water by khal deepening to the areas within the NNDIP area. That study has also identified that other than in exceptional flood years (eg 1988 and 1974) there would be virtually no flood benefits from a tidal regulator located just upstream of the Chabagodi Pump Station and therefore such a regulator cannot be justified in terms of flood benefits.

In order to verify the previous hydraulic calculations concerning the quantity of water which could be reliably pumped back up the Dakatia a model run was carried out for a whole dry season (1986/87). This year was chosen as having the lowest data of the last ten years in the critical month of March (1993 might now be lower).

The assumptions were that the Chandpur Irrigation Project would be extracting 35 m^3/s and pump operating rules were adopted such that pump units were cut off progressively as water levels on the river side of the station fell below certain pre-determined levels and were switched back in as the levels rose again.

This test was carried out for two sizes of pump station as follows:

a) 8 No 10 m^3/sec units - maximum lift 2.25 m.

b) 10 No 10 M^3/sec units - maximum lift 2.25 m.

The results of these tests are reproduced in Figures 7.3.1 to 7.3.4. The results show the following reliable discharges:

	Reliable	Flow
Duration	100 m^3/s Capacity	80 m^3/s Capacity
1 day	68	65
7 day	71	66
14 day	77	69

Figure 7.3.1

Dakatia Pump Station Capability 80m^3/s

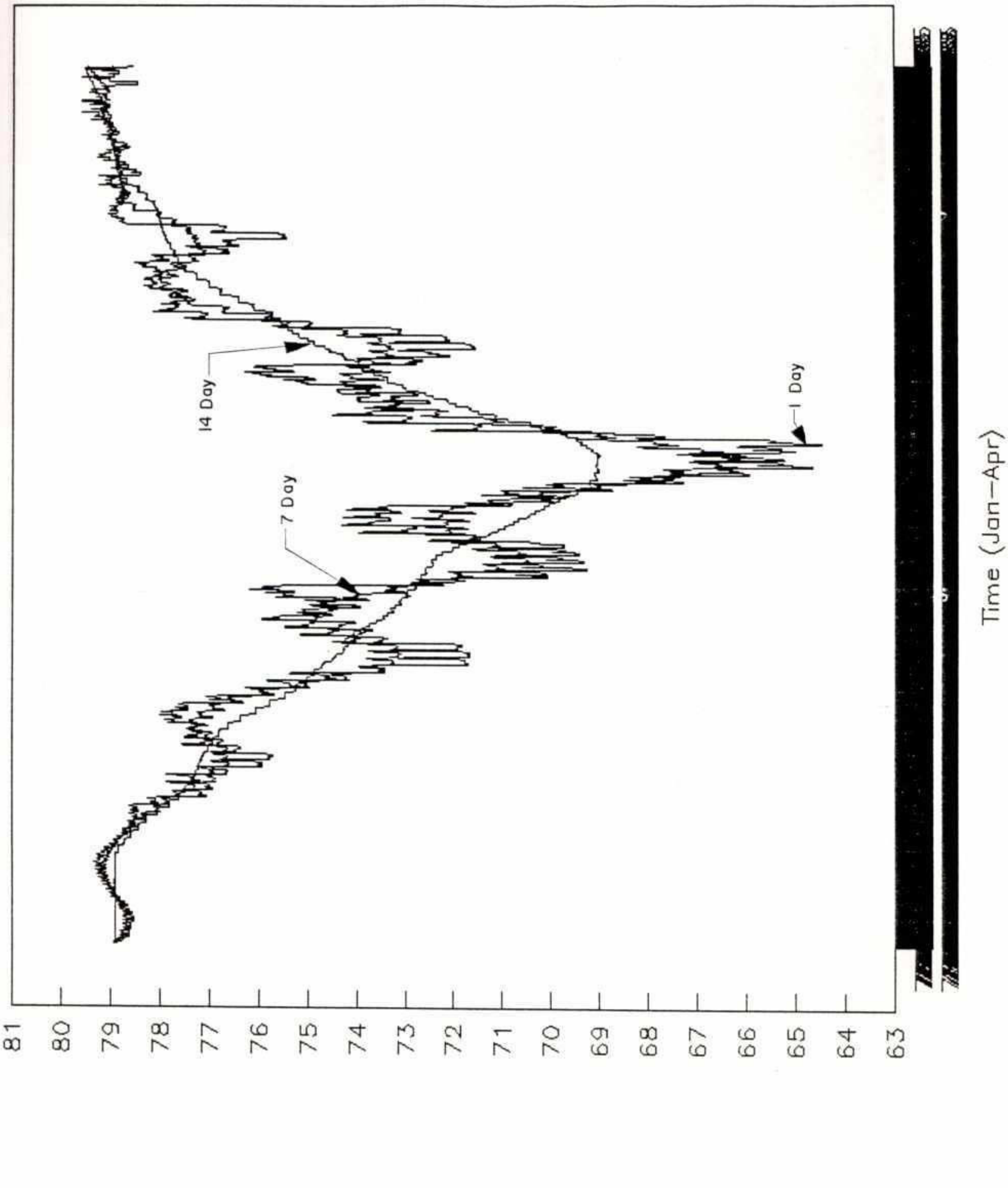


Figure 7.3.2

Dakatia Pump Station Operation $80m^3/s$

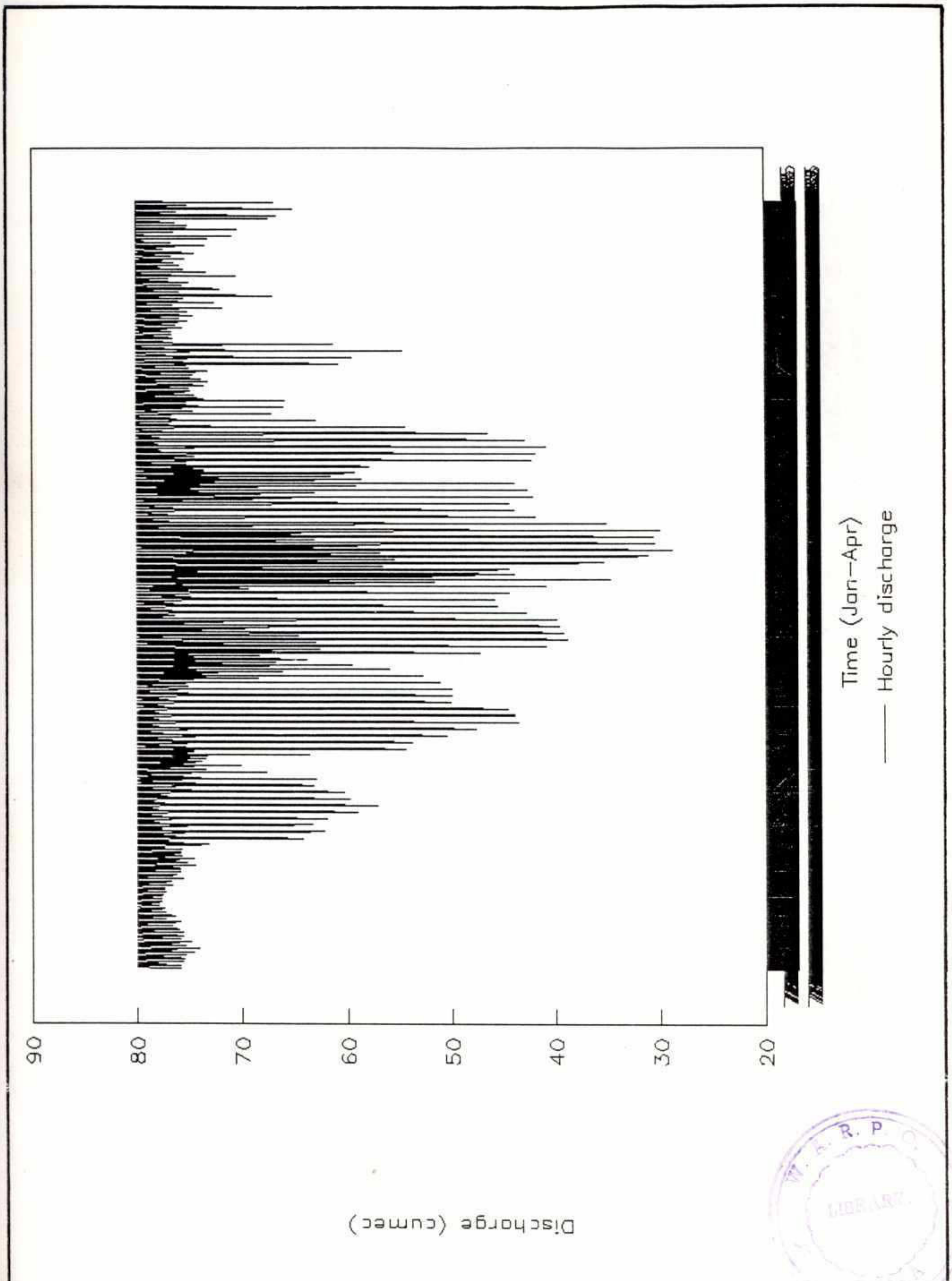
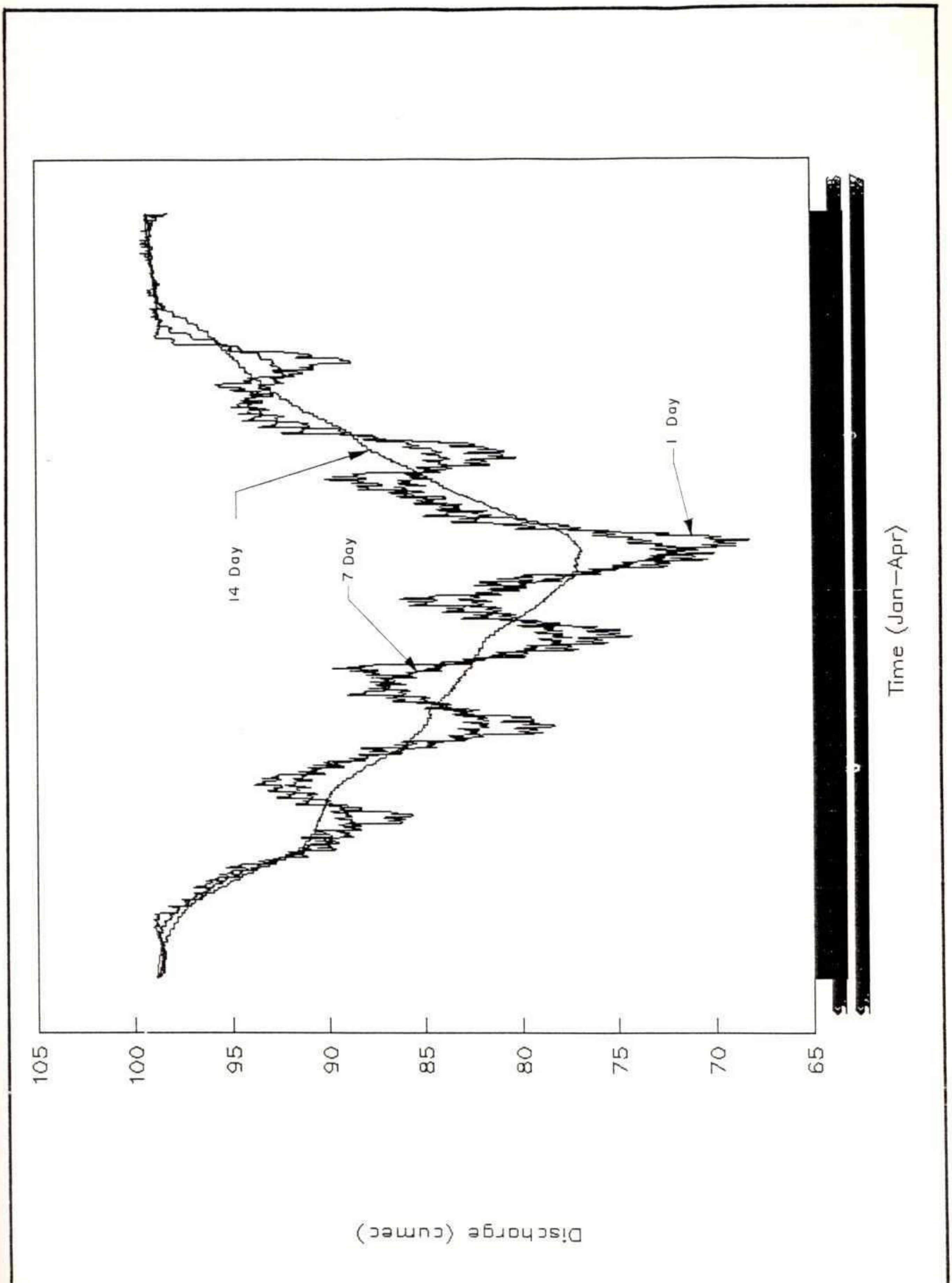


Figure 7.3.3

Dakatia Pump Station Capability $100m^3/s$



This suggests that for a 25% increase in pump capacity the reliable 7 day discharge only increases by less than 10%. For the purposes of this analysis it has been assumed that by successive optimisation of pump operating rules it would be possible to achieve a reliable flow of 70 m^3/s from the 80 m^3/s capacity station whilst allowing some variation of level in the reservoir of water in the Dakatia river, in a similar manner to that described for WAPDA khal in the NNDIP study.

The design water level upstream of the pump station was set at + 2.50 m. Obviously for most of the season less than the full number of pumps will be operating and therefore no spare capacity at peak requirement has been allowed for.

The total discharge being abstracted from the Meghna with this arrangement is thus 35 + 70 or 105 m^3/s.

Having established the potential diversion capacity it is necessary to evaluate how the capacity might be utilised and the following rules have been adopted in devising priorities for supply:

(a) All existing irrigated areas drawing water from the Dakatia river and its adjacent Khals must continue to be supplied. This has been taken to include all the known LLP and traditional irrigation identified in DAE blocks (South of Dakatia river) or in thanas (north of Dakatia) which lie within 1.3 Km of the khals which it is possible to serve directly from the Dakatia water reservoir after deepening. This rule is similar to that adopted for the NNDIP study and is based on equivalent data.

(b) Presently unirrigated areas within the same boundaries as (a) above.

(c) Areas in Little Feni meeting the same criteria is in a) above

(d) Presently unirrigated areas in Little Feni within the irrigable boundaries (1.3 Km) or in some cases less where there are substantial ground slopes up from the river.

The boundaries of the areas so identified are shown on Figure 7.3.5. The calculation of presently irrigated and potentially irrigated areas calculated as described is shown in Table 7.3.1 and 7.3.2. The total area irrigable by surface water within the shaded areas on Figure 7.3.5 is 44,348 ha of which 30073 ha are within the Dakatia Southern part of the Dhonagoda planning units and 14,275 ha within Little Feni planning unit of this total 23,807 ha are existing irrigated areas and 20,541 ha would be new irrigation areas.

It has been assumed that all the water requirements for the existing irrigated areas using surface water will now come from the diverted Meghna water. This is clearly not the situation at present, since much of the water currently used is stored rainfall, carefully harvested. This is particularly the case in the Little Feni Catchment where boro yields are substantially the lowest of any district in the region (see Chapter 6 in Volume 1) and this is largely due to water constraints.

Figure 7.3.4

Dakatia Pump Station Operation 100m^3/s

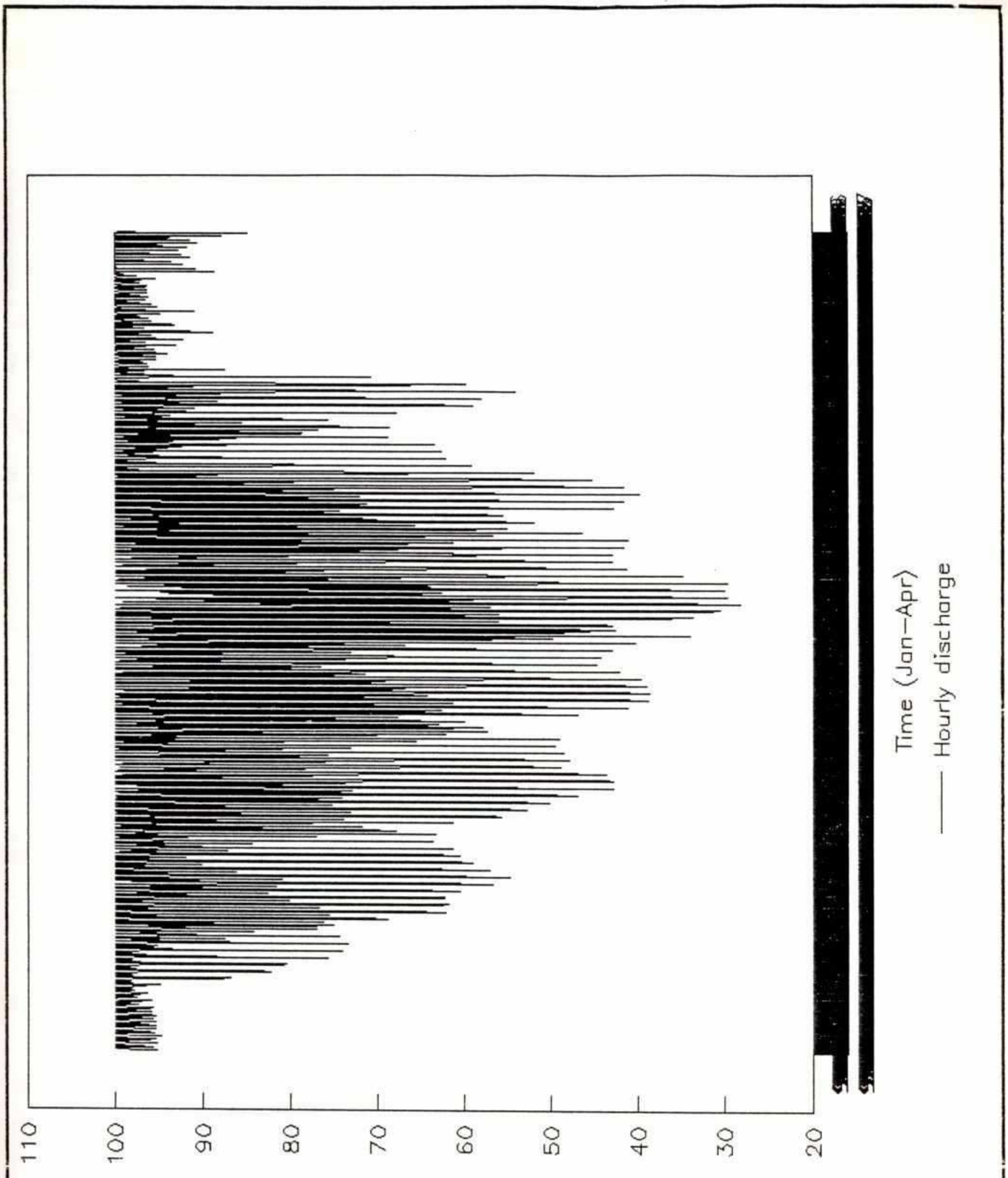


Figure 7.3.5

Dakatia-Little Feni Transfer Proposals

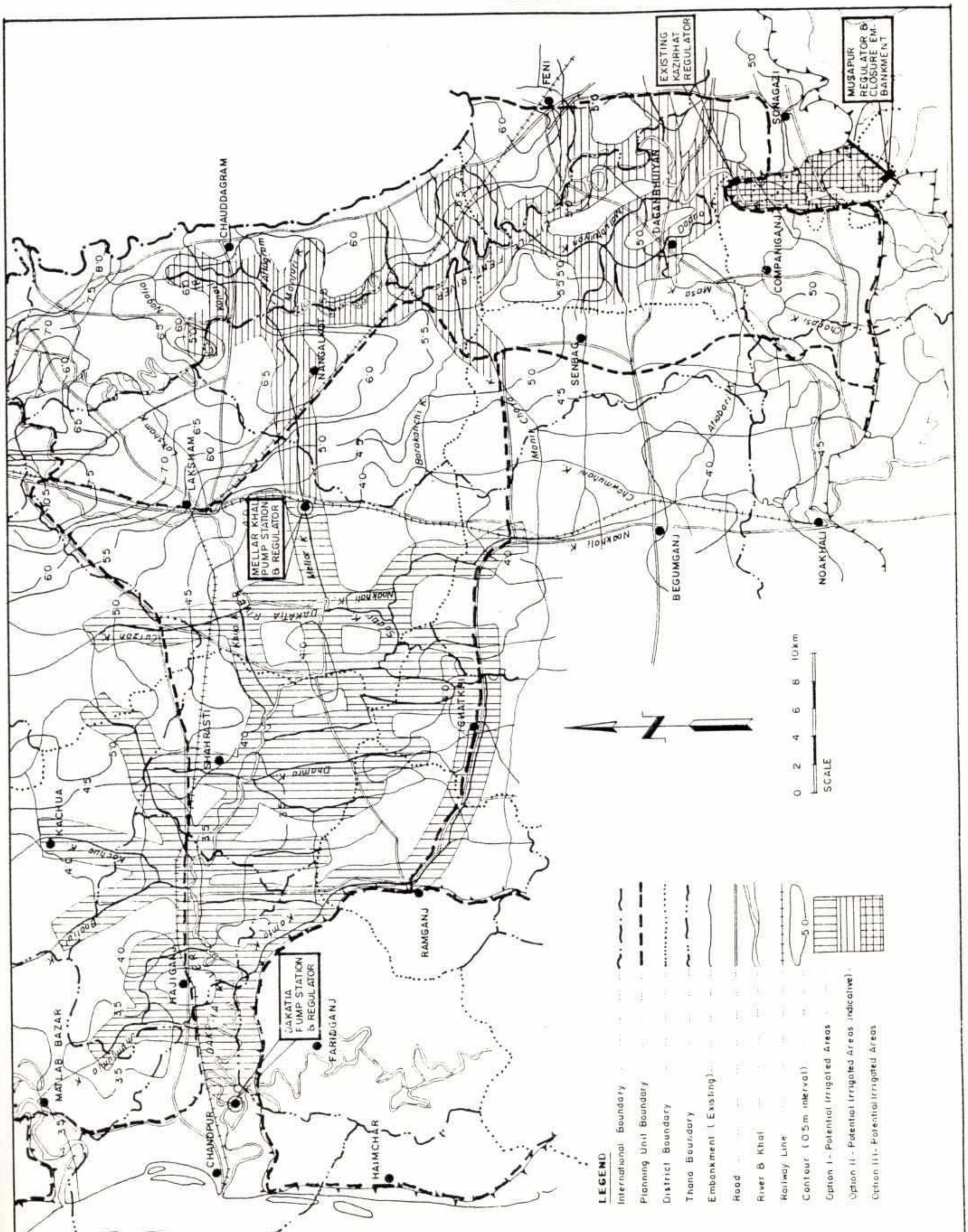


TABLE 7.3.1

Estimated Irrigation Areas from Dakatia River

Mode	Present (ha)	Future Without (ha)	Future With (ha)	GCA (ha)
LLP	16,032	16,032	29,400	
Traditional	2,403	2,001	673	
STW	902	1,504	1,504	
FMTW	1,934	2,565	2,565	
Total	21,271	22,102	34,148	50,958

TABLE 7.3.2

Estimated Irrigation Areas from Little Feni River

Mode	Present (ha)	Future Without (ha)	Figure With (ha)	G.C.A. (ha)
LLP	4,575	4,575	13,675	
Traditional	1,199	1,199	600	
STW	1,423	1,423	1,423	
FMTW	3,227	8,060	5,060	
Total	10,424	15,257	20,758	30,982

The peak water requirements including transmission losses have been taken as 1.5 l/s/ha continuous supply. This is the same number as that calculated for the NNDIP study and is considered a reasonably conservative figure given the type of system being proposed.

The areas identified for irrigation supply and therefore the preliminary water resources allocations are summarised below in Table 7.3.3.

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TABLE 7.3.3

Provisional Water Allocations

Location	Surface Irrigation Potential (ha)	Water Requirement m^3/s
1. Dakatia/Dhonagoda	30,073	45.1
2. Gajaria/Little Feni	14,275	21.4
3. Muhuri or Noakhali	2,332	3.5
Total	46,680	70 m^3/s

The calculations of potential irrigation areas are necessarily approximate and the system would have to be demand led however the figures given in Table 7.3.3 above suggest that the size of the pump station which would be needed for transferring water from the Dakatia to the Little Feni catchment is approximately 25 m^3/s. The above figures also suggest that the transfer scheme would meet all the potential in both the Dakatia and Little Feni catchments if the assumption concerning the limited growth of groundwater development is correct. In addition there would be a small amount of spare capacity which could be transferred either to the Muhuri basin or through the khal network back into the eastern part of the Noakhali area which is not served from the NNDIP proposal. Also in the event that the groundwater development exceeded expectations or that water is used more sparingly than assumed here then there would be additional surplus water resources for new areas in Muhuri or Noakhali.

This allocation of water resources was used to calculate the water profile for the Dakatia river and for the transfer system through the Mellar and Gagaria khals to the Little Feni river. These two sets of calculations are reproduced as Table 7.3.4 and a graphical representation is shown in figure 7.3.6. These tables and figures demonstrate that the second lift pump station is now more sensibly located adjacent to the Laksham to Begumganj road which avoids the need for an embanked channel along the Mellar khal. Also a regulator would be provided at this point to allow drainage in the monsoon season. The Mellar Khal pump station would have a capacity of 25 m^3/s and a pumping lift of 4.15 m and would deliver water into the Little Feni at a level of + 5.06 m PWD.

All khal excavation has been designed to ensure that required sections are within existing bank top widths in the same way as for the NNDIP.

In the Dakatia and Dhonagoda areas the water levels will allow delivery to khals with design bed levels of + 0.50 and 2:1 side stopes.

These proposed developments have been costed on the basis of a possible two stage development. The first stage would include all the development in the Dakatia catchment including the Dakatia regulator and pump station but not requiring any excavation in the Dakatia or Mellar khal since the additional channel capacity would not be required with the small stage one capacity requirement at this location.

Figure 7.3.6

Longitudinal Profile - Dakatia River and Mellar/Ghagaria Khal

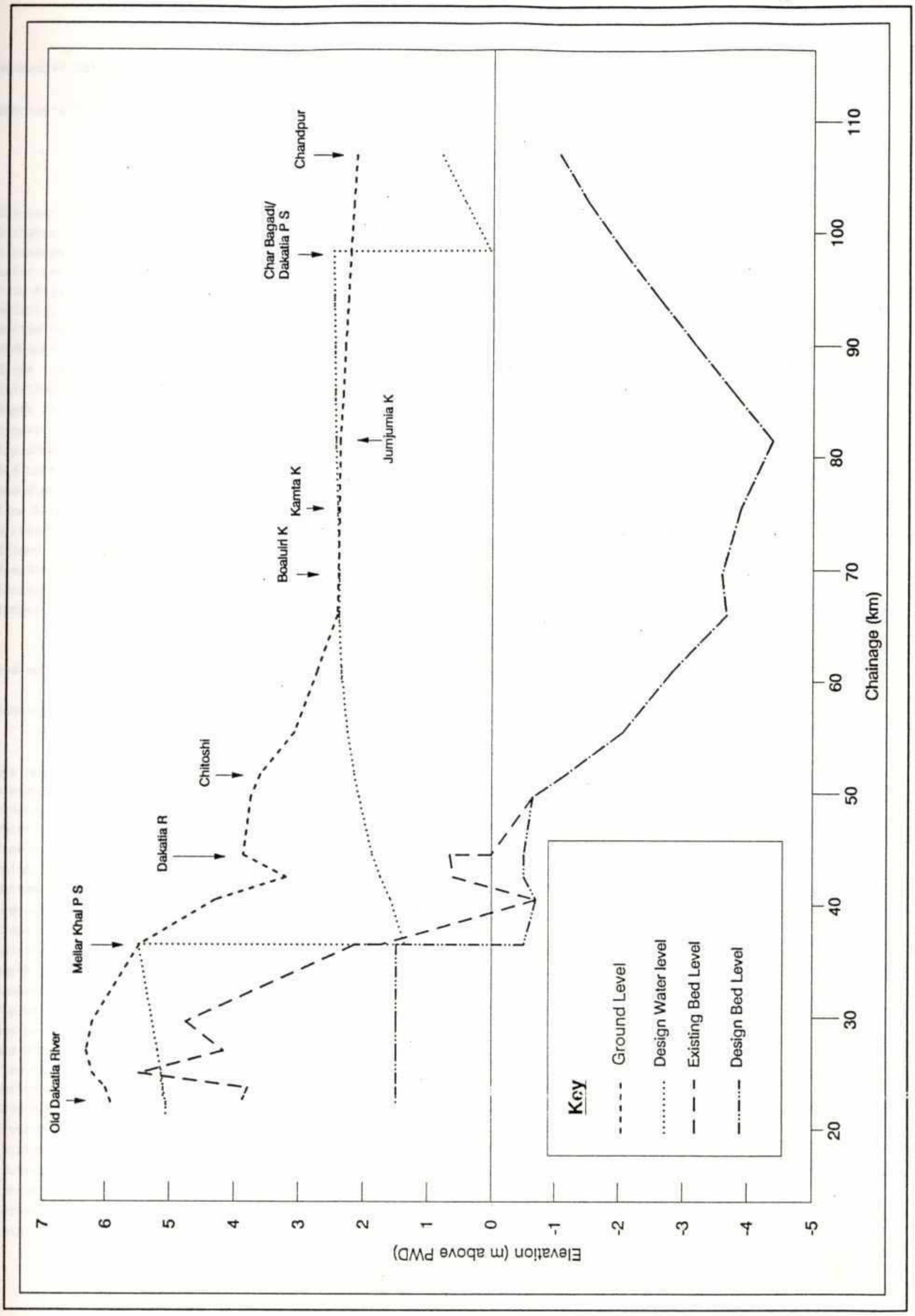

TABLE 7.3.4

Dakatia/Little Feni Transfer Scheme

Hydraulic Calculations for Irrigation Water Entering the Dakatia River (Development Stage 2)

Manning's "n" 0.025

	Chandpur	-	Char Bagadi/ Dakatia PS	Jumjumia Khal	Kamta Khal	Boaliuri Khal	Sailkhali Khal	Shahrasti Khal	Chitoshi Khal	Mohandra Khal	Mellar Khal
Chainage (km)	106.90	102.60	98.40	81.40	75.40	69.60	65.90	55.40	51.60	49.60	44.50
Distance (m)		4 300	4 200	4 250	6 000	5 800	3 700	5 500	3 800	2 000	5 100
Discharge (m3/s)	102	102	70.00	67	65	57	54	43	38	38	27
Water Level (m), PWD	0.800	0.421	2.500	2.448	2.425	2.402	2.387	2.260	2.155	2.082	1.868
Flow Area (sq.m)	253.49	200.08	478.57	376.72	332.50	301.87	262.06	120.55	116.17	101.44	65.59
Velocity (m/s)	0.40	0.51	0.15	0.18	0.20	0.19	0.21	0.36	0.33	0.37	0.42
Wetted Perimeter (m)	174.06	154.26	154.84	102.43	89.81	77.06	72.97	45.39	68.35	55.69	33.55
Hydraulic Radius (m)	1.46	1.30	3.09	3.68	3.70	3.92	3.59	2.66	1.70	1.82	1.96
Slope (cm/km)	6.13	11.48	0.300	0.35	0.42	0.365	0.48	2.15	3.35	3.94	4.45
Existing Bed Level(mPWD)	-1.05	-1.50	-2.04	-4.37	-3.89	-3.59	-3.67	-2.05	-1.16	-0.64	0.01
Depth (m)	1.85	1.92	4.54	6.82	6.31	5.99	6.06	4.31	3.32	2.72	2.37
Excavated Section											
Top Width (m)	-	-	-	-	-	-	-	-	-	-	40.4
Bed Level (mPWD),	-	-	-	-	-	-	-	-	-	-	-0.50
Bed Width (m)	-	-	-	-	-	-	-	-	-	-	22.96
Flow Area (sq.m)	-	-	-	-	-	-	-	-	-	-	65.59
Wetted Perimeter (m)	-	-	-	-	-	-	-	-	-	-	33.55
Ground Level (mPWD),	-	-	-	-	-	-	-	-	-	-	3.86
Present Area (m2)	-	-	-	-	-	-	-	-	-	-	97
Excavation Area (m2)	-	-	-	-	-	-	-	-	-	-	41.1
Excavation Vol. (m3)	-	-	-	-	-	-	-	-	-	-	104 868

Hydraulic Calculations for Irrigation Water Entering Mellar/Ghagaria Khal (Development Stage 2)

Manning's "n" 0.025

	Dakatia R.				Mellar K. PS					Old Dakatia
Chainage (km)	0.00	2.00	4.00	8.00	8.00	14.90	17.50	19.5	20.8	22.4
Distance (m)		2 000	2 000	4 000	0	6 900	2 600	2 000	1 300	1 600
Discharge (m3/s)	26.25	25.94	25.62	24.99	24.99	23.91	23.50	23.19	22.98	22.73
Water Level (m)	1.846	1.736	1.586	1.354	5.500	5.265	5.189	5.134	5.100	5.058
Flow Area (sq.m)	61.21	55.16	47.93	36.76	56.80	61.49	61.17	62.74	63.35	62.32
Velocity (m/s)	0.43	0.47	0.53	0.68	0.44	0.39	0.38	0.37	0.36	0.36
Wetted Perimeter (m)	31.89	30.20	28.13	24.41	24.09	25.64	25.70	26.25	26.50	26.31
Hydraulic Radius (m)	1.92	1.83	1.70	1.51	2.36	2.40	2.38	2.39	2.39	2.37
Slope cm/km	4.82	6.19	8.78	16.73	3.86	2.94	2.90	2.67	2.57	2.63
Existing Bed Level (m)	0.65	0.60	-0.69	1.73	2.14	4.75	4.16	5.47	3.80	3.91
Depth (m)	2.35	2.24	2.09	1.85	4.00	3.77	3.69	3.63	3.60	3.56
Excavated Section										
Top Width (m)	40	35	38	40	25	28	28	28	28	28
Bed Level (m)	-0.5	-0.5	-0.5	-0.5	1.5	1.5	1.5	1.5	1.5	1.5
Bed Width (m)	21.4	20.2	18.8	16.12	6.2	8.8	9.2	10	10.4	10.4
Flow Area (sq.m)	61.21	55.16	47.93	36.76	56.80	61.49	61.17	62.74	63.35	62.32
Wetted Perimeter (m)	31.89	30.20	28.13	24.41	24.09	25.64	25.70	26.25	26.50	26.31
Ground Level (m)	4.15	3.2	4.3	5.47	5.47	6.20	6.30	6.20	6.00	5.90
Present Area (m2)	120	62	65	59	59.74	26.01	38.39	13.10	39.47	35.7
Excavation Area (m2)	22.8	40.3	71.6	108.4	13.6	62.3	49.0	72.4	45.0	48.8
Excavation Vol. (m3)	0	63 057	111 860	359 892	0	261 814	144 737	121 433	76 321	75 034
Excavation from 0 km to 8 km (m3)				534 808						
Excavation from 8 km to 24 km (m3)				679 340						
Total Mellar/Ghagaria Khal Excavation (m3)				1 214 148						

The second stage allows for enlargement of the Mellar Khal, the construction of the Mellar khal pump station and regulator and excavation of the Gagaria khal.

Also some local improvements to the Little Feni and its side khals has been allowed for although the design water levels at Kasirhat regulator (+3.65 m) and the supply level at the Gagaria outfall (+5.06 m PWD) suggest that such requirements should be small.

7.3.6 Flood Control and Drainage

Section 7.2 of this chapter has described in some detail the problems of the drainage congestion in the Sonaichari area and has recommended detailed survey and investigations in order to identify, quantify and cost the most cost effective measures to produce improvements in this area. However as has already been observed these will affect the downstream areas in Dakatia and / or Little Feni depending on the measures adopted and therefore the drainage of these areas also needs to be studied.

The NNDIP feasibility study has already identified that a regulator on the Dakatia produces no meaningful agricultural benefits in terms of flood protection and if operated in the monsoon season would have a definite negative effect on fisheries in the Dakatia basin. The NNDIP study also identified through modelling work that the inter basin flow between the Little Feni and the Noakhali catchments was limited and almost unaffected by changes in the regime at Kasirhat since the interbasin channels are small and the drainage problems at Kasirhat are primarily confined to the early monsoon period before the channel downstream of the regulator has been cleared of sediments.

The NNDIP study also established that a new regulator at Musapur about 16 Km downstream of Kasirhat would substantially improve water levels at all flood seasons (pre-monsoon, monsoon and post-monsoon) in the catchments upstream of Kasirhat. However the model runs also showed that about 20 Kms upstream of Kasirhat the peak water level was almost unaffected and that constrictions in the Little Feni river itself had become the dominant influence on water levels upstream of this. These findings lead back to the conclusion that it is necessary to obtain up to date accurate information concerning the Little Feni river cross section data and a full topographical survey is required as described in section 7.2 before any reliable estimates would be made of either costs or benefits.

However the consultants have considered the possibility of constructing the new regulator at Musapur without considering any benefits further upstream than Gunabati railway bridge which were the areas modelled and evaluated during the NNDIP study.

The new Musapur regulator as modelled in the NNDIP study has 22 gates of 3.05 x 3.05 with a sill level of +1.20 m the regulator would have counterweighted flap gates for drainage operation and downstream of these vertical lifting gates to retain fresh water during the dry season between Kasirhat and Musapur.

The surveyed sections at Musapur showed existing bed levels in March/April lower than the proposed sill level. However closure at this point would encourage more active siltation and therefore some operation of gates in the dry season as at the Feni regulator may be required.

The areas affected by the regulator area shown in table 7.3.5 below:

TABLE 7.3.5

Musapur Drainage Improvement Areas

Catchment Area	NCA ha.	Flood Phase Percentage			
		F0	F1	F2	F3
K2	21,295	100 (95)	0 (4)	0 (1)	0 (0)
LF1	12,056	40 (22)	58 (69)	2 (9)	0 (0)
LF2	9,733	61 (54)	18 (21)	20 (23)	1 (2)
Musapur Polder	2,312	60 (0)	40 (0)	0 (100)	0 (0)
Total	45,396	74 (62)	21 (25)	5 (13)	0 (0)

Note : Figures in brackets represent the without project situation.

The benefits of the scheme are varied and include:

- i) Cyclone Protection of the 2,312 ha NCA of the newly empoldered area.
- ii) Flood control and improvement for the areas as set out in Table 7.3.5.
- iii) Reduced salinity problems in the empoldered area.
- iv) The 16 km river reach between Kasirhat and Musapur regulators comprises approximately 496 ha of water body over 2.5 m deep which would be full of fresh water at the end of the monsoon season. This can be utilised to irrigate about 750 ha of irrigation even allowing for occasional flushing water to keep the regulator gates free of sediment.
- v) Elimination of the annual cost of building the cross dam and desilting the channel downstream of Kasirhat regulator.
- vi) Not only are cropping patterns improved by i) above but also there will be benefits owing to reduced boro crop damage.

It should be pointed out, however, that the construction of the regulator will adversely affect the fishery in the 16 km protected reach of river between the regulators (See section 7.3.9.

7.3.7 Cost of Proposed Works

The works required for the proposals described in sections 7.3.5 and 7.3.6 are set out in Table 7.3.6. The options 1 and 2 are the costs for the first stage development and the costs for stages one and two combined respectively. The works for the Musapur regulator and polder area are described as option 3.

The operation and maintenance costs are also set out and calculated in accordance with the FPCO guidelines.

TABLE 7.3.6

Engineering Quantities and Costs (1991 Prices)
(Dakatia-Little Feni Transfer (incl Dakatia irrigation)

Description	Unit	Unit Rate (Tk'000)	Quantity Option 1	Quantity Option 2	Quantity Option 3	Capital Cost (Tk'000) Option 1	Capital Cost (Tk'000) Option 2	Capital Cost (Tk'000) Option 3	O&M % of Cap.Cost	Annual O&M Cost (Tk'000) Option 1	Annual O&M Cost (Tk'000) Option 2	Annual O&M Cost (Tk'000) Option 3
1. Dakatia Regulator and Lock	Vent	6,500	1	1	-	195,000	195,000	0	3%	5,850	5,850	0
(30 Nr Vents, Size 3.04m x 3.04m)												
2. Mellar Khal Regulator												
Discharge (m3/s) Ventage												
25 - 5 Nr 1.52 m x 1.82 m	Vent	1,750	0	1	-	0	8,750	0	3%	0	263	0
3. Excavation of Dakatia River	000 m3	35	0	105	-	0	3,675	0	6%	0	221	0
4. Excavation of major tributary khals	000 m3	35	1,610	1,610	-	56,350	56,350	0	6%	3,381	3,381	0
5. Dakatia Pump Station (80 m3/s, 2.0 m head, 8 units)												
Civil Works	Nr	192,062	1	1	-	192,062	192,062	0	2%	3,841	3,841	0
E & M Works	Nr	184,589	1	1	-	115,368	184,589	0	2%	2,307	3,692	0
Electricity	-	-	-	-	-	-	-	-	sum	5,723	9,156	0
6. Mellar Khal Pump Station (25 m3/s, 4.15 m head, 4 units)												
Civil Works	Nr	56,411	0	1	-	0	56,411	0	2%	0	1,128	0
E & M Works	Nr	129,963	0	1	-	0	129,963	0	2%	0	2,599	0
Electricity	-	-	-		-	-	-	-	sum	0	5,937	0
7. Mellar Khal Excavation (8km)	000 m3	35	0	535	-	0	18,725	0	6%	0	1,124	0
8. Excavation of Ghagaria Khal (14km)	000 m3	40	0	679	-	0	27,160	0	6%	0	1,630	0

Description	Unit	Unit Rate (Tk'000)	Quantity Option 1	Quantity Option 2	Quantity Option 3	Capital Cost (Tk'000) Option 1	Capital Cost (Tk'000) Option 2	Capital Cost (Tk'000) Option 3	O&M % of Cap.Cost	Annual O&M Cost (Tk'000) Option 1	Annual O&M Cost (Tk'000) Option 2	Annual O&M Cost (Tk'000) Option 3
9. Coastal Embankment (Height 4 m)	km	5,956	0	0	5.5	0	0	32,758	6%	0	0	1,965
10. New Regulator at Musapur on Little Fen (22 Nr Vents, Size 3.05m x 3.05m)	Vent	8,554	0	0	1	0	0	188,190	3%	0	0	5,646
11. Saving on Desilting Kazirhat Regulator	-	-	-	-	-	-	-	-	sum	0	0	(3,500)
12. Excavation of Little Feni River and Formation of Embankments	000 m3	40	0	100	100	0	4,000	4,000	6%	0	240	240
13. Electricity Transmission Line	km	450	1	1	-	450	450	0	2%	9	9	0
14. Transformers	Nr	9,000	1	2	-	9,000	18,000	0	2%	180	360	0
15. Vehicles	Nr	1,000	4	6	1	4,000	6,000	1,000	4%	440	660	110
16. Buildings	Sum	-	-	-	-	500	500	0	6%	30	30	0
17. Land Acquisition	ha	400	27	48	66	10,800	19,200	26,400	-		0	0
Total Base Cost						583,531	920,835	252,348		21,761	40,120	4,461
Engineering & Administration (15% of Capital Cost+Contingencies)						109,412	172,657	47,315		0	0	0
Physical contingency (25%)						145,883	230,209	63,087		5,440	10,030	1,115
Total Cost						838,825	1,323,701	362,750		27,201	50,150	5,576

Note: Option 3 consists only of providing Musapur regulator downstream of Kazirhat Regulator

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7.3.8 Economic Evaluation

The changes in cropping pattern resulting from the three options are shown in Tables 7.3.7 to 7.3.9 and the economic costs are shown in Table 7.3.10.

For option 1 it has been assumed that boro yield with the existing water supply is 4.6 tons/ha/(a reduction of 10% compared with the with project condition). For option two the reduction is greater for the Little Feni catchment area at 15% which is in accordance with the published statistics which show consistently lower yields in this district than in any other.

The evaluation for Option 3 has assumed an annual reduction in boro crop flood damage of 7.5% on existing boro areas in addition to cropping pattern change benefits. The analysis of option 3 has also allowed for an annual fisheries loss of Tk. 15.0 m (See section 7.3.9 below and 7.3.6.

For options 1 and 2 no fisheries losses are anticipated since the Dakatia regulator and pump station will not be operated during normal flood season flows and during the dry season river and khal levels would be increased.

Summarises of the benefits are given in Table 7.3.11 and the summary of the economic analyses are given in Tables 7.3.12 to 7.3.1.14.

The rates of return for options one and two are of a similar order and the assumptions are considered conservative. It is interesting to note that if the water consumption rate was reduced from 1.50 l/s/ha to 1.30 l/s/ha then the benefits would increase by over 30% since the additional area irrigated by the project would increase by approximately 7,150 ha from 22,870 ha to 30,020 ha and all of this would be in the Muhuri or Noakhali areas. This in turn would raise the rate of return on option 2 to about 14% since the additional costs would be small (increased capacity in Mellar khal pump station and adjacent khals).

Option 3 shows a satisfactory rate of return and suggests that this relatively inexpensive proposal (capital cost Tk 363 m at financial prices) is viable. This is so even without considering the benefits which would accrue from improvements in the Little Feni upstream of Gunabati railway bridge and in Sonachari area. Thus the prospects for overall benefits including irrigation and drainage appear promising bearing in mind that the major cost element has already been accounted for in the option 3 analysis.

7.3.9 Qualitative Impacts

For options 1 and 2 the negative impacts should be minor since there would be no negative affect on fisheries and there should be no affect at all on external areas.

The reversal of dry season flows in the Dakatia in conjunction with greater water depths in the river and khals could have a minor beneficial effect on fisheries. Also the larger volumes of water will help to dilute any pollutants coming down the river which even under present conditions never get out of the Dakatia river since existing irrigation produces a net inflow and all flows are abstracted by irrigation pumps.

TABLE 7.3.7

Summary of Cropping Pattern Changes

Planning unit 4 - Little Feni River Option 1 (including 12871 ha irrigated from the Dakatia

	% of NCA	% of NCA	% of NCA	% of NCA	% of NCA
B Aus	11	10	9	5	3
T Aus, HYV	5	5	6	6	6
B Aman	19	19	19	14	15
LT Aman	21	21	20	20	19
HYV Aman	24	24	25	24	24
L Boro	2	2	2	2	2
HYV Boro	49	51	56	72	76
Wheat irrig.	5	5	6	7	7
Wheat unirrig.	1	1	1	0	0
Potato irrig.	1	1	1	1	1
Potato unirrig.	1	1	1	1	0
Jute	1	1	1	0	0
Sugarcane	0	0	0	0	0
Pulses	3	3	3	1	1
Oilseeds	4	4	4	1	1
Spices	0	0	0	0	0
Veg. irrig.	1	1	2	2	2
Veg. unirrig.	1	1	1	0	0
Total	149	151	154	156	160

TABLE 7.3.8

Survey of Cropping Pattern Changes

Planning Unit 4 Little Feni River Option 2 (including 12871 ha irrigated from the Dakatia and 2333 ha in Noakhali)

	% of NCA	% of NCA	% of NCA	% of NCA	% of NCA
B Aus	13	12	10	1	0
T Aus, HYV	5	6	6	7	7
B Aman	19	19	19	14	14
LT Aman	21	21	20	19	19
HYV Aman	25	25	25	26	26
L Boro	1	1	2	2	2
HYV Boro	47	49	53	82	84
Wheat irrig.	5	5	6	8	8
Wheat unirrig.	1	1	1	0	0
Potato irrig.	1	1	1	2	2
Potato unirrig.	1	1	1	0	0
Jute	1	1	1	0	0
Sugarcane	0	0	0	0	0
Pulses	3	3	3	1	1
Oilseeds	5	4	4	1	1
Spices	0	1	1	0	0
Veg. irrig.	1	1	2	2	2
Veg. unirrig.	1	1	1	0	0
Total	149	151	154	166	167

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TABLE 7.3.9

Summary of Cropping Pattern Changes

(% of NCA

Planning Unit 4 - Little Feni River Option 3

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus	23	21	19	22	20
T Aus, HYV	9	10	10	11	12
B Aman	3	3	3	1	1
LT Aman	30	30	29	29	28
HYV Aman	54	55	55	62	63
L Boro	0	0	0	0	0
HYV Boro	23	27	32	28	32
Wheat irrig.	4	4	5	5	6
Wheat unirrig.	0	0	0	0	0
Potato irrig.	1	1	1	1	1
Potato unirrig.	4	3	3	4	3
Jute	1	1	1	1	1
Sugarcane	1	1	1	1	1
Pulses	3	3	3	3	3
Oilseeds	3	3	3	3	3
Spices	0	0	0	0	0
Veg. irrig.	1	1	1	1	1
Veg. unirrig.	1	1	1	1	1
Total	160	164	168	172	176

TABLE 7.3.10

Capital and O & M Costs in Economic Prices
Dakatia-Little Feni Transfer (incl Dakatia irrigation)

(Tk'000)

	Description	Capital Cost (Financial Prices			Conversion	Capital Cost (Economic Prices)			O&M Cost (Financial Prices)			Conversion	O&M Cost (Economic Prices)		
		Option 1	Option 2	Option 3	Factor	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3	Factor	Option 1	Option 2	Option 3
1.	Dakatia Regulator and Lock (30 Nr Vents, Size 3.04m x 3.04m)	195,000	195,000	0	0.70	137,280	137,280	0	5,850	5,850	0	0.72	4,220	4,220	0
2.	Mellar Khal Regulator Discharge (m3/s) Ventage 25 - 5 Nr 1.52 m x 1.82 m	0	8,750	0	0.70	0	6,160	0	0	263	0	0.72	0	189	0
3.	Excavation of Dakatia River	0	3,675	0	0.66	0	2,433	0	0	221	0	0.70	0	154	0
4.	Excavation of major tributary khals	56,350	56,350	0	0.66	37,304	37,304	0	3,381	3,381	0	0.70	2,368	2,368	0
5.	Dakatia Pump Station (80 m3/s, 2.0 m head, 8 units)														
	Civil Works	192,062	192,062	0	0.71	136,038	136,038	0	3,841	3,841	0	0.71	2,738	2,738	0
	E & M Works	115,368	184,589	0	0.64	73,593	117,749	0	2,307	3,692	0	0.70	1,626	2,601	0
	Electricity	0	0	0	-	0	0	0	5,723	9,156	0	1.54	8,813	14,100	0
6.	Disaganj Pump Station (25 m3/s, 4.15 m head, 4 units)														
	Civil Works	0	56,411	0	0.71	0	39,956	0	0	1,128	0	0.71	0	804	0
	E & M Works	0	129,963	0	0.64	0	82,903	0	0	2,599	0	0.70	0	1,831	0
	Electricity	0	0	0	-	0	0	0	0	5,937	0	1.54	0	9,143	0
7.	Mellar Khal Excavation (8km)	0	18,725	0	0.66	0	12,396	0	0	1,124	0	0.70	0	785	0

Description	Capital Cost (Financial Prices			Conversion	Capital Cost (Economic Prices)			O&M Cost (Financial Prices)			Conversion	O&M Cost (Economic Prices)		
	Option 1	Option 2	Option 3	Factor	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3	Factor	Option 1	Option 2	Option 3
8. Excavation of Ghagaria Khal (14km)	0	27,160	0	0.66	0	17,980	0	0	1,630	0	0.70	0	1,141	0
9. Coastal Embankment (Height 4 m)	0	0	32,758	0.66	0	0	21,686	0	0	1,965	0.70	0	0	1,373
10. New Regulator at Musapur on Little Fen (22 Nr Vents, Size 3.05m x 3.05m)	0	0	188,190	0.70	0	0	132,486	0	0	5,646	0.72	0	0	4,073
11. Saving on Desilting Kazirhat Regulator	0	0	0	-	0	0	0	0	0	(3,500)	0.68	0	0	(2,368)
12. Excavation of Little Feni River and Formation of Embankments	0	4,000	4,000	0.66	0	2,648	2,648	0	240	240	0.70	0	168	168
13. Electricity Transmission Line	450	450	0	0.64	288	288	0	9	9	0	0.87	8	8	0
14. Transformers	9,000	18,000	0	0.64	5,756	11,513	0	180	360	0	0.87	157	313	0
15. Vehicles	4,000	6,000	1,000	0.68	2,720	4,080	680	440	660	110	0.87	383	574	96
16. Buildings	500	500	0	0.79	395	395	0	30	30	0	0.72	22	22	0
17. Land Acquisition	10,800	19,200	26,400	0.28	3,054	5,429	7,465	0	0	0	-	0	0	0
Total Base Cost	583,531	920,835	252,348		396,428	614,552	164,964	21,761	40,120	4,461		20,333	41,161	3,341
Engineering & Administration (15% of C	109,412	172,657	47,315		74,330	115,228	30,931	0	0	0		0	0	0
Physical contingency (25%)	145,883	230,209	63,087		99,107	153,638	41,241	5,440	10,030	1,115		5,083	10,290	835
Total Cost	838,825	1,323,701	362,750		569,865	883,418	237,136	27,201	50,150	5,576		25,416	51,451	4,176

Note: Option 3 consists only of providing Musapur regulator downstream of Kazirhat Regulator

TABLE 7.3.11

Summary of Benefits

Planning Unit 4 - Little Feni River Option 1

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Incremen (1)	% Increment (2)
Net Cultivated Area	'000 hectares	54.9	54.9	54.9	54.9	54.9	0	0
Irrigated Area	'000 hectares	31.4	33.1	36.0	46.0	48.9	39	36
Labour Requirement	million man day	14.3	14.5	15.0	15.7	16.1	8	8
Paddy Production	'000 tonnes	250	257	269	304	316	18	18
Cropping Intensity	% NCA	149	151	154	156	160	4	4
Irrigated area	% NCA	57%	60%	66%	84%	89%	39	36
Net Crop Income	million Taka	714	734	766	891	926	21	21
Crop flood loss reduction	million Taka				0	0		
Non-agric. flood loss reduction	million Taka				0	0		
Fish catch reduction	million Taka				0	0		
Little Feni River Option 2								
Net Cultivated Area	'000 hectares	57.2	57.2	57.2	57.2	57.2	0	0
Irrigated Area	'000 hectares	31.4	33.1	36.0	55.4	56.6	67	57
Labour Requirement	million man day	14.8	15.1	15.6	17.6	17.7	16	14
Paddy Production	'000 tonnes	258	265	277	348	353	31	28
Cropping Intensity	% NCA	149	151	154	166	167	10	8
Irrigated area	% NCA	55%	58%	63%	97%	99%	67	57
Net Crop Income	million Taka	730	750	781	1,023	1,038	36	33
Crop flood loss reduction	million Taka				0	0		
Non-agric. flood loss reduction	million Taka				0	0		
Fish catch reduction	million Taka				0	0		
Little Feni River Option 3								
Net Cultivated Area	'000 hectares	45.4	45.4	45.4	45.4	45.4	0	0
Irrigated Area	'000 hectares	12.6	15.0	17.6	15.8	18.3	5	4
Labour Requirement	million man day	12.6	13.0	13.4	13.7	14.1	5	5
Paddy Production	'000 tonnes	202	211	221	229	239	9	8
Cropping Intensity	% NCA	160	164	168	172	176	5	5
Irrigated area	% NCA	28%	33%	39%	35%	40%	5	4
Net Crop Income	million Taka	630	660	691	704	736	7	6
Crop flood loss reduction	million Taka				21	25		
Non-agric. flood loss reduction	million Taka				16	16		
Fish catch reduction	million Taka				15	15		

Notes:

Project Year 1: assumed 1994/95

Future Without (1): Future Without Project Conditions, 5 years after project would have been completed

Future Without (2): Future Without Project Conditions, Year 30

Future With (1): Future With Project Conditions, 5 years after project completion

Future With (2): Future With Project Conditions, Year 30

% Increment (1): % difference FW (1) over FWO (1)

% Increment (2): % difference FW (2) over FWO (2)

Flood losses refer to average annual losses that will be eliminated by the project.

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TABLE 7.3.12

Summary of Results and Sensitivity Analyses

Planning Unit 4 - Little Feni River Option 1

Capital cost 569.9 Tk.m. construction period 5 years
Annual O&M cost 25.4 Tk.m. (economic prices)

Net Present Value @12% -31.95 Taka million (economic prices)
Economic Internal Rate of Return 11.25 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	11.3	10.4	9.3	7.8	12.2	14.0	18.3	7.78
O&M Costs	11.3	11.0	10.6	9.9	11.5	11.9	12.6	28.24
Fisheries Losses	11.3	11.3	11.3	11.3	11.3	11.3	11.3	N/A
Reduced flood losses	11.3	11.3	11.3	11.3	11.3	11.3	11.3	N/A
Total Benefits	11.3	12.4	13.9	16.2	10.0	7.9	3.4	6.49
Incremental Net								
Crop Income	11.3	12.4	13.9	16.2	10.0	7.9	3.4	6.49
Delay in full benefits								
2 years	10.4							
4 years	9.5							
Delays in completion								
2 years	10.1							
4 years	9.0							

TABLE 7.3.13

Summary of Results and Sensitivity Analyses

Planning Unit 4 - Little Feni River Option 2

Capital cost 883.4 Tk.m. construction period 5 years
Annual O&M cost 51.5 Tk.m. (economic prices)

Net Present Value @12% -42.49 Taka million (economic prices)
Economic Internal Rate of Return 11.36 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	11.4	10.5	9.4	7.9	12.3	14.1	18.4	6.67
O&M Costs	11.4	11.0	10.5	9.6	11.7	12.2	13.0	18.56
Fisheries Losses	11.4	11.4	11.4	11.4	11.4	11.4	11.4	N/A
Reduced flood losses	11.4	11.4	11.4	11.4	11.4	11.4	11.4	N/A
Total Benefits	11.4	12.6	14.2	16.7	10.0	7.8	2.7	5.16
Incremental Net								
Crop Income	11.4	12.6	14.2	16.7	10.0	7.8	2.7	5.16
Delay in full benefits								
2 years	10.3							
4 years	9.5							
Delays in completion								
2 years	10.2							
4 years	9.1							

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TABLE 7.3.14

Summary of Results and Sensitivity Analyses

Planning Unit 4 - Little Feni River Option 3

Capital cost 237.1 Tk.m. construction period 3 years
Annual O&M cost 4.2 Tk.m. (economic prices)

Net Present Value @12% 114.77 Taka million (economic prices)
Economic Internal Rate of Return 17.60 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable						Switching Value (%)
		+10%	+25%	+50%	-10%	-25%	-50%	
Capital Costs	17.6	16.4	14.8	12.7	19.0	21.7	28.6	60.45
O&M Costs	17.6	17.5	17.3	17.0	17.7	17.9	18.2	486.08
Fisheries Losses	17.6	17.2	16.6	15.6	18.0	18.6	19.6	135.78
Reduced flood losses	17.6	18.6	20.0	22.3	16.6	15.1	12.3	53.04
Total Benefits	17.6	19.4	21.9	25.8	15.7	12.6	6.3	27.81
Incremental Net Crop Income	17.6	18.4	19.6	21.5	16.7	15.4	12.9	58.45
Delay in full benefits								
2 years	14.5							
4 years	13.0							
Delays in completion								
2 years	15.5							
4 years	13.7							

The monsoon river regime would normally be unaffected since there are no embankments proposed and the regulator should normally remain open. However the existence of the regulator would allow it to be used temporarily in the event of an exceptional flood event such as 1974 (1 in 50 years in the area) which could be beneficial in protecting homesteads and other infrastructure.

It should not be used in normal flood events since this would have an adverse affect on fisheries. At the feasibility stage it could be important to identify any possible benefits in this respect and to clearly define operating rules to ensure minimum obstruction to fish if the regulator were to be used in this way. In common with most irrigation interventions the encouragement of HYV boro crops at the expense of other rabi crops and aus crops would lead to loss of biodiversity and deterioration of diet. However this latter is not irreversible since there will always be sufficient non-irrigated land on which to grow pulse crops and a national health education programme combined with crop diversification programmes could overcome this problem.

The displacement of people required for land acquisition should be very small. A substantial proportion of the land required is for the new Dakatia regulator and pump station and the associated new channel. Therefore with careful planning it should be possible to reclaim almost as much land form the existing channel, which would be abandoned, as is required for the new channel although the full cost of compensation has been allowed for in the economic analysis.

As elsewhere, general increases in agricultural production tend to alleviate poverty, through increases in requirements for labour but the landless poor do not benefit to the same extent as landholders so social inequity can also be increased. The likely improvement in dry season capture fisheries would have a positive impact upon fishermen, unlike in most FCD project.

Local navigation is likely to be improved by the maintenance of water in the khals during the dry season, but this benefit will be offset by the inconvenience of having to pass through the lock at the Dakatia Regulator during the months of January to mid April.

Option 3 will have one substantial negative impact and this concerns the effect on the capture fishery between Kasirhat and Musapur. A small sample survey was carried out in this area which suggested that the few people in the area (it is very lightly populated) are involved both in farming and in fisheries but the survey suggested that they were more interested in protection from cyclones, salinity and flooding than they were concerned about loss of the fishery.

Other negative impacts concern a small area wetlands reduction and the possible affects on migrating birds (See Annex IV). Displacement in the case of option 3 is likely to be minor since the area is sparsely populated and again there will be opportunities to reclaim some of the land needed for the new channel.

Qualitative impacts are summarised in Table 7.3.15

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TABLE 7.3.15

Qualitative Impacts for Dakatia/Little Feni Proposals
(Ranked from - 5 to + 5).

Impacts	Rating	
	Option 1 and 2	Option 3
Physical		
Sea Level Rise Vulnerability	0	+ 1
Morphology (erosion and sedimentation)	0	+ 2
Surface Water Quality	- 1	+ 2
Cyclones	0	+ 2
Salinity	0	+ 2
Ecological		
Wetlands Reduction	0	- 3
Biodiversity - Crop Species	- 1	- 1
Biodiversity - Aquatic (Non-Fish)	0	0
Capture Fisheries	+ 1	- 2
Culture Fisheries	+ 1	+ 2
Socio-Economic		
Displacement	- 1	- 1
Social Conflicts	0	0
Investment Opportunities	+ 1	+ 1
Income Distribution	- 1	- 1
Poverty Alleviation	+ 1	+ 2
Quality of Life		
Housing and Public Buildings	0	+ 1
Nutrition	- 1	+ 1
Transport Systems	- 1	0
Public Health, Diseases and Vectors	- 1	0

7.4 Planning Unit 6 - Chandpur Irrigation Project

7.4.1 General Description

Chandpur Irrigation Project (CIP) was first identified by the Master Plan for the Tiperrah and Chittagong Multipurpose Development Scheme. General modifications were made over the years, construction commenced in 1963 and was completed in 1976. The scheme covers 53 800 ha gross, with a cultivable area of 39 750 ha and net irrigable area of 23 132 ha. The scheme consists of a polder and the west bank faces the Lower Meghna river, as shown in Figure 7.4.1. The South Dakatia is a meandering distributary of the Dakatia and bisects the area from north to south. There is a pump station in the north at Charbagadi which is reversible so that it is used for both irrigation and drainage. There is also a regulator and large navigation locks at Charbagadi and a regulator and a lock at Hajimara in the south.

Irrigation water is pumped from the main pump station in to peripheral canals which follow the boundary embankments and into the South Dakatia River. From the peripheral canals water is taken directly by low lift pumps or allowed to flow into secondary canals or khals, and the river. Secondary pumping is required everywhere. In isolated pockets of higher ground STW are used.

7.4 Previous Studies

The scheme has been studied extensively by Rahman, 1979, World Bank 1982, Alamgir 1983 Thompson 1986, Ahmed and Nishat, 1987, Systems Rehabilitation Project (EPC 1987) and the Systems Rehabilitation Project (SRP) is now also studying it under the O&M component, the erosion on the Lower Meghna bank is also being studied by the FAP 9B, the Meghna Short Term Protection Study and a new study is expected to start in 1992, FAP 5B. the Meghna Estuary Study.

7.4.3 Constraints

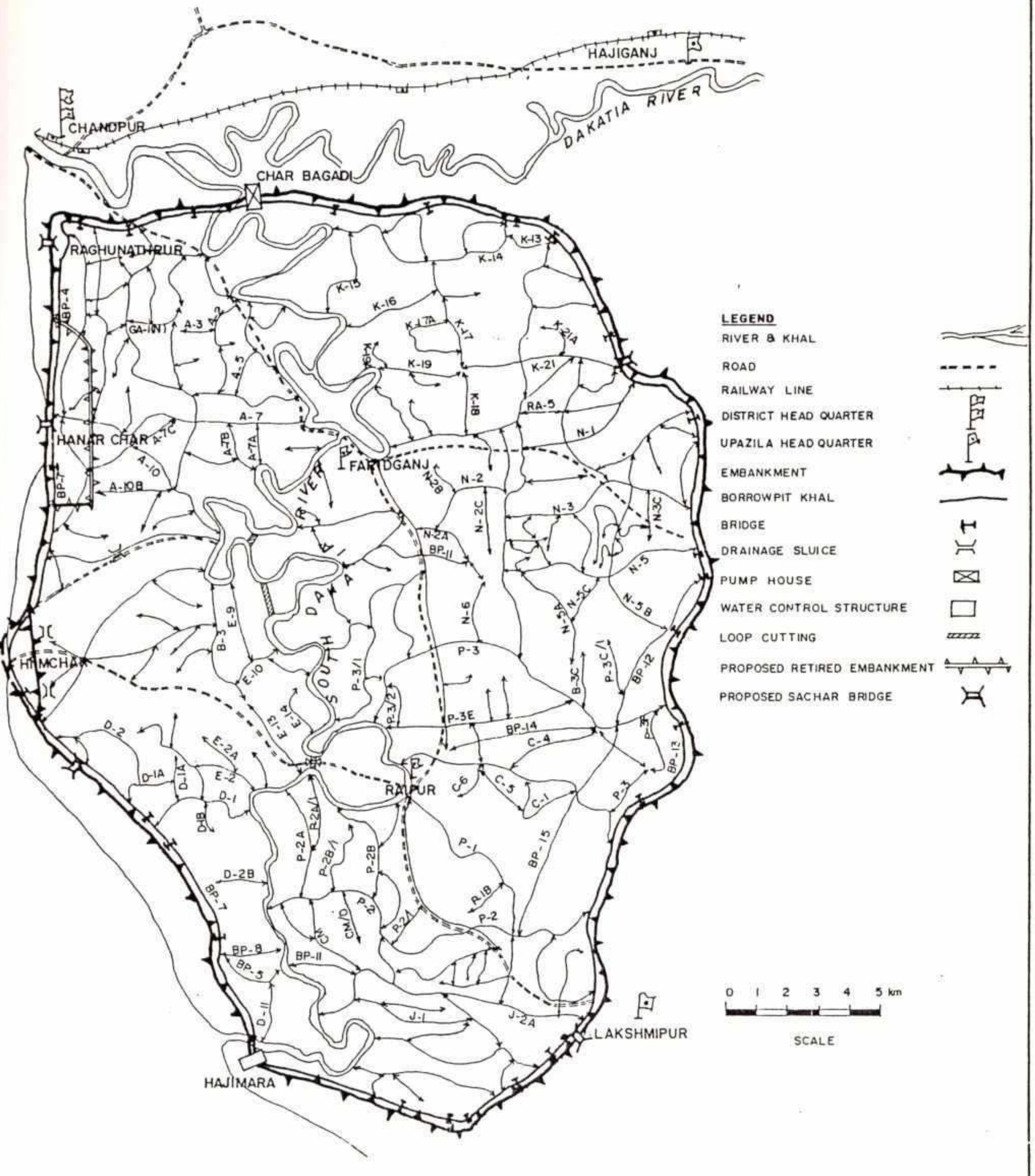
The scheme has faced four problems, namely bank erosion on the Lower Meghna side, structural problems at Charbagadi pump station, loss of capture fisheries and extensive growth of water hyacinth. These are dealt with below.

a) Lower Meghna Bank Erosion

Some years ago the bank on the Lower Meghna was breached at its most western point, at Haimchar, and subsequently retired. This was the location being studied by FAP 9B, but at present erosion appears to be slowing down and no problems have been reported in recent years. On the other hand the embankment at Hanarchar, about five km north of Haimchar breached in 1991, fortunately this breach was caused by the bank slipping on the falling flood and flooding of the scheme did not occur. This breach is being overcome by retiring the embankment by about 1 km under SRP financed by IDA funds. FAP 9B staff have indicated that if Eklaspur and Chandpur town are made into hard points then the Lower Meghna left bank may eventually stabilise, although a further intermediate hard point may be required. Further studies may be carried out under the proposed FAP 5B.

Figure 7.4.1

Chandpur Irrigation Project - General Layout



SOURCE : CHANDPUR O & M DIVISION.

The recent decision to delay any intervention at Chandpur could have serious consequences not only for the town but also for the CIP which must be considered to be at risk from any progression of the bend of the Padma/Lower Meghna downstream. The consequences of such progression could be extreme with the Lower Meghna taking a new course (perhaps eventually through a greatly enlarged South Dakatia river).

b) Charbagadi Pump Station

There have been two problems at this pump station, piping beneath the structure and structural cracking of the pump station. The piping appears to have been overcome by adding backfill and should be carefully monitored. The structural cracking is an old problem and the cracks do not appear to be deteriorating, they should also be carefully monitored. Previous reports have indicated that normal monitoring and 0 & M should be adequate.

c) Capture Fisheries

When the scheme was first completed the loss of capture fisheries was alarming due to the isolation of the scheme from the Lower Meghna which prevented the entry of migratory species. The Raipur Fish Hatchery was developed by the government and brought about major developments in culture fisheries. The Raipur hatchery is now in decline but it has inspired many small hatcheries and nurseries in the private sector which maintain culture fish stocks.

d) Water Hyacinth

Water hyacinth presently causes severe problems for fishermen and navigation. In parts it is reported to be so dense that it is very difficult to cut through. However there appears to be no reason why it could not be dealt with by timely O & M works (i.e. tackling the problem before it becomes too thick and difficult to cut through) a properly organised and supervised programme could ensure that the regulator at Hazimara is not obstructed.

7.4.5 Project Options

The SRP has collected extensive information on O&M costs and requirements. The major proposed works are retirement of the embankment at Hanarchar and excavation of canals and drainage channels. Other works include electrification of the regulator at Hajimara, (possibly by diesel electric generator) and supply of vehicles and office equipment. Other works may emerge in due course but for this regional plan only the retirement of the embankment and the excavation of canals and drainage channels are considered.

7.4.5. Costs

The costs of the works required for Chandpur have been taken from the BWDB SRP. These are shown in Table 7.4.1, they include retirement of the embankment at Hanarchar, re-excavation of canals and drainage channels, and land acquisition. For the O&M costs, the figures have also been taken from SRP.

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7.4.6 Economic Evaluation

The benefits of retirement are so great in comparison to cost that only a very broad analysis has been done. For the economic evaluation it has been assumed that if the work is not done then the scheme will no longer be an FCD project, however it is assumed that irrigation will continue very much in its present form; this assumption is based on the figures of Thompson (1990) which are summarised below in Table 7.4.2. The full Table on which these results are based is given in Table 7.4.3.

From Table 7.4.3 it may be seen that various economic analyses show that returns to the irrigation component are better then the returns to the FCD component, the exceptions being Appraisals 1 and 2. Therefore the assumption that only the FCD component would be lost is quite conservative. Strictly speaking the cost of irrigation should include the cost of a canal to take irrigation water past the breach but this has been excluded at this level of analysis. For this analysis the net differential economic return to FCD is taken as calculated in assessment 4. i.e. Tk 30.7 million, in 1978 prices. To make these commensurate with 1991 prices a factor of 1.77 has been used, based on Interim Report Annex V Table VII-1. (it should be noted that these figures are only concerned with returns to irrigation and FCD they have no bearing on capital or O & M costs).

The other assumptions that have been made are that the change to fisheries is nil, since any increase in capture fisheries brought about by a breach in the embankment would be offset by the loss in culture fisheries which are now very substantial in Chandpur.

TABLE 7.4.1

Chandpur Irrigation Project - Cost (Tk 000)

	Financial Capital Cost	SCF	Economic Capital Cost
Embankment at Hanarchar	12 000	0.66	7 920
Re-excavate canals and drainage channel	12 150	0.66	8 019
Land acquisition	19 433	0.28	5 441
Sub-total	43 583		21 780
Physical contingencies 15%	8 172		4 009
Engineering & administration 25%	10 896		5 345
Sub-total capital costs	62 651		30 734

O&M Costs

	Financial O & M Cost	SCF	Economic O & M Cost
Pumping costs	10 197	1.54	15 703
Maintain embankments	5 768	0.70	4 038
Establishment etc.	15 141	0.72	10 902
	31 106		30 643

All costs abstracted from BWDB Systems Rehabilitation Project.

TABLE 7.4.2

Net Economic Returns to Different Scenarios (Tk million pa)

	Without Project	Full Project	FCD only	Irrigation only
Total	196.0	329.0	226.7	257.3
Differential		133.0	30.7	61.3

TABLE 7.4.3

Returns (Tk million) to Alternative Scenarios and Alternative Evaluation Parameters

Alternative evaluation	Before	Without	With CIP (1)	With CIP (2)	CIP FCD only	Irrigation only	Columns represent cropping patterns and associated yields, hence FCD only yields are "with" yields for aus and aman season crops but "without" yields for boro and rabi crops, irrigation only yields are the reverse. All values are in Tk millions and at 1978/9 prices; the table summarises the results of seven sets of micro computer spread sheet calculations.
1 World Bank (1981) Net Econ Ret total Net Econ Ret diff Gross Ret diff Farm Cost diff	193.9	244.9	564.9 320.0 555.2 235.1	520.8 275.9 503.3 227.4	452.9 208.0 436.4 228.4	423.0 178.1 349.3 171.2	(1) World Bank (1981) cropping pattern (2) This study's cropping pattern Net Econ Ret: Net economic return to agriculture in each situation. Gross Ret: Gross return to agriculture (all products multiplied by economic values).
2 Net Econ Ret total Net Econ Ret diff Gross Ret diff Farm Cost diff	193.9	244.9	564.9 282.0 443.2 161.2	520.8 237.9 391.4 153.4	452.9 170.0 324.4 154.4	423.0 140.1 237.4 97.2	Farm Cost: All production costs, including labour, at economic values. diff: Difference between value of relevant total for each "with" situation and the "without" total - represents the incremental impact of the alternative project condition.
3 Net Econ Ret total Net Econ Ret diff Gross Ret diff Farm Cost diff	193.9	282.9	309.2 26.3 187.5 161.2	345.3 62.4 215.8 153.4	216.4 -66.4 88.0 154.4	256.2 -26.7 70.6 97.2	Assessment 1: replicates closely the assumptions in World Bank (1981) - the revised project appraisal, survey based without yields are used, but the without cropping pattern, with yields and values in World Bank (1981) are used.
4 This evaluation Net Econ Ret total Net Econ Ret diff Gross Ret diff Farm Cost diff	144.6	196.0	320.4 124.4 163.4 39.0	329.0 133.0 165.4 32.4	226.7 30.7 62.5 31.8	257.3 61.3 61.9 0.6	Assessment 2: as assessment 1, but the without cropping pattern found in this study is used. Assessment 3: as assessment 2, but using expected with project yields derived from surveys.
5 Net Econ Ret total Net Econ Ret diff Gross Ret diff Farm Cost diff	121.9	163.3	278.2 114.9 161.5 46.6	286.8 123.4 162.4 39.0	186.4 23.0 60.0 36.9	220 56.7 59.0 2.2	Assessment 4: as assessment 3, but using economic values estimated in this study. This forms the main Post-Evaluation. The following parameters are used: a standard conversion factor of 0.8, traded good values from Table 7.7, and shadow wage rates of TK.7.5 per day (hired) and Tk.5.5 a day (family). Note that in this and following assessments the operating costs of LLP schemes are included in on farm costs, whereas in assessments 1.3 they are treated separately (excluded from this table) following World Bank (1981).
6. Net Econ Ret total Net Econ Ref diff Gross Ret diff Farm Cost diff	148.9	198.7	318.5 119.9 161.5 41.6	326.5 127.8 162.4 34.6	227.3 28.6 60.0 31.4	254.6 56.0 59.0 3.0	Assessment 5: as assessment 4, but using higher economic values: a standard conversion factor of 1.0 and a shadow wage rate of Tk 10 per day for all work.
7 MPO (1987e)values Net Econ Ret total Net Econ Ret diff Gross Ret diff Farm Cost diff	121.8	154.5	224.2 69.7 107.6 37.9	236.3 81.8 112.6 30.9	168.8 14.2 39.2 25.0	183.4 28.8 36.1 7.3	Assessment 6: as assessment 4, but using intermediate economic values - the same as in assessment 4 except for a standard conversion factor of 1.0. Assessment 7: as assessment 4, but using economic values given in MPO (1987e) deflated to 1978/9 prices.

Extracted from the Impact of Flood Control on Agriculture and Rural Development in Bangladesh, Post Evaluation of the Chandpur Project P.M Thomson 1990.

CH7F-P2

The economic costs of the retirement and rehabilitation may be summarised as follows:

Capital costs	Tk	30.7 million
O&M costs	Tk	30.6 million p.a.

It has been assumed that BWDB still has to pay for pumping etc. and maintaining existing embankments (for irrigation canals).

The benefits are:

Incremental crop income	Tk	54.3 million p.a.
Non agricultural flood damage avoided		59.2
Fisheries losses		NIL

Total benefits		113.5
Deduct cost of pumping Maintenance of embankments for irrigation etc.		34.9

Net incremental benefits	Tk	78.6 million p.a.

This analysis suggests that the projected benefits will recover costs of retirement of the embankment in one year after completion. The economic evaluation has been based on the assumption that the costs are spread over two years and the benefits do not arise until year 3.

The key economic indicators of the project are:

EIRR base case	78%
EIRR allowing for 25% increase in capital cost	65%
EIRR allowing for 25% increase in O&M cost	64%
EIRR allowing for 25% decrease in total benefit	46%
EIRR allowing for 25% decrease in incremental net crop income	51%
EIRR allowing for 2 yr delay in benefits	26%

7.4.7 Qualitative Criteria

The qualitative criteria are summarised in Table 7.4.4. The assessment is the reverse of the normal one but the scheme will still be subject to a possibly extreme erosion threat from the Lower Meghna River. This possibility cannot be averted by any proposal other than the hardpoint suggested by FAP 9B. If those works are not undertaken then the CIP must be considered at risk, although the timing and degree of damage is extremely difficult to predict. The capture fisheries would improve slightly but it is considered that the inhabitants would take steps to preserve their culture fisheries.

However, on social grounds, it would be most undesirable to allow the system to revert to its previous situation. The population has adjusted to the project and there would be a great upheaval if such a catastrophic negative change were to occur.

Retirement of embankments always requires substantial land acquisition with the consequent displacement of many people and the ensuring conflict between those inside and outside the new alignment.

TABLE 7.4.4

Qualitative Impacts of Retirement of Chandpur Embankment
(Ranked from - 5 to + 5)

Impact	Rating
Morphology (Sedimentation erosion etc)	+ 1
Surface Water Quality	0
Ecological	
Wetlands Reduction	0
Biodiversity - Crop Species	- 1
Biodiversity - Aquatic (Non-Fish)	- 1
Capture Fisheries	1
Culture Fisheries	0
Socio-Economic	
Displacement	- 2
Social Conflicts	- 1
Investment Opportunities	1
Income Distribution	1
Poverty Alleviation	2
Quality of Life	
Housing and Public Buildings	1
Nutrition	1
Transport Systems	0
Health Diseases and Vectors	0

7.5 Planning Unit 8 - Dhonagoda

7.5.1 General Description and Constraints

This planning unit is bounded by the Daudkandi-Comilla road in the north, the Lalmai Hills in the east, the Chandpur-Comilla road in the south and the Meghna Dhonagoda Irrigation Project (MDIP) and the Chandpur-Matlab road in the west. Its gross area is 112 405 ha, and net cultivable area (NCA) 88 065 ha. The thanas included, in whole or in part, are Matlab, Hajiganj, Kachua, Shahrasti and Chandpur in Chandpur District and Daudkandi, Chandina, Barura, Burichang and Kotwali in Comilla District.

The planning unit may be considered in two parts:

- the generally low-lying Meghna flood plain, including particularly deeply flooded areas south of Daudkandi. In addition to the peak flood depths which tend to prevent the cultivation of T. aman and HYV aman, some areas, particularly in the west, suffer from early monsoon flooding which may damage aus crops and in the lowest areas the boro crop. These low lying areas, however, often have surface water available for irrigation. Groundwater potential is limited by salinity in some of the thanas and possibly also by gas.

- the higher land in the east, rising to the Lalmai Hills. Flooding is less of a problem here, and deep tubewell (DTW) potential is high, with little salinity constraint. Surface water is scarce.

In the north west of the area (Figure 7.5.1) is the Gugrajola Irrigation Project, which was completed during this study although not all the khal deepening proposed has been implemented.

7.5.2 Previous Studies

(i) Master Plan (International Engineering Co., December 1964).

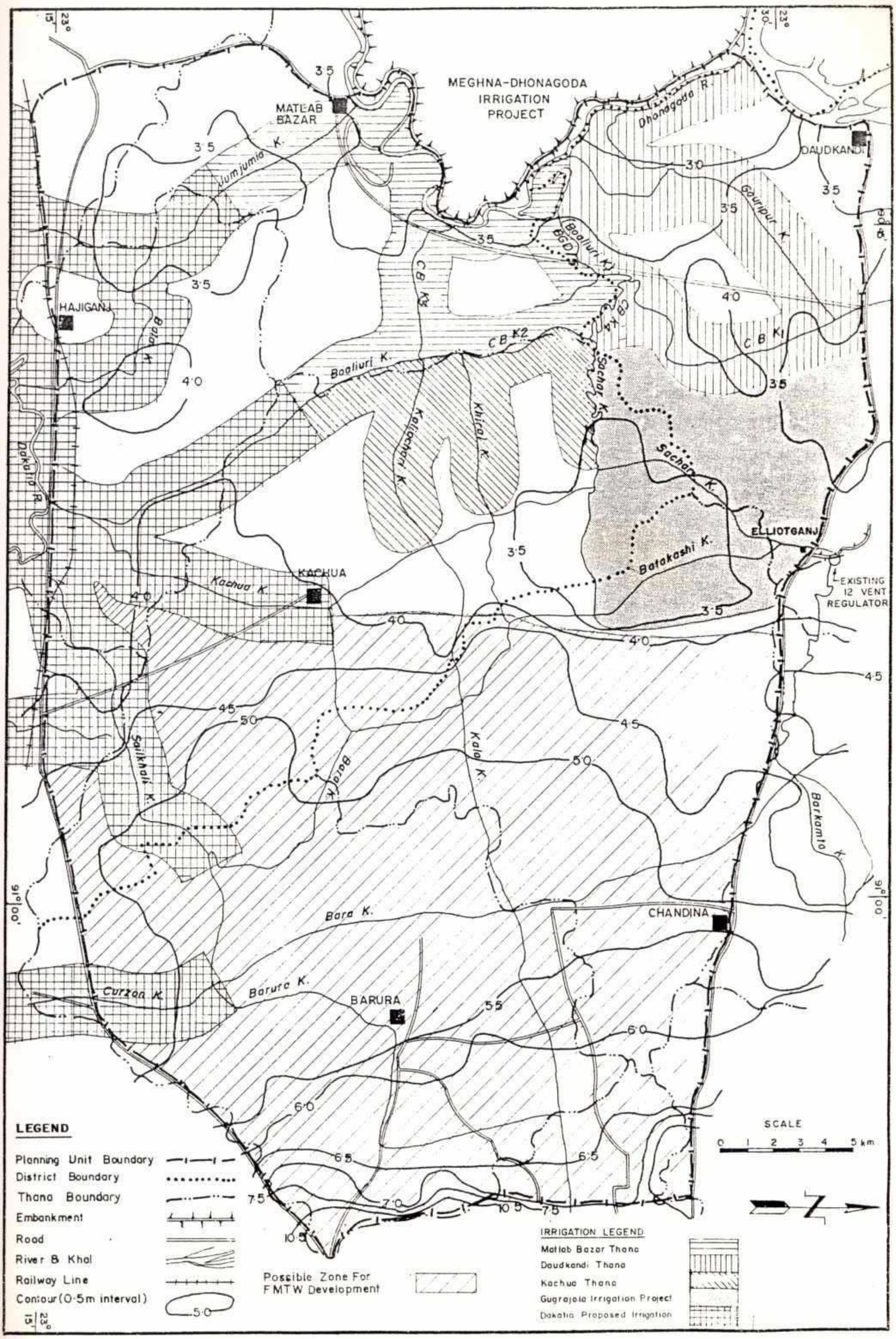
The Master Plan envisaged a single Comilla-Noakhali Project of 336 000 ha gross covering the whole of the Noakhali North, Dakatia, Dhonagoda and Gumti Phase I planning units, with the exception of the south west portion of the Dhonagoda planning unit; this was treated as the North Unit of the Chandpur Project which, like the Meghna-Dhonagoda Project, was treated as a separate project. The Dhonagoda planning unit overlaps the North and Central Areas designated in the Master Plan. It was proposed to provide full flood protection with pumped drainage initially, followed by surface water irrigation from the Lower Meghna River, although a small area of surface water irrigation was anticipated in the north east of the planning unit from the Gumti River, under the separate Gumti River Project.

(ii) Meghna Muhuri Water Transfer. Draft Planning Report (International Engineering Co/Rahman & Associates, September 1972).

The planning unit formed a component of Phase II of the water transfer scheme proposals, although irrigation water was to be abstracted separately from the Meghna River, and not via the main water transfer channel. Development was anticipated in two stages.

Figure 7.5.1

Dhonagoda Planning Unit - Irrigation Development Potential



Stage I

The Dhonagoda River was to be closed at both ends, with a ship lock at the northern end, and regulator and ship lock in the south. A pump station at the northern end would raise the water level, which would enter Kala Khal, and thence pass into the minor khals throughout the bulk of the area (after substantial excavation), for raising into the tertiary irrigation system by low lift pumps (LLP). The Dhonagoda River and Kala Khal were both to be embanked over their whole length. East of Bara Khal, a relift pumping plant was to be provided on Kala Khal, with a further lift at the edge of the Lalmai Hills serving a gravity distribution area.

Stage II

Full flood control was to be provided by the closure of drainage crossings on the Daudkandi-Comilla road, and providing roadside embankments as necessary, and a main river embankment in the west from Daudkandi southwards to Chandpur. The Chandpur-Comilla railway line would be embanked as far as Hajiganj, where it would meet the Dakatia embankment proposed under the Dakatia Project. Pumped drainage would be provided by operating the main pump station in reverse mode, probably with additional capacity installed.

The existing MDIP was to be a unit of the Dhonagoda Project, but this has been implemented separately, with independent pump stations.

(iii) Small Scale Irrigation Sector Project. Gugrajola Irrigation Project Appraisal Report (BWDB/Coode and Partners, July 1985).

This project, recently implemented under the Food For Work Programme, provides submersible embankments to a gross area of some 8 500 ha (see Figure 7.5.1), thus enabling an HYV boro crop to be harvested safely. The irrigation water supply is to be drawn from the Meghna River via the Gumti and Dhonagoda Rivers and the existing khal network, through deepening some 50 km of existing khals, typically by about 1.2m. The LLP irrigated area is expected to increase from 360 to 3 240 ha, although the report recognizes the formidable amount of excavation involved, and the possibility that this may not be achieved. An additional 1 420 ha is expected to be irrigated by shallow tubewells.

(iv) Model Rural Development Project Plan for Homna and Daudkandi Thana, Comilla District - Final Report (JICA November 1989).

This master plan study of the two thanas covers all aspects of rural development. The southern part of Daudkandi thana lies within the planning unit. Within Daudkandi thana, the provision/construction/rehabilitation of the following items of irrigation infrastructure is included, for implementation primarily in the period 1990 to 1993.

- 125 km of irrigation canal (56 km within the planning unit)
- 148 Nr LLP for rental
- 2 Nr buried irrigation pipelines for use with DTW.

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(v) The Master Plan Study on the Model Rural Development Project Phase II for Kachua, Nabinagar, Bancharampur and Debidwar Thanas (JICA, February 1991)

This study is similar to (iv) above, and includes Kachua thana within the planning unit. Proposals are divided into priority projects, targeted for completion in 1995, and a longer term programme with an 18 year implementation period.

For Kachua thana, the following items are included in the irrigation, drainage and flood control sector.

	Priority (1993-1995)	Overall (1993-2010)
Re-excavation of khals for irrigation and drainage improvement	38 km khal length	138.5 km khal length
and provision of LLP for lease to Water Users' Associations by Co-operatives	28 Nr LLP 550 ha command area	60 Nr LLP 1 100 ha command area
Low capacity (0.5 to 0.75 cusec) fractional pumps for supplemental	50 Nr pumps	150 Nr pumps
irrigation of upland winter crops from ponds etc.	250 ha command area	750 ha command area
Pump Maintenance Workshop	1 Nr	1 Nr

The programme also includes components for the re-excavation and embankment of fish ponds and the provision of extension and credit for semi-intensive fish culture.

7.5.3 Groundwater Development Potential

As already noted, some of the planning unit is affected by groundwater salinity, but the eastern portion has good FMTW potential. On the basis of the studies described in Annex V, the total potential for groundwater irrigation within the planning unit allowing for the salinity constraint, assuming a net irrigation requirement of 625 mm for a boro crop, together with the existing area irrigated, is as follows:

	Potential(ha)	Existing (ha)
Shallow and Deep Set Shallow Tubewells (STW/DSTW)	9 572	5 855
Force Mode tubewells (FMTW) - 1 cusec or less	16 301	8 780

In the proposals evaluated, it has been assumed that the shallow tubewells potential is eventually used to its full extent, in both with and without project conditions. However we have restricted the force made tubewell development as it will be difficult to maximise the FMTW potential because of the financial constraints and the present lack of experience with shallow FMTWs. Also extensive development of SFMTWs could produce conflicts with existing STWs and DSSTWs.

7.5.4 Fisheries in Dhonagoda Planning Unit

This Unit is the second largest with respect to the gross area. The culture fisheries situation is similar to the other planning units in the area in general. There are about 20,000 ponds with an area of 2,400 ha and the total production obtained is 4,000 tonnes. Dhonagoda Planning Unit is within the core area of the Chandpur and Comilla region where fish hatcheries and nurseries have sprung up and could be expected to play a useful role in developing pond culture fisheries.

Openwater in the form of standing waters and rivers amount to 122 ha and 314 ha respectively. The unit has a total of about 7,000 ha of F_3 and F_4 lands and extensive F_1 and F_2 lands. This suggests that the area has potential for flood plain fishery in the vicinity of the Dhonagoda river and the many khals that criss-cross the unit. The total length traversed by all these khals and the Dhonagoda river is 262 km.

Two thanas - Matlab and Hajiganj were studied. 5,000 tonnes of fish is caught annually from the rivers and khals of Matlab thana. The total number of full time and subsistence fishermen in the thana are 2,000 and 25,000 respectively. There are 14 fish cooperatives in the thana. The shrimp fishery in the Dhonagoda river is important; 23 tonnes of shrimp is reported to be caught annually in the river and 1,000 fishermen are engaged in shrimp fishery. From Hajiganj thana data could not be obtained, however, it is known that there are 25 jalmahals. There are 2,000 and 4,000 full time and subsistence fishermen respectively in the thana and 80 fish nurseries.

This unit has been studied intensively and closure of the Dhonagoda river has been contemplated, this would have a serious effect on deepwater fisheries and therefore an alternative proposal where the line of the embankment was moved away from the river to the new Matlab-Gouripur road, has been tested. Any proposal to develop irrigation further in the area would be beneficial.

The presumed increased opportunities for the development of culture-based capture fishery in the semi-closed waters of khals, creeks or in the depressions within the PU, will require large quantities of fish seed of the desired species. Although it is said the fish seed technology has been disseminated well in the region, it is difficult at this stage to calculate the demand and supply of fish seed required. However, depending upon the exact situation, which should be investigated at feasibility study stage, proposals can be made on the establishment of fisheries facilities to be built up by the public/private sector in the area.

7.5.5 Project Options

In the Interim Report, four options were evaluated, summarised as follows:

Flood Control by Closure of Dhonagoda River	Flood Control West of New Matlab-Gouripur Road Embankment	Irrigation via Daudkandi Pump Station
Option 1	-	-
Option 2	-	Option 2
-	Option 3	Option 3
-	Option 4	-

These four options were supplemented by a fifth option in the draft regional plan which included pumped supplies to the Gumti Phase I area. All five of those options showed very poor rates of return. Nevertheless the consultants were requested to reconsider some of these options. This review has led to the abandonment of the old options 2 and 3 and option 5 all of which included irrigation from Daudkandi pump station. This is because with the completion of the Gugrajola scheme and the implementation of the Japanese funded Model Rural Development Project in Daudkandi which is now ongoing, these projects are already providing or will provide irrigation benefit to substantial parts of the area for which these options 2,3 and 5 were designed. Thus with the reduced benefits of irrigation these options could never be economically viable. In addition the consultants have considered the possibility of extending the Daudkandi khal deepening programme to other parts of the planning unit and the southern part of the unit could benefit from the Dakatia - Little Feni transfer proposal described in earlier sections of this chapter.

Therefore for this final report only three options have been considered using the revised methodology set out in Chapter 3 and with the engineering proposals simplified to obtain the maximum benefit at the maximum cost as follows:-

Option	Description
1.	Flood control by closure of Dhonagoda River
2. (previously by 4)	Flood control behind Chandpur-Matlab-Gouripur Raod
3.	Irrigation by khal deepening

Options 1 and 2 are alternatives whilst option 3 is independent and could operate with or without either options 1 or 2.

a) Option 1.

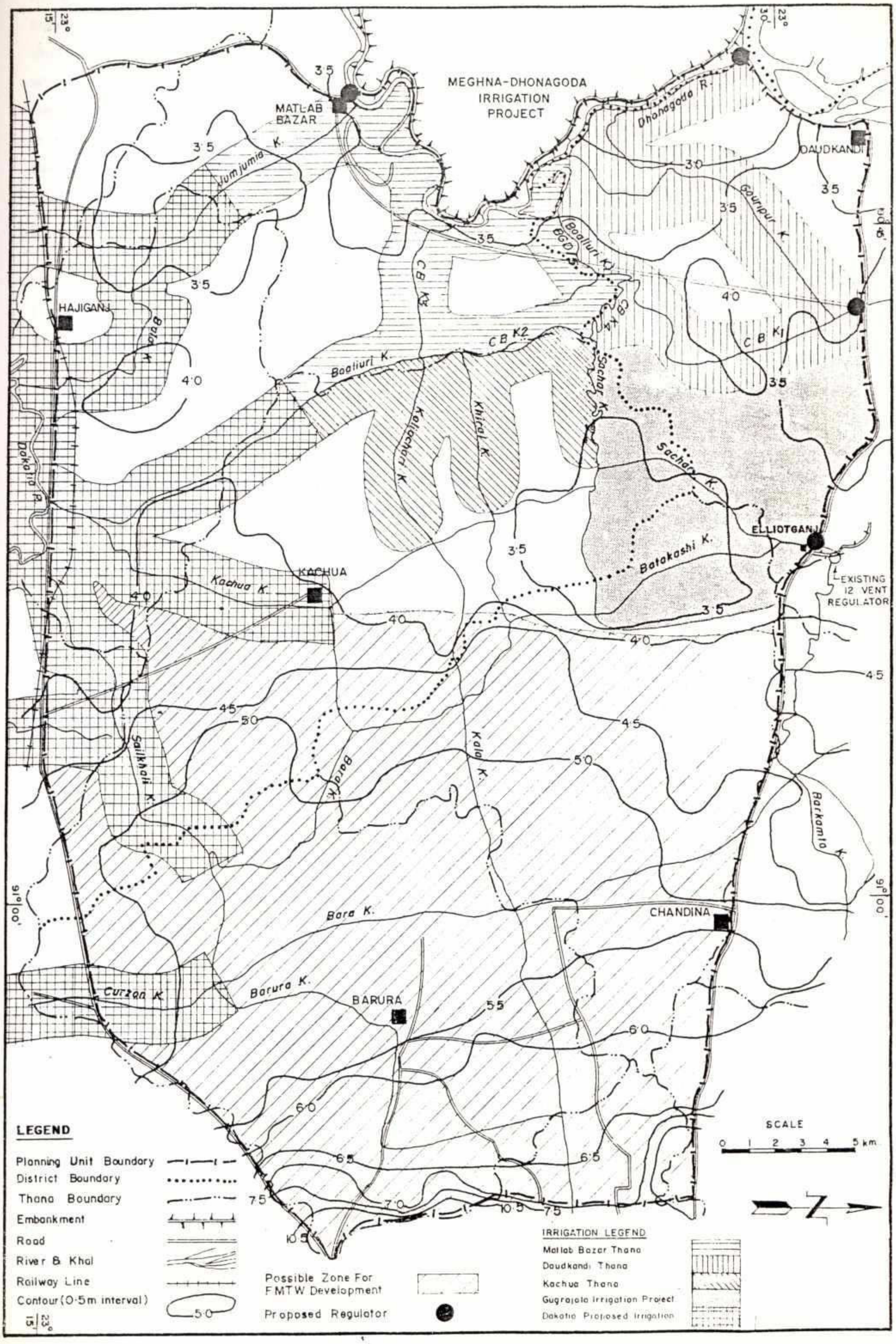
This option provides for improved flood control and drainage. the Dhonagoda River is largely a diversion channel of the Meghna River, and under the option it would be closed at both ends so that it does not carry Meghna floods.

At the northern closure at Moltakandi a regulator would permit the channel to be flushed, and a lock would be provided for navigation. The closure would be linked by a new embankment to the existing Meghna-Dhonagoda Irrigation Project (MDIP) and Daudkandi-Comilla road embankments.

At the southern closure at Matlab, a flap-gated structure would exclude high Meghna water levels, whilst evacuating drainage water whenever levels permit. Again, a lock would be provided, although navigation to Matlab from the Meghna should not need to pass through it. This closure would be linked by a new embankment to the existing Chandpur Irrigation Project (CIP) and Chandpur-Matlab road embankments. The locations of structures and shown in Figure 7.5.2.

Figure 7.5.2

Dhonagoda Flood Control - Option 1



Complete closure of the entire Planning Unit from direct meghna floods is thus effected. It had originally been hoped to provide a closure only at Moltakandi, and leave the southern end open. However, this approach was shown by the South East Regional Model to give significant benefits only during very high Meghna floods, when the head difference between the north and south ends of the Dhonagoda River is nearly 1 m. During normal floods, the difference is very much smaller. The options run on the SERM for this area are described in Annex VI and these options analysed here are based on the results of run 34 a. Closure the Dhonagoda River has a major impact upon navigation, since it is understood that this route is used by vessels as a safer alternative route to the main Meghna channel during the monsoon season. Other serious impacts include fisheries and possibly river morphology.

On the credit side, an opportunity is given for road links between MDIP and both Chandpur and Daudkandi/Dhaka. The pressure is also relieved on the existing eastern MDIP embankment, which breached in both 1987 and 1988.

Throughout the Planning Unit the only change in irrigation is the natural growth in groundwater irrigation, as constrained by development potential.

The proposals primarily affect the flood phasing, the estimated areas by flood phase in the future without project (FWO) and future with (FW) project conditions are given in Table 7.5.1.

The engineering components are:

i) Moltakandi Regulator

This regulator is located at the northern end of the Dhonagoda River where it diverges from the Meghna River. It is tentatively sized for a flushing discharge of 50 m^3/s. Simple manually operated lifting gates are provided, together with a lock for navigation.

ii) Moltakandi Link Embankment

This embankment joins Moltakandi Regulator to the MDIP and the Daudkandi-Comilla road embankments. it is assumed to have the following characteristics:

Length	-	6 500 m
Average Ground Level	-	3.0 m above Public Works Datum
1:20 year flood height (Daudkandi)	-	6.3 m above Public Works Datum
Freeboard	-	1.5 m
Average Height	-	4.8 m

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TABLE 7.5.1

Distribution of Land by Flood Phase/Irrigation (ha)

Planning Unit 8, Dhonagoda Project: Option 1

Gross area 112405

Net Cultivated Area (NCA) 82144 (excluding orchards)

Land Category	F0I0	F0Ir	F1I0	F1Ir	F2I0	F2Ir	F3I0	F3Ir	All I0	All Ir	All I0+Ir
Present											
Area (ha)	16264	9871	7563	4590	22962	13937	4329	2628	51118	31026	82144
% NCA	20	12	9	6	28	17	5	3	62	38	100
Project year 1											
Area (ha)	16264	9871	7563	4590	22962	13937	4329	2628	51118	31026	82144
%NCA	20	12	9	6	28	17	5	3	62	38	100
Future Without (1)											
Area (ha)	12688	13447	5900	6253	17914	18985	3378	3580	39880	42264	82144
% NCA	15	16	7	8	22	23	4	4	49	51	100
Future Without (2)											
Area (ha)	12688	13447	5900	6253	17914	18985	3378	3580	39880	42264	82144
% NCA	15	16	7	8	22	23	4	4	49	51	100
Future With (1)											
Area (ha)	12987	13764	7910	8382	16845	17852	2138	2266	39880	42264	82144
% NCA	16	17	10	10	21	22	3	3	49	51	100
Future With (2)											
Area (ha)	12987	13764	7910	8382	16845	17852	2138	2266	39880	42264	82144
% NCA	16	17	10	10	21	22	3	3	49	51	100

Note: F0I0 land excludes orchards

iii) Matlab Regulator

This regulator is located towards the southern end of the Dhonagoda River where it rejoins the Meghna River. It is tentatively sized for a discharge of 400 m^3/s and counterweighted flap gates are provided since it is desirable that the gates should be capable of being manually raised clear of the water, to allow the passage of floating water hyacinth etc, as well as to admit floating fish spawn at the appropriate season. A lock is also to be incorporated as at Moltakandi.

iv) Matlab Link Embankment

This embankment joins Matlab Regulator to the MDIP and the Chandpur-Matlab road embankments. It is assumed to have the following characteristics:

Length	-	1 000 m
Average Ground Level	-	3.0 m above Public Works Datum
1:20 year flood height (Matlab)	-	5.5 m above Public Works Datum
Freeboard	-	1.5 m
Average Height	-	4.0 m

v) Closure of Two Drainage Crossings beneath Daudkandi-Comilla Road

Allowance has been made for the closure of two existing drainage crossings where Boaliuri Khal (also known as Gouripur Khal) and Batakashi Khal pass beneath the Daudkandi-Comilla road. These khals largely carry Gumti River overflow water, which will now be forced to remain in the Gumti/Meghna River. These closures will be effected by installing small regulators (10 m^3/s) to permit flows of irrigation water to the Gugrajola scheme and to other irrigated areas in Daudkandi south of the road.

vi) Minor Regulators

It is known that there are several existing drainage crossings on the Chandpur-Matlab road these crossings should be closed with single vent (5 m^3/s) drainage sluices fittted with flap gates to allow continued drainage of local areas. Careful design of invert levels is required to avoid siltation problems.

b) Option 2

This option provides flood control and drainage like option 1. However, rather than closing the Dhonagoda River, advantage is taken of the new road embankment (with bridges) being constructed under the Food For Works programme between Matlab and Gouripur, just east of Daudkandi (Figure VI.3.3). The flood control component is thus obtained at the expense only of providing regulators at the drainage crossings (plus the cost of maintaining the embankment, which does not appear to come under the control of the Roads and Highways Department).

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The area west of the road is thus excluded from flood control. This deeply flooded area is however very important from the point of view of fisheries, and leaving it open to the main river reduces fisheries losses.

The benefits of a road link to MDIP are lost, in comparison with Option 1, but morphological problems and the obstruction of navigation associated with closure of the Dhonagoda River are avoided.

The area of flood phases for the area protected both for with and without project conditions are shown on Table 7.5.2.

The engineering works required are as follows:

i) Closure of drainage crossings on Daudkandi-Comilla road as in option 1. (2) No 10 m^3/s regulators.

ii) Regulators to be installed at the major khal crossings on the Matlab Gouripur road as follows:-

(i) Gouripur Khal 15 m^3/s.
(ii) Boaljuri Khal 160 m^3/s
(iii) Kaliachari Khal (CBk5) 100 m^3/s
(iv) Jumjuria Khal 50 option 1.

The locations of structures required are shown on figure 7.5.3

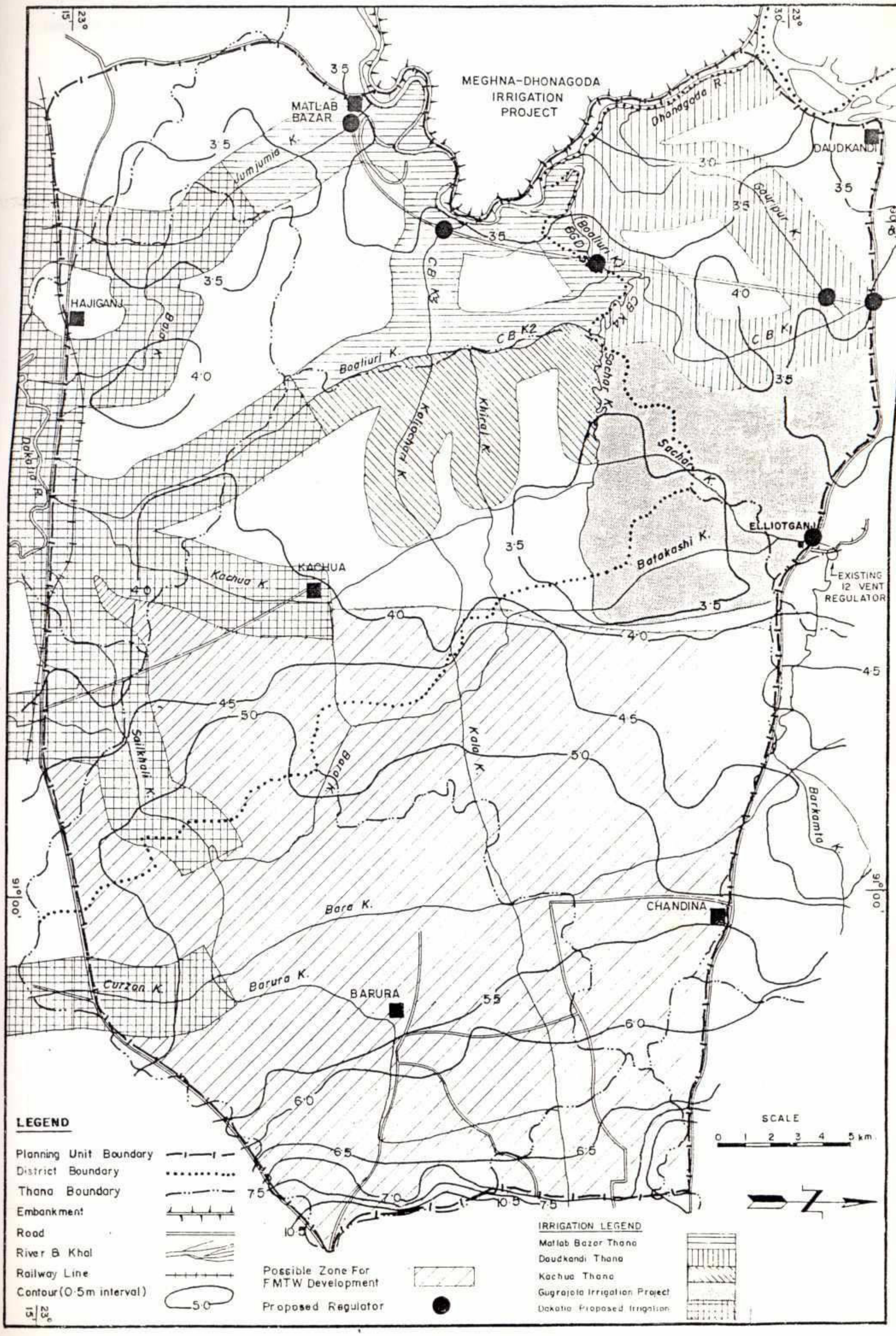
c) Option 3

This option is basically an extension of the Model Rural Development Project irrigation component which is currently ongoing in Daudkandi thana in the extreme northwest of the planning unit. Analysis of dry season water levels and the available cross section data from the SERM indicates that quite limited quantities of earthworks for khal deepening could provide guaranteed all season water supplies for substantial areas in the west of the planning unit, particularly in thanas Matlab and Kachua. Figure 7.5.1 indicates the extent of potential irrigation by khal deepening and also shows those areas already proposed for development by ongoing projects, by the potential Dakatia-Little Feni transfer scheme and by potential groundwater development. The combination suggests that extensive coverage of the planning unit should be possible in the long term with surface water development predominating in the west and south of the unit and groundwater in most of the remainder. Table 7.5.3 indicates the areas with the shaded command zones for Matlab and Kachua thanas which could be irrigated from deepened khals supplied from the Dhonagoda river. The table indicates that some of the potential area might be developed by groundwater but that an additional 3,032 ha might be developed by the khal deepening programme.

The design bed levels have been taken as - 0.25 m PWD and side slop[es as 2:1. All earthworks can be accommodated within the existing bank top widths of the khals eliminating the need for land acquisition if spoil spreading can be utilised (as in NNDIP). Since the volumes of earth works per metre length of khal are relatively small this should not be too difficult to achieve.

Figure 7.5.3

Dhonagoda Flood Control - Option 2



All these earthworks could be done by hand labour. No structures are required but annual maintenance of the channels would be essential.

TABLE 7.5.2

Distribution of Land by Flood Phase/Irrigation (ha)

Planning Unit 8, Dhonagoda Project: Option 2

Gross area 101686

Net Cultivated Area (NCA) 75361 (excluding orchards)

Land Category	F0I0	F0Ir	F1I0	F1Ir	F2I0	F2Ir	F3I0	F3Ir	All I0	All Ir	All I0+Ir
Present											
Area (ha)	15438	9162	7088	4207	21237	12603	3530	2095	47293	28067	75361
% NCA	20	12	9	6	28	17	5	3	63	37	100
Project year 1											
Area (ha)	15438	9162	7088	4207	21237	12603	3530	2095	47293	28067	75361
%NCA	20	12	9	6	28	17	5	3	63	37	100
Future Without (1)											
Area (ha)	12120	12481	5565	5730	16672	17168	2771	2854	37127	38234	75361
% NCA	16	17	7	8	22	23	4	4	49	51	100
Future Without (2)											
Area (ha)	12120	12481	5565	5730	16672	17168	2771	2854	37127	38234	75361
% NCA	16	17	7	8	22	23	4	4	49	51	100
Future With (1)											
Area (ha)	12402	12772	7431	7653	15540	16004	1753	1806	37127	38234	75361
% NCA	16	17	10	10	21	21	2	2	49	51	100
Future With (2)											
Area (ha)	12402	12772	7431	7653	15540	16004	1753	1806	37127	38234	75361
% NCA	16	17	10	10	21	21	2	2	49	51	100

Note: F0I0 land excludes orchards

TABLE 7.5.3

Irrigation by Mode in Matlab and Kachua Thanas in Areas Served by Deepened Khals

Scenerio/Mode	LLP	STW	FMTW	Manual	Total
Present	2448	324	815	854	4442
Future Without	2449	1016	1731	854	6050
Future With	6868	567	1193	454	9082

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7.5.6 Project Costs

The estimated capital and annual costs for the three different options described for this planning unit are described in financial prices in Table 7.5.4 and may be summarised in 1991 prices as follows:-

Option	Capital Cost (Tk million)	O&M Costs (Tk million/yr).
1	394.90	7.74
2	237.04	6.68
3	11.65	0.61

The economic costs have been estimated by applying the specified conversion factors from the FPCO guidelines and the resulting costs are given in detail in Table 7.5.5.

The other component of project costs is losses to capture fisheries. For options 1 and 2 these have been calculated, in accordance with the methodology described in chapter 3 and these are valued in economic prices. These losses will be incurred from project year 6 (ie, the first year of project operation) onwards. For Option 1 the losses are estimated at Tk. 45 m/yr and for Option 2 at Tk. 30 m/yr.

7.5.7 Project Benefits

The changes in cropping patterns for the three options are shown in Table 7.5.6 to 7.5.8. For options one and two they are for the unit areas protected and in option 3 only for the areas within the irrigation zones.

Project benefits comprise incremental net crop income and non-agricultural damage avoided as a result of project implementation. The latter is the result of protection against extreme events as described in chapter 3.

Incremental crop income would be achieved as a result of changes in flood phasing with the implementation of the proposed engineering for options 1 and 2. Present (without project) and future with project flood phasing have been estimated, on the basis of the South East Regional Model results, to be as follows:

Proportion of Project Area (Per Cent)

	Present		With Project	
Flood Phase	Option 1	Option 2	Option	Option 2
F0	31.8	32.6	32.6	33.4
F1	14.7	15.0	19.8	20.0
F2	45.0	44.9	42.2	41.8
F3	8.5	7.5	5.4	4.7
Total				

TABLE 7.5.4

Planning Unit 8, Dhonagoda, Options 1 to 3

Engineerjng Quantities and Costs (1991 Prices)		Unit Rate	Quantity			Capital Cost (Tk'000			O&M % of	Annual O & M Cost		
Description	Unit	(Tk'000)	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3	Cap.Cost	Option 1	Option 2	Option 3
1. Link Embankment MDIP to Daudkandi	km	4 700	6.5	-	-	30 550	0	0	6%	1 833	0	0
2. Link Embankment at Matlab	km	3 500	1	-	-	3 500	0	0	6%	210	0	0
3. Saving on O&M of MDIP Dhonagoda R. embankment	km	-	23	-	-	0	0	0	6%	(2 415)	0	0
4. Regulators Discharge (m3/s) Ventage												
400 - 22 Nr. 3.04 m x 3.04 m	Vent	6 000	1	-	-	132 000	0	0	3%	3 960	0	0
160 - 9 Nr. 3.04 m x 3.04 m	Vent	6 000	-	1	-	0	54 000	0	3%	0	1 620	0
100 - 6 Nr. 3.04 m x 3.04 m	Vent	8 000	-	1	-	0	48 000	0	3%	0	1 440	0
50 - 10 Nr. 1.52 m x 1.82 m	Vent	1 600	1	1	-	16 000	16 000	0	3%	480	480	0
15 - 3 Nr. 1.52 m x 1.82 m	Vent	2 000	-	1	-	0	6 000	0	3%	0	180	0
10 - 2 Nr. 1.52 m x 1.82 m	Vent	2 250	2	2	-	9 000	9 000	0	3%	270	270	0
5 - 1 Nr. 1.52 m x 1.52 m	Vent	2 500	5	5	-	12 500	12 500	0	3%	375	375	0
5. Navigation Locks (Dhonagoda River)	Nr.	20 000	2	-	-	40 000	0	0	3%	1 200	0	0
6. Khal Excavation	000 m3	35	-	-	232	0	0	8 107	6%	0	0	486
7. Upgrading Gouripur to Matlab Road embankment (assumed 85% in place)	km	525	-	24	-	0	12 600	0	6%	0	756	0
8. Vehicles	Nr.	1 000	2	2	-	2 000	2 000	0	4%	220	220	0
9. Buildings	sum	-	-	-	-	1 000	0	0	6%	60	0	0
10. Land Acquisition	ha	400	70	12	-	28 160	4 800	0	-	0	0	0
Total Base Cost						274 710	164 900	8 107		6 193	5 341	486
Engineering & Administration (15% of Capital Cost & Contingency						51 508	30 919	1 520		0	0	0
Physical contingency (25%)						68 678	41 225	2 027		1 548	1 335	122
Total Cost						394 896	237 044	11 654		7 741	6 676	608

Note: Vehicle O&M cost includes Tk 70 000 annual running cost per vehicle

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TABLE 7.5.5

Planning Unit 8, Dhonagoda, Options 1 to 3

Capital and O & M Costs in Economic Prices (Tk'000)

Item Nr.	Description	Capital Cost (Fin. Prices) Option 1	Option 2	Option 3	Conversion Factor	Capital Cost (Econ. Price) Option 1	Option 2	Option 3	Annual O&M Cost(Fin. Prices) Option 1	Option 2	Option 3	Conversion Factor	Annual O&M Cost(Econ. Prices) Option 1	Option 2	Option 3
1.	Link Embankment MDIP to Daudkandi	30 550	0	0	0.66200	20 224	0	0	1 833	0	0	0.70	1 281	0	0
2.	Link Embankment at Matlab	3 500	0	0	0.66	2 317	0	0	210	0	0	0.70	147	0	0
3.	Saving on O&M of MDIP Dhonagoda R embankment	0	0	0	0.66	0	0	0	(2 415)	0	0	0.70	(1 687)	0	0
4.	Regulators Discharge (m3/s) Ventage														
	400 - 22 Nr. 3.04 m x 3.04 m	132 000	0	0	0.70	92 928	0	0	3 960	0	0	0.72	2 857	0	0
	160 - 9 Nr. 3.04 m x 3.04 m	0	54 000	0	0.70	0	38 016	0	0	1 620	0	0.72	0	1 169	0
	100 - 6 Nr. 3.04 m x 3.04 m	0	48 000	0	0.70	0	33 792	0	0	1 440	0	0.72	0	1 039	0
	50 - 10 Nr. 1.52 m x 1.82 m	16 000	16 000	0	0.70	11 264	11 264	0	480	480	0	0.72	346	346	0
	15 - 3 Nr. 1.52 m x 1.82 m	0	6 000	0	0.70	0	4 224	0	0	180	0	0.72	0	130	0
	10 - 2 Nr. 1.52 m x 1.82 m	9 000	9 000	0	0.70	6 336	6 336	0	270	270	0	0.72	195	195	0
	5 - 1 Nr. 1.52 m x 1.52 m	12 500	12 500	0	0.70	8 800	8 800	0	375	375	0	0.72	271	271	0
5.	Navigation Locks (Dhonagoda River)	40 000	0	0	0.70	28 160	0	0	1 200	0	0	0.72	866	0	0
6.	Khal Excavation	0	0	8 107	0.66	0	0	5 367	0	0	486	0.68	0	0	329
7.	Upgrading Gouripur to Matlab Road embankment (assumed 85% in place)	0	12 600	0	0.66	0	8 341	0	0	756	0	0.70	0	528	0
8.	Vehicles	2 000	2 000	0	0.68	1 360	1 360	0	220	220	0	0.87	191	191	0
9.	Buildings	1 000	0	0	0.79	790	0	0	60	0	0	0.72	43	0	0
10.	Land Acquisition	28 160	4 800	0	0.28	7 963	1 357	0	0	0	0	-	0	0	0
	Total Base Cost	274 710	164 900	8 107		180 142	113 490	5 367	6 193	5 341	486		4 509	3 868	329
	Engineering & Administration (15% of Capital Cost & Contingency)	51 508	30 919	1 520		33 777	21 279	1 006	0	0	0		0	0	0
	Physical contingency (25%)	68 678	41 225	2 027		45 035	28 373	1 342	1 548	1 335	122		1 127	967	82
	Total Cost	394 896	237 044	11 654		258 954	163 143	7 715	7 741	6 676	608		5 636	4 836	411

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TABLE 7.5.6

Summary of Cropping Pattern Changes

(% of NCA)

Planning Unit 8, Dhonagoda Project: Option 1

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus	20	16	16	17	17
T Aus, HYV	6	6	6	7	7
B Aman	22	20	20	17	17
LT Aman	19	19	19	21	21
HYV Aman	30	29	29	31	31
L Boro	2	3	3	2	2
HYV Boro	30	41	41	42	42
Wheat irrig.	3	4	4	4	4
Wheat unirrig.	3	2	2	2	2
Potato irrig.	1	1	1	1	1
Potato unirrig.	0	0	0	0	0
Jute	1	1	1	1	1
Sugarcane	0	0	0	0	0
Pulses	2	2	2	2	2
Oilseeds	6	5	5	5	5
Spices	1	1	1	1	1
Veg. irrig.	1	2	2	2	2
Veg. unirrig.	2	1	1	2	2
Total:	150	153	153	157	157

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TABLE 7.5.7

Summary of Cropping Pattern Changes

(% of NCA)

Planning Unit 8, Dhonagoda Project: Option 2

	Year 1	Future w'out(1)	Futue w'out(2)	Future with(1)	Future with(2)
B Aus	19	15	15	16	16
T Aus, HYV	6	6	6	6	6
B Aman	19	18	18	15	15
LT Aman	17	18	18	19	19
HYV Aman	28	27	27	29	29
L Boro	2	3	3	2	2
HYV Boro	28	38	38	38	38
Wheat irrig.	3	4	4	4	4
Wheat unirrig.	2	2	2	2	2
Potato irrig.	1	1	1	1	1
Potato unirrig.	0	0	0	0	0
Jute	1	1	1	1	1
Sugarcane	0	0	0	0	0
Pulses	2	2	2	2	2
Oilseeds	5	4	4	4	4
Spices	1	1	1	1	1
Veg. irrig.	1	2	2	2	2
Veg. unirrig.	2	1	1	2	2
Total	139	141	141	144	144

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TABLE 7.5.8

Summary of Cropping Pattern Changes
(% of NCA

Planning Unit 8, Dhonagoda Project: Option 3 (Khal Excavation for Irrigation)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus	15	10	10	0	0
T Aus, HYV	6	5	5	5	5
B Aman	22	18	18	12	12
LT Aman	20	21	21	22	22
HYV Aman	25	25	25	23	23
L Boro	6	8	8	13	13
HYV Boro	37	50	50	75	75
Wheat irrig.	3	5	5	7	7
Wheat unirrig.	2	1	1	0	0
Potato irrig.	1	1	1	2	2
Potato unirrig.	0	0	0	0	0
Jute	1	1	1	0	0
Sugarcane	0	0	0	0	0
Pulses	2	1	1	0	0
Oilseeds	5	3	3	0	0
Spices	1	1	1	0	0
Veg. irrig.	2	2	2	4	4
Veg. unirrig.	2	1	1	0	0
Total	150	154	154	161	161

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The second component of incremental crop income benefits is due to crop flood damage reductions. These have been estimated as an addition to yields of Aus and Aman of 3.26 per cent and an addition to jute yields of 0.63 of one per cent. Boro is not expected to be affected since with appropriate planting and harvesting dates the crop could not be affected by the rising flood.

7.5.8 Economic Evaluation

Results of the economic analyses of the different options, including economic capital and O&M costs, and the Economic Internal Rates of Return (EIRRs) for the different options are estimated to be as follows:

Option	Capital Cost (Tk. million)	O&M Cost (Tk./million/yr)	EIRR (per cent)
1	258.95	5.64	10.7
2	163.14	4.84	15.9
3	7.72	0.41	89.0

The summarises of benefits and the sensitivity analyses for each option are given in Tables 7.5.9 to 7.5.14.

As anticipated option 3 shows exceptionally good returns for the khal deepening component. The other two options show better returns than previously as a result of the more rigorous control of costs. Option 2 provides the clearly preferable situation both in economic terms and environmentally. (See Following section). However the project could not proceed before the Matlab Gouripur load is completed and it will be necessary to confirm that the embankment is adequate throughout its length to withstand all flood conditions. The existing sections of completed road would seem to be adequate.

7.5.9 Environmental Evaluation

Option 1 and 2 will both affect capture fisheries to a substantial degree. the existing (and under construction) Chandpur Matlab-Gouripur road is already a substantial impediment to floating spawn but presently fish can migrate up the principal khals unimpeded. Even if all the regulators are kept open until the end of May there will still be an increased impediment to the migratory species. Use of counterweighted flap gates could significantly reduce this during both rising and falling floods. Since option 1 covers a larger area it has a correspondingly greater effect and would also impact the entire length of the Dhonagoda river which may include important fish breeding habitats.

Option 1 also involves substantially reducing flood season flows in the Dhonagoda river with possibly serious morphological consequences both within the river and upstream. It also has negative effects on navigation in the Dhonagoda. None of these affects apply to Option 2. A third disadvantage of Option 1 is the displacement of people on land required for the construction of the new embankments to close off each end of the Dhonagoda river and again Option 2 does not have this negative impact.

Option 3 does not affect capture fisheries, morphology or navigation and should not require any land acquisition if the recommended spoil spreading technique is used. The perennial presence of water in the excavated khals should slightly improve conditions for capture fisheries in those locations.

TABLE 7.5.9

Summary of Benefits

Planning Unit 8, Dhonagoda Project: Option 1

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	82.1	82.1	82.1	82.1	82.1	0	0
Irrigated Area	'000 hectares	31.1	42.3	42.3	42.3	42.3	0	0
Labour Requirement	million man day	20.8	21.7	21.7	22.5	22.5	3	3
Paddy Production	'000 tonnes	328	363	363	380	380	5	5
Cropping Intensity (excluding orchard)	% NCA	150	153	153	157	157	2	2
Irrigated area	% NCA	38%	52%	52%	52%	52%	0	0
Net Crop Income	million Taka	1 029	1 124	1 124	1 160	1 160	3	3
Crop flood loss reduction	million Taka				32	32		
Non-agric. flood loss reduction	million Taka				27	27		
Fish catch reduction	million Taka				45	45		

Notes:

Project Year 1 : Assumed 1994/95
Future Without (1) : Future Without Project Conditions, 5 years after project would have been completed
Future Without (2) : Future Without Project Conditions, Year 30
Future With (1) : Future With Project Conditions, 5 years after project completion
Future With (2) : Future With Project Conditions, Year 30
% Increment (1) : % difference FW (1) over FWO (1)
% Increment (2) : % difference FW (2) over FWO (2)
Flood losses refer to average annual losses that will be eliminated by the project.

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TABLE 7.5.10

Summary of Results and Sensitivity Analyses

Planning Unit 8, Dhonagoda Project: Option I

Capital cost	259.0 Tk.m.	Construction period	5 years
Annual O&M cost	5.6 Tk.m. (economic prices)		
Net Present Value @12%	-26.53 Taka million (economic prices)		
Economic Internal Rate of Return	10.67 %		

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	10.7	9.9	8.8	7.4	11.6	13.2	17.2	14.21
O&M Costs	10.7	10.5	10.3	10.0	10.8	11.0	11.3	105.75
Fisheries Losses	10.7	9.6	8.0	4.9	11.7	13.1	15.4	13.39
Reduced flood losses	10.7	12.0	13.7	16.4	9.3	7.0	2.0	10.38
Total Benefits	10.7	12.6	15.1	18.7	8.5	4.6	-9.0	6.92
Incremental Net								
Crop Income	10.7	11.3	12.3	13.7	10.0	8.9	6.9	20.78
Delay in full benefits								
2 years	7.9							
4 years	6.7							
Delays in completion								
2 years	9.5							
4 years	8.4							

TABLE 7.5.11

Summary of Benefits

Planning Unit 8, Dhonagoda Project: Option 2

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	75.4	75.4	75.4	75.4	75.4	0	0
Irrigated Area	'000 hectares	25.8	35.1	35.1	35.1	35.1	0	0
Labour Requirement	million man day	17.6	18.4	18.4	19.0	19.0	3	3
Paddy Production	'000 tonnes	277	306	306	320	320	5	5
Cropping Intensity (excluding orchard)	% NCA	139	141	141	144	144	2	2
Irrigated area	% NCA	34%	47%	47%	47%	47%	0	0
Net Crop Income	million Taka	870	949	949	979	979	3	3
Crop flood loss reduction	million Taka				27	27		
Non-agric. flood loss reduction	million Taka				24	24		
Fish catch reduction	million Taka				30	30		

Notes:

Project Year 1	: Assumed 1994/95
Future Without (1)	: Future Without Project Conditions, 5 years after project would have been completed
Future Without (2)	: Future Without Project Conditions, Year 30
Future With (1)	: Future With Project Conditions, 5 years after project completion
Future With (2)	: Future With Project Conditions, Year 30
% Increment (1)	: % difference FW (1) over FWO (1)
% Increment (2)	: % difference FW (2) over FWO (2)

Flood losses refer to average annual losses that will be eliminated by the project.

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TABLE 7.5.12

Summary of Results and Sensitivity Analyses

Planning Unit 8, Dhonagoda Project: Option 2

Capital cost	163.1 Tk.m.	Construction period	5 years
Annual O&M cost	4.8 Tk.m. (economic prices)		
Net Present Value @12%	56.69 Taka million (economic prices)		
Economic Internal Rate of Return	15.90 %		

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable						Switching
		+10%	+25%	+50%	-10%	-25%	-50%	Value (%)
Capital Costs	15.9	14.9	13.6	11.9	17.0	19.1	24.1	48.20
O&M Costs	15.9	15.8	15.5	15.2	16.0	16.2	16.6	263.44
Fisheries Losses	15.9	15.0	13.7	11.3	16.8	18.0	20.0	42.57
Reduced flood losses	15.9	17.3	19.2	22.1	14.4	12.0	7.2	25.28
Total Benefits	15.9	17.9	20.5	24.4	13.7	9.9	0.3	17.23
Incremental Net								
Crop Income	15.9	16.5	17.4	18.9	15.2	14.2	12.3	54.13
Delay in full benefits								
2 years	12.1							
4 years	10.6							
Delays in completion								
2 years	14.2							
4 years	12.6							

TABLE 7.5.13

Summary of Benefits

Planning Unit 8, Dhonagoda Project: Option 3 (Khal Excavation for Irrigation)

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	9.1	9.1	9.1	9.1	9.1	0	0
Irrigated Area	'000 hectares	4.4	6.1	6.1	9.1	9.1	50	50
Labour Requirement	million man day	2.3	2.4	2.4	2.7	2.7	10	10
Paddy Production	'000 tonnes	39	44	44	53	53	22	22
Cropping Intensity (excluding orchard)	% NCA	150	154	154	161	161	5	5
Irrigated area	% NCA	49%	67%	67%	100%	100%	50	50
Net Crop Income	million Taka	118	131	131	157	157	20	20
Crop flood loss reduction	million Taka				0	0		
Non-agric. flood loss reduction	million Taka				0	0		
Fish catch reduction	million Taka				0	0		

Notes:

Project Year 1	: assumed 1994/95
Future Without (1)	: Future Without Project Conditions, 5 years after project would have been completed
Future Without (2)	: Future Without Project Conditions, Year 30
Future With (1)	: Future With Project Conditions, 5 years after project completion
Future With (2)	: Future With Project Conditions, Year 30
% Increment (1)	: % difference FW (1) over FWO (1)
% Increment (2)	: % difference FW (2) over FWO (2)

Flood losses refer to average annual losses that will be eliminated by the project.

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TABLE 7.5.14

Summary of Results and Sensitivity Analyses

Planning Unit 8, Dhonagoda Project: Option 3 (Khal Excavation for Irrigation)

Capital cost	7.7 Tk.m.	Construction period	2 years
Annual O&M cost	0.4 Tk.m. (economic prices)		
Net Present Value @12%	113.60 Taka million (economic prices)		
Economic Internal Rate of Return	88.97 %		

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable						Switching Value (%)
		+10%	+25%	+50%	-10%	-25%	-50%	
Capital Costs	89.0	84.2	78.2	70.2	94.5	104.9	131.7	1742.47
O&M Costs	89.0	88.8	88.4	87.9	89.2	89.5	90.0	4337.46
Fisheries Losses	89.0	89.0	89.0	89.0	89.0	89.0	89.0	NA
Reduced flood losses	89.0	89.0	89.0	89.0	89.0	89.0	89.0	NA
Total Benefits	89.0	94.2	101.6	113.1	83.5	74.7	57.8	92.55
Incremental Net								
Crop Income	89.0	94.2	101.6	113.1	83.5	74.7	57.8	92.55
Delay in full benefits								
2 years	71.0							
4 years	62.1							
Delays in completion								
2 years	62.5							
4 years	48.9							

TABLE 7.5.15

Qualitative Impacts of Option - Planning Unit 8 (Ranked from - 5 to + 5)

Impact	Option 1 FCD	Option 2 FCD	Option 3 FCD
Physical			
Morphology (erosion and sedimentation)	- 2	0	0
Surface Water Quality	0	0	0
Navigation	- 3	- 1	0
Ecological			
Wetlands Reduction	0	0	0
Biodiversity - Crop Species	0	0	- 1
Biodiversity - Aquatic (Non-Fish)	0	0	0
Capture Fisheries	- 4	- 3	0
Culture Fisheries	0	0	+ 1
Socio-Economic			
Displacement	- 2	0	0
Social Conflicts	0	- 1	0
Investment Opportunities	+ 1	+ 1	+ 1
Income Distribution	- 1	- 1	-1
Poverty Alleviation	+ 1	+ 1	+ 1
Quality of Life			
Housing and Public Buildings	0	0	0
Nutrition	0	0	0
Transport Systems	+ 1	+ 1	0
Public Health, Diseases and Vectors	0	0	- 1

Note: Impacts relate to foreseen differences between future with and future without situations.

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7.6. Meghna-Dhonagoda Irrigation Project - Planning Unit 7

7.6.1 General Description and Constraints

The Meghna-Dhonagoda Irrigation Project (MDIP) is located near the confluence of the Padma and the Meghna in Chandpur district, as shown on the location map, Figure 7.6.1. It is a multi-purpose project which includes flood protection, drainage and irrigation and consists of a polder circumscribed by the Meghna and the Dhonagoda, about 18 800 ha in area. The project is a single lift irrigation project and the fields are mostly irrigated by gravity from the canals but there are two booster pump stations; the major pumps are reversible to permit them to be used for both irrigation and drainage.

The project was officially completed in June, 1988. In 1987, the flood embankment on Dhonagoda River was breached at Durgapur and the next year in 1988 it was again breached near the same place at Krishikandi. This also caused serious damage to the infrastructure within the project.

The present offset distance from the Meghna river at Eklashpur is only 200 m and from the Dhonagoda river at Amirabad about 240 m, bank revetment works were being undertaken in 1991/92 at both places. Eklashpur was one of the eight places studied by the Meghna Short Term Protection Study, FAP 9B. Table 5.7.1 gives the estimated rate of erosion at Eklashpur according to FAP 9B draft Morphology Report.

TABLE 7.6.1

Estimated Erosion Rates at Eklashpur

Year	Erosion rate (m/year)	Total erosion (m)
1991	40	0
1993	40	80
1998	70	180
2004	100	700

From this it may be seen that the embankment may be breached at any time. FAP 9B has proposed a hard point on the Meghna river at Eklashpur but this is very expensive and other solutions have also to be considered. FAP 9B proposals are discussed in Section 7.6.6.

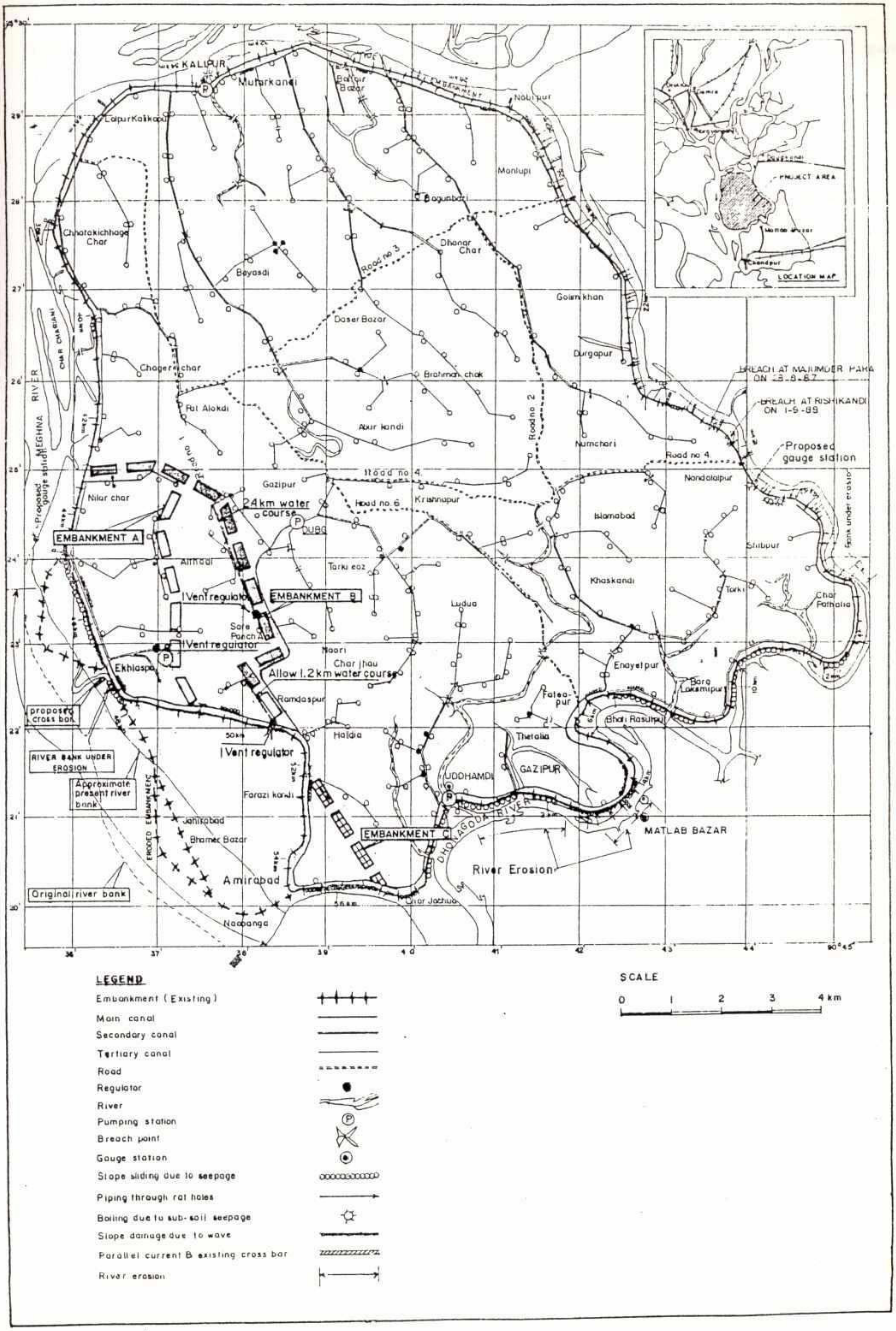
On the eastern side the embankment has failed twice and there is piping under the embankment at high river levels. This indicates that the embankment may fail again.

It has been reported that one quarter of the area in the centre of the project does not receive irrigation water since the secondary canals were seriously damaged in the 1987 and 1988 floods and have not been repaired. In fact many farmers are irrigating by low lift pump from khals, constructing their own channels. This needs attention.

Finally it is necessary to consider the problems of transport.

Figure 7.6.1

Meghna Dhonagoda Irrigation Project Constraints



7.6.2 Project Options and Costings

One obvious remedy is retirement of the embankments; three solutions have been considered, these are shown in Figure 7.6.1 and described below:

(a) Retirement about 1.5 km behind Eklashpur.
(b) Retirement about 3 km behind Eklashpur.
(c) Retirement about 1.5 km behind Amirabad.

Options 'a' and 'b' are alternatives whereas 'c' is independent and can be combined with 'a' or 'b'. For the regional plan, only embankments (a) and (c) have been considered. The new embankment would have to carry the peripheral canal since the original peripheral canal would be lost if the existing embankment fails. The new embankments do not necessarily lead to abandoning of the irrigation and flood control outside the embankment; the embankment may be considered as an internal embankment until the external embankment fails. Even then the repair of the external embankment could be justified on the basis of the value of flood control of the compartment between the old embankment and the retired embankment. The extent of the works required should be reviewed at the design stage. Costs of this option are summarised in Table 7.6.2 from where it may be seen that two navigation locks have been included. An additional provisional sum of Tk 2.5 million has been included for alterations to structures and other measures deemed necessary to control seepage. This will greatly facilitate transport. It may be that feeder roads should also be considered but this should be left to the design study and considered as an alternative.

The proposed solution for the eastern embankment is to increase the width of the embankment to the original design width i.e., from 17 feet to 21 feet (5.2 m to 6.4 m). Other remedial works may be necessary and an alternative solution may be found but at this level of study this has not been considered.

The reconstruction of the secondary canals in the centre of the system has been analysed separately.

At present there is no road transport within the scheme, which is an island. Navigation locks were omitted from the project at construction stage and the area suffers from high transport costs, to overcome this.

7.6.3 Economic Analysis

For the economic analysis the work has been divided into two parts, works on the main embankment and reconstruction of the secondary canals in the centre of the scheme.

The works on the main embankment consist of the following:

- Retirement of embankments at Eklashpur (embankment A) and Amirabad (embankment C)
- Widening of the embankment on the east side.
- Provision of navigation locks.

TABLE 7.6.2

Costs of remedial work to embankments (Tk 000)

Description	Embankments Eklashpur	Almirabad	Financial Capital Cost	Conversion Factor	Economic Capital Cost	O & M %	Financial O & M Cost	Conversion Factor	Economic O & M Cost
Retire embankments									
Earthworks	26805	15900	42705	0.66	28271	6%	2562	0.70	1790
Road paving	4940	3063	8003	0.78	6205	6%	480	0.71	340
Turfing	225	140	365	0.66	242	6%	22	0.70	15
Regulator	2500		2500	0.70	1760	3%	75	0.72	54
Watercourse	800	480	1280	0.66	847	6%	77	0.70	54
Land acquisition	40000	24000	64000	0.28	18097	0%	0	-	0
Forestry	2000	1200	3200	0.87	2784	6%	192	0.87	167
Khal crossing	1000		1000	0.71	711	3%	30	0.72	22
Sub-total			123053		58917		3438		2441
Engineering & administration 15%			23072		11047		645		458
Physical contingencies 25%			30763		14729		860		610
Total			176889		84693		4942		3510
Navigation locks									
Locks			12000	0.70	8448	3%	360	0.72	260
Engineering & administration 15%			2250		1584		68		49
Physical contingencies 25%			3000		2112		90		65
Total			17250		12144		518		373
Widen eastern embankment									
Earthworks			2600	0.66	1721	6%	156	0.70	109
Turfing			255	0.66	169	6%	15	0.70	11
Structures			2500	0.70	1760	3%	75	0.72	54
Sub-total			5355		3650		246		174
Engineering & administration 15%			1004		684		46		33
Physical contingencies 25%			1339		913		62		43
Total			7698		5247		354		250
Saving on O & M cost (pumping etc)							31090	0.96	29847
Grand total			201837		102083		36904		33979

The analysis is based on the assumption that all expenditure to date is sunk and cannot be recovered. If the remedial works are not carried out the benefits of the scheme are lost and the area will revert to its original condition. The benefits to the project are therefore the following:

- annual agricultural benefits of Tk 20 860/ha over 13 440 ha (FAP 12 Draft Final Report Vol 1 December 1991 Hunting Technical Services Limited et al.)

- avoidance of non agricultural losses (See Chapter 3 and Annex VIII).

The costs to the project are:

- capital cost
- loss of capture fisheries considering the case where the scheme breaches and capture fisheries would return to their original level; for this a figure of Tk 8 340 per ha has been used calculated from FAP 12 Draft Final Report Table 3.17.
- additional O&M cost of maintaining the locks
- O&M cost of operating the whole scheme, Tk 2 164 per ha (FAP 12 Draft Final Report Table 3.17), if the scheme were allowed to breach these costs would no longer be required.

The savings in transportation cost have not been estimated. It has also been assumed that the land between the original embankment and the retired embankment will revert to its original condition and no benefits have been calculated from that area. The results of the sensitivity analysis is given in Table 7.6.3. From these tables and Table 7.6.2. it may be seen that the proposal has a total cost of Tk 201 million including land purchase, the EIRR is 60% but drops to 18% if the benefits are delayed for four years. This is still a good rate of return and covers the case where the embankments are retired or widened long before any breach would have occurred. In view of the uncertainty of the projected time of breaching; it is recommended that the works commence as soon as possible.

The capital costs are low compared to the benefits, and this is common in rehabilitation work. As a check on the sensitivity to capital costs it was assumed that the new embankment failed ten years after completion. This gave an EIRR which was very little changed from the base case, again because the capital costs are low in comparison with the benefits.

For the rehabilitation of the secondary canals in the centre of the project a simple form of analysis has been used. The costs are taken as the cost of installing a secondary canal network as new. The benefits have been calculated on the assumption that as soon as the canals are built all pumping by LLP will cease and the saving in cost will be a benefit. No allowance has been made for savings in power costs at the main pump station since all the water is pumped to the high level peripheral canals in any case even if it is at present allowed to fall into the khals.

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TABLE 7.6.3

Summary of Results and Sensitivity Analyses

Planning Unit 7, Meghna Dhonagoda, Remedial Works to Main Embankment

Net Present Value @12%	815.88 Taka million
Economic Internal Rate of Return	60.76 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	60.8	58.0	54.5	49.6	63.9	69.5	82.9	1108.57
O&M Costs	60.8	60.3	59.5	58.2	61.3	62.0	63.2	539.53
Fisheries Losses	60.8	59.1	56.4	51.4	62.4	64.7	68.3	126.80
Total Benefits	60.8	65.5	71.8	80.6	55.3	45.4	17.6	-52.70
Incremental Net Crop Income	60.8	64.7	70.0	77.6	56.4	48.7	30.6	-64.29
Delay in benefits								
2 years	30.3							
4 years	18.3							
Delays in implementation								
2 years	46.7							
4 years	38.3							

The cost of installing a secondary irrigation distribution system has been taken at Tk 2 600/ha. (MPO/WRPO Technical Report Nr 13 - Procedure for Preparing Cost Estimates, 1987). The cost of LLPs has been taken as an annualised cost of Tk 778 per ha contingencies of 25% and engineering and administration costs of 15% have been added. For the purposes of this evaluation it has been assumed that the distribution works will continue for five years and the pumps will cease to operate immediately the works are completed on each part of the area. The area considered has been one quarter of the total NCA ie 3592 ha.

The estimated cost of the works is Tk 17.9 million and the NPV at 12% is Tk 3.7 million, the EIRR is 16.5%. The sensitivity analysis is given in Table 7.6.4.

TABLE 7.6.4

Summary of Results and Sensitivity Analyses

Planning Unit 7, Meghna Dhonagoda, Remedial works to Distribution System

Net Present Value @12%	3.69 Taka million
Economic Internal Rate of Return	16.49 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	16.5	15.1	13.3	11.0	18.2	21.4	30.1	38.10
O&M Costs	16.5	16.4	16.3	16.0	16.6	16.7	17.0	448.29
Fisheries Losses	16.5	16.5	16.5	16.5	16.5	16.5	16.5	n.a.
Total Benefits	16.5	18.1	20.4	24.1	14.8	12.2	7.2	-25.99
Incremental Net Crop Income	16.5	18.1	20.4	24.1	14.8	12.2	7.2	-25.99
Delay in benefits								
2 years	12.7							
4 years	10.3							
Delays in implementation								
2 years	16.4							
4 years	16.2							

7.6.4 Qualitative Impacts

a) Remedial Works to Embankments

This project is the reverse of the normal project since the intention of the project is to prevent a return to the old situation, (i.e., before the polder was completed), and therefore other considerations have to be taken into account. The area was deeply flooded previously and the proposed works will prevent the deep flooding from returning. Therefore many impacts are related to a comparison with the previous situation before the construction was completed. FAP 12 Draft Final Report Vol 2 states that the project "offers excellent opportunities for monitoring two major aspects of FCD projects for which little or no data now exists:

- water quality in ponds, khals, drains, rivers and (especially) groundwater, to establish baseline figures and then to assess the impacts of agrochemicals and sewage.

- soil physical characteristics and fertility under the paddy monoculture created by the project".

This highlights two of the important impacts which have been reported by the inhabitants, reduction in soil fertility and contamination of the water so that bathers often suffer from skin irritations. The latter problem may be partially overcome by regular flushing of the system and this should be investigated but if the system is closed, or drainage pumping is reduced to save cost, there is likely to be a build up of chemicals and pathogens in the system. There may be ways to reduce these effects but further research is clearly required and this will be beneficial to the FAP as a whole.

The main qualitative impacts are summarised in Table 7.6.5.

TABLE 7.6.5

Qualitative Impacts Planning Unit 7 (Ranked form - 5 to +5)

Impact	Remedial Works of main embankment	Completion of distribution system
Physical		
Morphology (erosion etc).	- 2	- 2
Surface Water Quality	- 1	0
Ecological		
Wetlands Reduction	- 2	- 1
Biodiversity-Crop Species	- 1	0
Biodiversity-Aquatic (Non-Fish)	- 1	0
Capture Fisheries	- 2	0
Culture Fisheries	+ 1	0
Socio Economic		
Displacement	- 2	0
Social Conflicts	- 2	0
Investment Opportunities	+ 1	0
Income Distribution	+ 1	+ 1
Poverty Alleviation	+ 2	1
Quality of Life		
Housing and Public Buildings	+ 1	0
Nutrition	0	0
Diseases and Vectors	- 1	0
Transport Systems	+ 2	0
Health (sewage etc)	- 1	0

b) Remedial Works to Distribution System.

The remedial works to the distribution system form a minor intervention and the negative impacts are not major, provided that the outside embankments are safeguarded. The major risk is a failure of the outer embankment which would render the works useless and the works themselves would lead to slightly more extensive irrigation in some areas. The qualitative valuations are summarised in Table 7.6.5.

7.6.6 River Bank Protection at Eklashpur

As mentioned earlier the protection of the existing line at Eklashpur has been investigated by FAP 9B. The consultants for FAP 9B have designed and costed a major scheme to make a hard point at Eklashpur which will help to constrict the Meghna more or less to its present channel. The next hard point downstream would be Chandpur town. If both proposals were to go ahead the prediction is that the Meghna course would be fixed in this reach although there may be intermediate erosion between the two hard points but this would eventually stabilise. This erosion would not affect MDIP apart possibly from slight further erosion at Amirabad.

The estimated cost of the hard point at Eklashpur in 1991 economic prices is:

Tk 284.5 m in 1993
Tk 246.5 m in 1998 and
Tk 246.5 m in 2005

Tk 777.5 m Total (1991 prices)

The O&M costs vary in stages from Tk 8.9 m per year in 1993 to Tk 17.7 m per year in 2005 and thereafter. The benefits would be the savings in cost of retirement of embankments plus the benefits to be obtained in the area between the new works and the retired embankment and the non-agricultural benefits.

The consultants for FAP 9B have compared the cost of the protection works with the cost of constantly retiring the embankment.

The EIRR is about 3% and the NPV at 12% is Tk. -293 million. Whilst these benefits are low the protection must be seen as part of a larger scheme involving the stabilizing of the entire river bend of the Padma into the lower Meghna which could have profound and long term consequences for a substantial part of the South East Region. This presents a dilemma for the planners since the retirement of the embankments within MDIP would not be required if this protection were to go ahead quickly. However this now seems unlikely.

CHAPTER 8

GUMTI PHASE II DEVELOPMENT PROPOSALS

8.1 Introduction

The Government of Bangladesh, in implementing the third Flood Control and Drainage Project financed under IDA Credit 591-BD, undertook the preparation of a feasibility study of Phase II of the Gumti Project. This study was to formulate a project that would mitigate the effects of periodic flooding and poor drainage in the project area, develop its irrigation potential and alleviate any adverse effects of the Gumti Phase I Project on the adjoining Gumti Phase II area. The study report, referred to hereafter as the "1990 Report" was accepted by the Bangladesh Water Development Board (BWDB) but not IDA, who believed that less capital-intensive options should also have been investigated and evaluated. In addition, IDA considered that the study should be compatible with the framework and guidelines of the Flood Action Plan (FAP) and current IDA project preparation policy. This implied the need for an environmental impact assessment of the project and consideration of any dis-economies and their mitigation measures in the economic analysis. In order to continue its support of project preparation, IDA requested that the feasibility study be revised and extended.

New Terms of Reference for the Study, were drawn up and funds were provided from a Japanese Grant Facility executed by the World Bank.

This chapter summarises the findings of the Gumti II revised study and outlines the various feasible interventions in the area for consideration in the Regional Plan.

8.1.1 Project Location

The Gumti Phase II project area lies to the north-west of Comilla. It is bounded to the south by the Gumti River, to the west by the Meghna River, to the north by the Titas (or Pagla) River and to the east by the border with India.

The project area, is 141,000 hectares in size and generally varies between 2.5 and 6 metres above sea level. An exception to this is a small area of relatively high land, rising to 9 m asl, just north of Comilla.

The area lies within the two districts of Comilla and Brahmanbaria and 11 thanas of Comilla Sadar, Burichang, Debidwar, Brahmanpara, Kasba, Akhaura, Nabinagar, Muradnagar, Bancharampur, Homna and Daudkandi. The most remarkable feature of the project area is the difference of topography and water problems, with comparatively high ground and flash flooding to the east and low ground, high fisheries content and Meghna related flooding to the west.

8.1.2 Population

On the basis of the 1981 census data and an annual growth rate of 1.8%, the population within the Gumti Phase II project area is estimated to be 1.9 million, with an average density of 1300 persons per square kilometre. The population density is thus nearly twice the national average (although the figures may not be directly comparable because of differences in the treatment of open water areas in the major rivers) and substantially

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8.1.3 Objectives and Targets of the Project

The principal objectives of the current project are that technically and economically viable project alternatives are to be identified and evaluated, in addition to those put forward in the 1990 report. These alternatives must fulfil regional development objectives in a cost effective manner.

The economic objectives of the project are maximization of the net present value of aggregate consumption benefits and employment generation, with as large a private sector participation in project investment as possible. Fulfilment of these objectives should minimize any regressive effects on the poorer population's income and welfare and adverse impacts on the physical environment.

The targets to achieve the above objectives are as follows:

- reduction of crop losses due to seasonal and flash flooding
- creation of controlled flooding in the aman season to facilitate the transformation of areas normally under deep water broadcast rice to HYV or LIV transplanted rice cultivation.
- increase of the area under boro and rabi cultivation by facilitating surface irrigation by low lift pumps and further groundwater development
- conserve and if possible improve capture fisheries potential and develop pond fisheries
- improve physical infrastructure needed to complement flood control
- improve agricultural support services needed to sustain increased agricultural production
- minimise the new land required for embankments and its associated resettlement by using existing roads and embankments wherever possible

8.1.4 The Approach

a) Relationship with South East Regional Study (FAP 5)

The South East Regional Study (SERS) is an ongoing Flood Action Plan study financed by UNDP and administered by the World Bank. The Gumti Phase II area lies within SERS project boundary and actually forms Planning Unit 11 of the regional study.

In addition to the regional study, SERS was required to identify and carry out a Feasibility Study within one of the planning units. The Noakhali North Feasibility Study was selected and work on this started in August 1992.

In order to minimise the costs associated with the Gumti Phase II study, it was decided that resources were to be shared with the SERS Feasibility Study, which was run in tandem with the Gumti Project. This brought about the advantages of shared methodology, where viable, as well as reduced air travel costs. It did however produce problems of resource use, with both projects requiring key resources at critical times. The problem was further exacerbated by the fact that both studies had the comparatively short duration of approximately 11 months in which to complete the final reports.

b) Staffing

Suggested personnel inputs were given in the Terms of Reference, split into man-months for expatriate and local staff. The TOR and actual inputs, as presented in the Inception Report, are presented in Table 1.1.

The most notable alteration is the increase in expatriate and local man-months for environmental work. Although it is beyond the scope of the present study to follow the FPCO guidelines for Environmental Analysis, it was considered essential to devote more time to this aspect of the study in order to arrive at an environmental impact assessment which is compatible with the framework and guidelines of the Flood Action Plan.

As the study budget could not be increased, the additional man-months used for the environmental side of the study had to be taken from the engineers' and economists' time.

c) FPCO Guidelines

The Flood Plan Coordination Organisation (FPCO) produced a set of guidelines for project assessment which was finalised in May 1992. The guidelines for Environmental Impact Assessment were produced in October 1992, after submission of the project Inception Report.

The purpose of the guidelines is to assist members of teams undertaking the Regional Water Resource Planning Studies and feasibility studies for investment projects under the Flood Action Plan. One of the main objectives of the guidelines is to standardise methods and procedures for Flood Action Plan Projects, so different projects may be appraised on an equal basis.

The Gumti Phase II feasibility study does not come under the FPCO, however, the project follows these guidelines wherever possible. It should be noted that due to the constraints concerning the 11 month duration of the study it will not always be possible to follow the guidelines comprehensively. In addition, the very low water levels of the 1992 wet season will be detrimental to achieving the databases required by the Guidelines.

d) Surveys and Investigations

The 1990 report contains a great deal of valuable data which was used during the course of this project. In addition to this, there is a substantial amount of secondary data available from agencies such as the Bangladesh Bureau of Statistics (BBS), Agricultural Sector Team (AST), Department of Agricultural Extension (DAE) and individual thanas. A considerable effort was made to collect and use this data for the project.

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8.2 Hydrology and Hydrogeology

8.2.1 Rainfall

The annual rainfall over the project area varies from about 2300 mm in the south to about 2100 mm at Brahmanbaria. At 80% exceedance probability, annual rainfall drops to about 2000 mm at Comilla, and to about 1700 mm at Brahmanbaria.

The peak rainfall months are June, July and August. During these three months, about 55-60% of the annual rainfall total can be expected.

There is no effective rainfall for agriculture in the project area between mid October and the end of April. Even going into May supplemental irrigation will often be required.

8.2.2 Drainage Conditions

A general map of the drainage system in the project area is presented in Figure 8.1. The entire area is bounded to the west by the River Meghna, and it is this that dominates drainage of the greater part of the project area. The mean annual flow at Bhairab Bazar is of the order of 4600 m^3/s, but seasonally the discharge varies between a mean monthly minimum of 260 m^3/s in February and a mean monthly maximum of 12,400 m^3/s in August. The Meghna is joined by the Padma about 100 km downstream of Bhairab Bazar. The Padma carries the combined discharges of the Ganges and Jamuna (Brahmaputra) Rivers. Mean annual runoff in the Padma is of the order of 30,000 m^3/s, and on average varies between 75,000 m^3/s in August and 6000 m^3/s in February. There are backwater influences in the Meghna upstream of its confluence with the Padma, and the project area is thus affected by the major river systems. The coincidence of seasonal rainfall with peak flood discharges in the Meghna does, however, exacerbate internal drainage problems. Figure 8.2 shows hydrographs of mean decad discharges in the Padma and Meghna Rivers, along with mean decad rainfalls over the project area. The basic parameters of the internal drainage problem of the project area are the same as those for the country as a whole.

The Meghna is the outfall water level control on drainage for the entire project area. The seasonal range in Meghna water levels reduces in a southerly direction towards the Bay of Bengal. At Bhairab Bazar, the seasonal range of water levels is of the order of three metres, and there is very little tidal influence in the dry season. At Satnal the seasonal range in water levels is of the order of 2.5 m, and the dry season tidal range of the order of 300 mm. There is a notable change in water surface slope in the Meghna between wet and dry seasons.

There are areas of relatively deep flooding in the project area close to the Meghna. Drainage in these areas is complex, with a series of interconnected channels and remnants of former main river courses. It is difficult to identify any singularly important main rivers, other than perhaps the Hawrah which flows into the Buri and Titas rivers, and the Salda River. Some of the channels in the area had formerly been fed by spills from the Gumti River, prior to completion of embankments and the construction of a regulator at the head of the Buri Nadi River. The area does receive inflows from a number of rivers draining the western slopes of the Tripura Hills.

Figure 8.1

General Map of Main Drainage System and Data Collection Stations

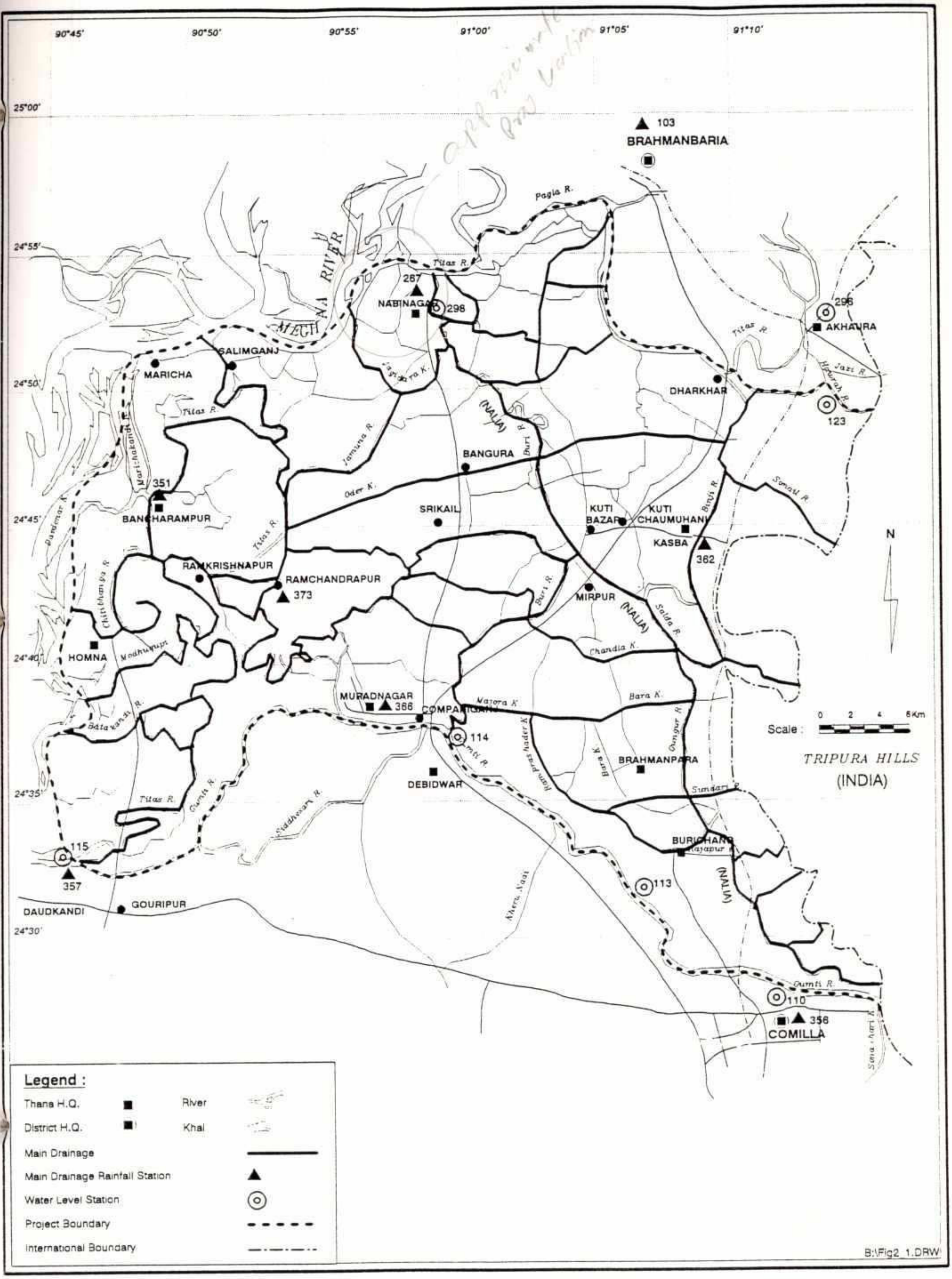
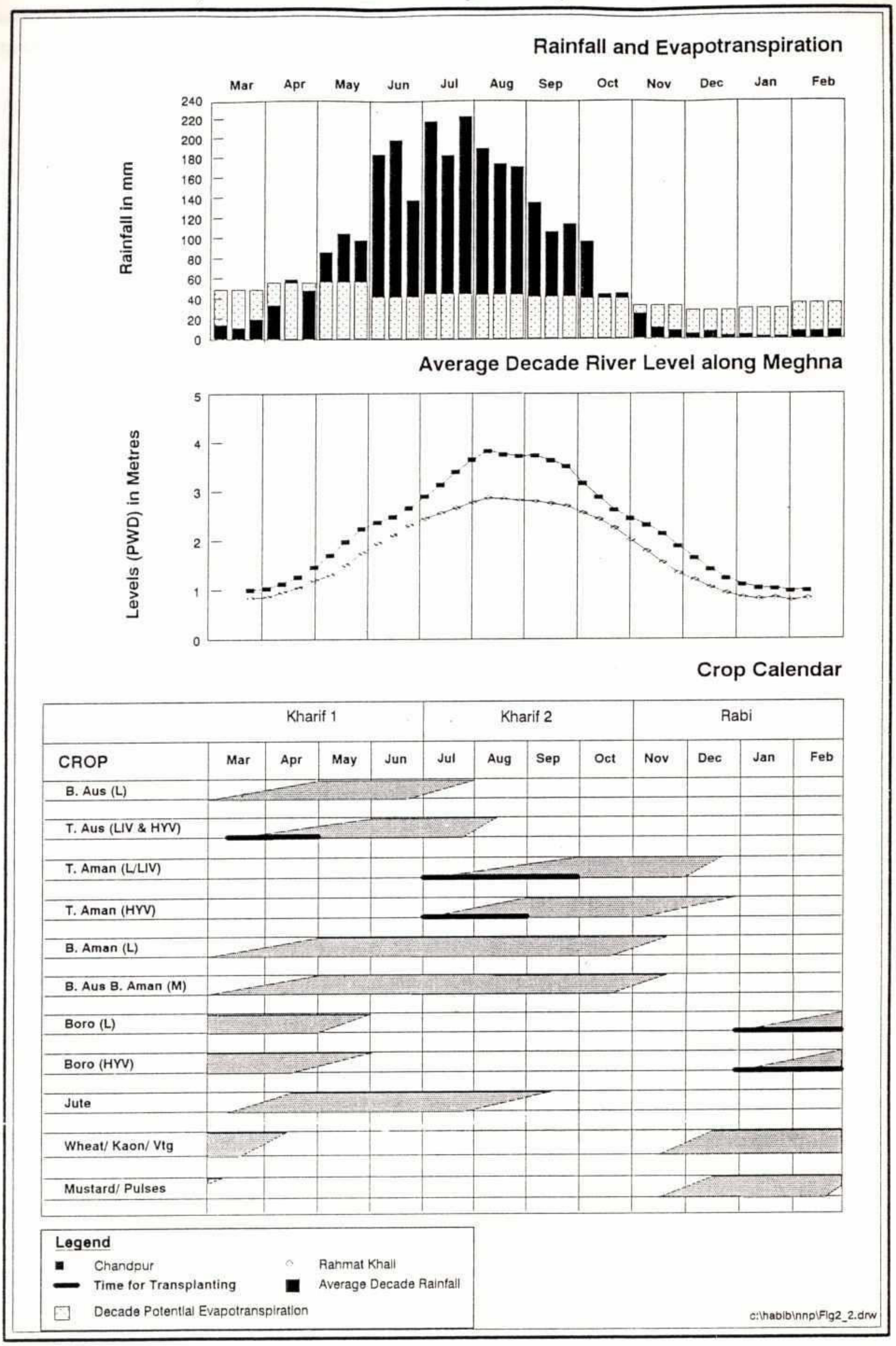


Figure 8.2

Relationship Between Rainfall Evapotranspiration, Floods and Crops



The area in Bangladesh between the Bhairab to Comilla railway and the Gumti River is about 1400 km^2. Thus about 50% of the drainage through the project area is generated in external catchments. Flash floods in these rivers can cause serious damage.

The Gumti River forms the southern boundary of the project area. It is embanked through most of its length in Bangladesh. It can contribute to flooding in the south western part of the project area. The Gumti is embanked from upstream of Comilla, almost to its confluence with the Meghna. The annual maximum mean daily flood in the Meghna at Comilla is 500 m^3/s. During times of flood, water levels in the Gumti are significantly higher than the surrounding land. Historically, the Gumti did spill through the project area through the Buri Nadi River. This is now controlled with gated inlets from the Gumti.

8.2.3 Flooding Characteristics

On the basis of the MPO flood phase classification system, only 15% of the area is flood free. The timing, rate of rise, and duration of flooding are, in addition to the flood peak attained, very important factors influencing agricultural damage and cropping patterns, fisheries, and indeed the general disruption caused. Seasonality of flooding is therefore a key variable.

In terms of seasonality, the flood problems are:

pre-monsoon	: April-June	rapid rise in water level before boro crops are harvested, and kharif I crops planted; loss of young crops and seedlings;
monsoon	: July-August	the rate of rise of flood levels exceeding the rate of growth of rice; peak main river levels and prolonged flooding partly through backing up from the main rivers and reduced gradients for local rainfall; duration of flood inundation is important, and whether flood water is clear or sediment laden;
post-monsoon	: Sept-Oct	drainage at too slow a rate to permit timely planting of certain crops;

In addition to the above flood periods, the general categories under which flooding in the project area can be considered are:

- monsoon floods from the River Meghna and Lower Meghna;
- flash floods from those rivers rising in the Tripura Hills to the east of the project area;
- localised flooding as a result of heavy and intense rainfall.

The project area is well defined from a flood characteristics point of view, being bounded by the River Titas in the north, the Gumti River in the south, and the Meghna in the west. The areas close to the Meghna are particularly susceptible to deep flooding. During the main monsoon season, the Meghna dominates flood extent in the area, and in the northern part of the area, there is very little west to east gradient. From the elevation area characteristics published for MPO planning areas 29 and 31, and water level records, it is apparent that the Meghna is the primary source of prolonged monsoon flooding.

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The nature of the drainage system through the project area is such that its evaluation required the application of computational hydraulic modelling techniques.

8.2.4 River Morphology

a) Upper Meghna Erosion

Any development of the Gumti Phase II project area must take account of possible shifting of the existing bank line of the Upper Meghna, particularly in determining the appropriate set-back for embankments.

FAP 9B (Meghna Left Bank Protection) and BWDB reports relating to erosion problems along the Upper Meghna at the boundary of the project area were reviewed, and field visits undertaken along the Meghna-Titas left bank from Nabinagar to Bancharampur and the nature and extent of erosion along the bank line studied. Available aerial photography, SPOT satellite imagery and maps from 1952 to 1990 were also studied. Subsequently a series of LANDSAT images (December 1973 - January 1993) covering part of the area also became available.

From all these sources it was observed that the Meghna is gradually shifting from a braided to a meandering form, apparently as a result of the diversion of the Brahmaputra flow through the present Jamuna channel in 1776. This shift is mainly due to the reduction of flow and the process is still continuing.

It is concluded that there is significant erosion in the northern project boundary downstream of where the Meghna meets the Pagla River (the Upper Reach). However, no major infrastructure is presently situated in this reach, and the cost of effective protective works is unlikely to be justified.

The recommended strategy is therefore to provide an adequate set back to any embankment, so that it is unlikely to be threatened within a project lifetime of, say, 30 years. An erosion rate of 20 m per year therefore suggests a set back distance of 600 m in this reach. Allowing a safety margin, the figure of 700 m proposed by FAP 9B seems entirely reasonable, and the set back of 500 m to 800 m already adopted by the 1990 feasibility study is consistent with this.

In the Lower Reach from Shantinagar to Daudkandi (forming the western boundary to the project area), a set back distance of 300 m has been adopted by the 1990 study, and this figure is considered adequate.

The above recommendations on set back distances do of course assume that present trends continue (or are not exceeded). Major interventions in the North East Region (FAP 6), for instance, could have significant effects upon the morphology of the downstream channel, although these would be very difficult to predict. At the time this report was written the FAP 6 "With Project" computer model runs had not been done.

b) Gumti Right Embankment

The right bank of the Gumti River, adjacent to the project area, is now embanked from the Indian border as far as the village of Daskandi, about 65 km downstream, following completion of the Gumti Phase I Project in 1992. This river has a substantial catchment in the Tripura Hills of India, and is subject to flash flooding.

The Gumti Phase I project was merely the latest in a series of works to try and contain it. Embankment protection works have been provided on the outer banks at several bends, but erosion is still serious in some reaches, which need additional protection. The cost of carrying out these works, which are strictly speaking outside the project area, has not been included in the project proposals, and they should be regarded as part of the maintenance requirements of the Gumti embankment. Nevertheless, failure of the embankment arising from their neglect would cause serious damage to the project area, whether or not the proposals arising from the present study are implemented.

Howard Humphreys and Partners (Hydrological and Morphological Studies of the Gumti, Titas and Atrai Basins, April 1990) performed a hydrodynamic and morphological model analysis of the behaviour of the river with its embankments, substantially as now implemented. According to both the Howard Humphreys study and the 1983 confinement study by NEDECO the embankment as constructed is liable to overtop under 1 in 20 year conditions. The overtopping at the downstream end under conditions of high Meghna water levels is not of major concern, since in the absence of a Meghna embankment, protection from main river floods is in any case not available. Indeed the right embankment has not actually been constructed beyond about chainage 60 km (although extension as a low submersible embankment is recommended in the Zone D proposals under the present study).

Previously, up to about 30% of the discharge at Comilla used to escape into the Buri Nadi at kilometre 41 (Feasibility Report on the Gumti South Project, Annex C, NEDECO, 1984). This escape has effectively been closed as part of the Gumti Phase I works, which arguably was as major an intervention morphologically as construction of the embankments themselves. Floodplain levels are not available from the Howard Humphreys study, but comparisons have been made between floodplain (and bed) levels extracted from the South East Regional Model (surveyed in 1986 approx) with those obtained from the 1993 surveys, within the embankments. This shows that there is a distinct rise between the two surveys, more or less mirroring the drop in bed level. In the reaches which have been embanked for many years, the land within the embankments is distinctly higher than that outside (viewed either in the field or from the Water Development Maps), confirming this tendency. The one-dimensional morphology model used by Howard Humphreys may therefore have been correct in finding no net erosion or accretion within the channel, but was not able to show the redistribution from bed to flood plain.

The removal of the hump in the bed downstream of the Buri Nadi offtake would have a major positive impact upon the availability of water for irrigation within the Gumti River, since it would then be possible to draw a backflow from the Meghna River during the dry season for perhaps up to 50 km upstream. The mean February/March low water level at Daudkandi is about 1 m above PWD, so under static conditions the water depth at the Buri Nadi offtake could be nearly 2 m, but a water surface slope of 3 or 4 cm/km would reduce this to zero. It is recommended that the channel be surveyed every year or two to check whether the trend is continuing. It may be worthwhile to dredge the channel artificially in order to achieve the benefits earlier, but it is unlikely that the channel could be economically maintained at a size in excess of its natural equilibrium.

The schemes as presently envisaged could have a serious detrimental affect on the fish who use the beel. This is because the gates are not fish friendly and they will be closed during the pre-monsoon period, when it is critical for the fish to move between river and beel. Since the construction is now complete, the effect of the fisheries should be carefully monitored in relation to the agricultural improvements obtained from protection of the boro crop.

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8.2.5 Impacts of Floods

Discussion with people during surveys and people's participation meetings concluded that the normal annual floods were not a problem to people in the project area.

The flood of 1988 was the highest recorded flood in the Gumti Phase II project area. Along with most of the rest of the country, significant damage was done to both aman crops and infrastructure.

The major impact of floods in the area is caused by flash floods which come from the Indian border. From our surveys, significant damage is caused in Zones A and B on a regular basis to crops, generally the boro crop. Flash floods also caused damage to the area downstream of the existing Gumti North embankment in Daudkandi thana.

It should be noted that the 1993 pre-monsoon period has been especially prone to flash floods. Heavy rainfall from 17 to 19 February 1993 affected rabi crops on about 1200 ha downstream of the completed embankment.

On 10 May 1993 approximately 200 ha of boro in Kasba and 60 ha in Akhaura went under water. A few days after that, approximately 7000 ha north of Brahmanpara went under water for several days. Project staff witnessed farmers trying to harvest the boro crop from boats but it would have to be assumed that most of this crop would have been completely destroyed.

Although 1993 is an unusually bad year, it can be concluded that protection should be targeted against flash floods and the damage they cause. This is because the costs of protection against the major floods of 1988 would be enormous and difficult to justify, while protection against annual Meghna related floods would produce little benefit, as they cause little hardship.

8.2.6 Groundwater Development Potential

The groundwater potential for each abstraction mode was estimated using a combination of the potential recharge estimates of FAP:5 and new determinations of the depth - storage curves, to which the gas and salinity constraints were applied. For the areas with complications due to salinity and multiple aquifer configurations, these results were further investigated using the SUTRA solute transport model, and a multi-layer groundwater model (SCTM).

Tables 8.1 to 8.3 describe the probable impact of increased groundwater irrigation, **without project intervention**, which has been assessed on the assumption that it would occur in three phases:

- additional STWs up to suction limits (without deep setting)
- additional STWs and DSSTWs up to suction limits
- development by suction mode wells first, followed by force mode wells where land resources remain un-irrigated

TABLE 8.1

Analysis of Future Groundwater Development by STWs Only

Thana	Total Area Irrigated ha	Cultivable Area Irrigated %	Suction Mode ha	Force Mode ha	Net GW Abstn. mm	% of Constrained Potential Recharge	*Water table at full development* Est. SWL m	Int. Specific Yield	Vol. Released mm
Akhaura	5 753	90%	1 668	567	120	14%		–	–
Kasba	11 914	65%	5 143	2 240	183	28%	5.0	0.028	184
Nabinagar	16 855	60%	7 168	535	120	16%	2.4	0.020	124
Bancharampur	17 492	90%	12 272	230	272	58%	5.1	0.053	272
Homna	13 468	88%	10 136	20	266	46%	5.3	0.046	263
Daudkandi	9 307	90%	4 008	235	166	28%	1.9	0.041	169
Muradnagar(2)	6 055	28%	857	1 385	44	8%	2.0	0.024	44
Debidwar	2 632	40%	1 567	141	111	19%	3.0	0.020	108
Brahmanpara	5 148	56%	2 389	1 808	167	32%	5.5	0.028	164
Burichang	4 519	62%	828	2 840	190	37%	7.2	0.028	188
Comilla	2 483	69%	729	898	179	33%		–	–
Total / Average	95 625	67%	46 764	10 899	165	29%	4.2	0.026	138

TABLE 8.2

Analysis of Future Groundwater Development by STWs and DSSTWs

Thana	Total Area Irrigated ha	Cultivable Area Irrigated %	Suction Mode ha	Force Mode ha	Net GW Abstn. mm	% of Constrained Potential Recharge	*Water table at full development* Est. SWL m	Int. Specific Yield	Vol. Released mm
Akhaura	5 753	90%	1 668	567	–	–		–	–
Kasba	14 947	82%	8 176	2 240	259	39%	6.9	0.031	258
Nabinagar	20 487	73%	10 800	535	177	24%	3.9	0.026	177
Bancharampur	17 492	90%	12 272	230	–	–		–	–
Homna	13 746	90%	10 414	20	273	48%	5.4	0.047	273
Daudkandi	9 307	90%	4 008	235	–	–		–	–
Muradnagar(2)	7 343	34%	2 145	1 385	69	13%	3.0	0.024	68
Debidwar	3 163	48%	2 098	141	146	25%	4.0	0.024	144
Brahmanpara	7 459	81%	4 701	1 808	258	50%	7.6	0.032	254
Burichang	4 794	66%	1 103	2 840	204	39%	7.9	0.028	208
Comilla	2 773	77%	1 019	898	210	38%			53
Total / Average	107 264	75%	58 403	10 899	145	25%	5.5	0.021	131

TABLE 8.3

Analysis of Future Groundwater Development by Suction and Force Mode Wells

Thana	Total Area Irrigated ha	Cultivable Area Irrigated %	Suction Mode ha	Force Mode ha	Net GW Abstn. mm	% of Constrained Potential Recharge	Water table at full development Est. SWL m	Int. Specific Yield	Vol. Released mm
Akhaura	5 753	90%	1 668	567	567	–		–	–
Kasba	16 420	90%	8 176	3 713	295	44%	7.9	0.032	297
Nabinagar	25 349	90%	10 800	5 397	253	34%	5.5	0.032	252
Bancharampur	17 492	90%	12 272	230	230	–			–
Homna	13 746	90%	10 414	20	20	–		–	–
Daudkandi	9 307	90%	4 008	235	235	–		–	–
Muradnagar(2)	19 215	90%	2 145	13 257	301	55%	7.8	0.039	300
Debidwar	5 955	90%	2 098	2 933	328	55%	10.0	0.028	328
Brahmanpara	8 324	90%	4 701	2 673	293	57%	8.3	0.034	293
Burichang	6 514	90%	1 103	4 561	293	56%	9.5	0.032	291
Comilla	3 238	90%	1 019	1 363	261	48%		–	–
Total / Average	131 314	90%	58 403	34 950	280	32%	8.2	0.020	160

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Suction and force mode tubewells each have their optimum roles in irrigation. The primary determinant of this is the depth to water. Under more difficult aquifer conditions, where gas constraints apply, or at more advanced stages of irrigation development there will be a natural transition from suction mode to force mode pumping. An economic comparison of STW and (private sector) DTW irrigation shows that except with very shallow water tables, DTWs are economically preferred when irrigation is examined as an isolated activity. Most of the advantages of STWs lie in their easier financing, smaller group sizes and the possibility of alternative uses for the prime mover.

8.2.7 Minor Irrigation

All existing irrigation within the project area comes under the category of minor irrigation; that is to say that there are no schemes involving major pump stations and/or extensive gravity distribution. The CIDA funded Agriculture Sector Team (AST), in its Census of Lift Irrigation, categorises minor irrigation modes as follows:

- Low Lift Pumps (LLP)
- Deep Tubewells (DTW)
- Shallow Tubewells (STW)
- Deep Set Shallow Tubewells (DSSTW)
- Hand Tubewells (HTW)
- Traditional Methods

A database of gross (GA) and net cultivable arable (NCA) areas by one minute square is available as part of the land level database prepared for the study. The AST data was used to estimate the percentage of the NCA within each block which is presently (1991) irrigated by various modes. Details of results obtained for all modes of irrigation are given the feasibility study. Features which become apparent are:

- the relative sparseness of irrigation in the centre of the project area, which the Zone C irrigation proposal seeks to address,
- the concentration of DTW in the east and especially the south-east,
- the concentration of LLP along the major rivers and surprisingly along the Salda River mid-way up the eastern boundary. In the latter case there is probably a severe risk of water shortage as the Salda flow dwindles late in the season,
- the sparsity of STW in the central areas, presumably due to the problems of gaseous aquifers, and
- the significant contribution of traditional methods over most of the area.

8.3 Fisheries in the Gumti II Area

8.3.1 Secondary Data Collection

Data collected from secondary sources have been used to evaluate the status of the existing fisheries in the area. The majority of the statistics have been obtained from the Fisheries Resources Survey System (FRSS) of the Directorate of Fisheries (DOF) sources in Dhaka. However, it is recognized that the use of these data is of limited value due to the unavailability of up to date information. The latest complete set of available figures for this study correspond to 1988-89, as riverine data for 1989-90 is missing. Furthermore, the present system has many weaknesses such as small sample sizes, very few sampling villages and a backlog of data due to insufficient processing capacity.

All Thanas Fisheries Offices in the project area were requested to provide information on the number of fishermen and categories of operation, i.e. full-time, part-time, occasional (FAO/UN, 1962). Additional information resulting from this survey includes fish production estimates, dominant species caught per Thana, fish species occurring in the area, fisheries developments and main problems related to fisheries in each Thana.

Information on hatcheries and nurseries in the area was gathered from secondary sources, mainly FRSS, and Thana Fisheries Offices.

The number of fishing households in the Gumti Phase II area has been estimated from information received from the Thana Fisheries Office survey. This indicates the number of fishermen per Thana and the number of households in the area as per the 1981 census (BBS, 1981). It would be valuable to verify these data from the 1991 BBS census when this becomes available. Table 8.4 shows details of these results per zone.

TABLE 8.4

Number of Fishing Households in the Gumti Phase II Study Area

	Number of Fishing Households								
	Number of Households	Full - Time	%	Part - Time	%	Occasional	%	Total	%
Zone A	61.140	1.207	2	1.888	3	11.034	18	14.129	23
Zone B	53.193	2.173	4	3.374	6	19.807	37	25.354	47.7
Zone C	82.281	7.650	9	11.270	13	21.092	26	40.012	48.6
Zone D	96.653	5.428	6	18.363	18	63.876	66	87.667	90
Total	293.267	16.458	5.6	34.895	11.9	115.809	39.5	167.162	57

Source: BBS 1981 Census for Number of Households.
Gumti Phase II Thana Fisheries Office Survey for Number of Fishermen

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8.3.2 Primary Data Collection

A short fishery survey of eight weeks duration was undertaken in an attempt to gather useful information regarding the project area in particular.

Although great care was taken at all stages of this study, it should be reiterated that this type of survey is inadequate both in terms of time and funding, to adequately describe the fisheries and to predict future changes in a complex system such as that which exists in the Gumti Phase II area.

This study was carried out during the period from September 1992 to February 1993, and field data were collected during mid-October to 1 December 1992. Fishing patterns, gears used and operators were addressed for each type of capture fishery system.

Unfortunately, the results from this short field study cannot be cross- checked with existing data from the DOF (1983-84 to 1989-90) as their data for the last 3 years is not available as yet. Furthermore, given that this catch assessment survey was carried out in collaboration with the local fishermen, most likely to be full time and part time fishermen, the recorded catches are assumed to be commercial catches, whereas those reported by DOF are for subsistence household fisheries. Subsistence fishing is defined in this report as being carried out by people who directly catch and consume "common good" fish resources for a large proportion of the animal protein in their diet and who are mostly landless and poor.

The surveys carried out were as follows:

a) Catch Assessment Survey

The emphasis of the catch assessment survey was placed on the capture floodplain fisheries and thus data were collected for some beels, khals and sections of rivers within the project area. The FRSS catch assessment forms were used to record leasing arrangements and fish catches in the area.

b) Fish Market Survey

Eleven fish markets in Planning Zones B, C and D were surveyed during the same field visit as for the catch assessment. This has allowed for some fish price analyses and fish availability levels to be detected as well as the type of operators.

c) Agro-Socio-Economic Survey

This survey was carried out by the agro-socio-economic team, to establish the typology of fishing operators. Three surveys relevant to fisheries included a) fish pond, b) fishermen and c) farmers' questionnaires.

d) Fish Pond Production

Data on pond production was also collected through the agro-socio-economic survey, along with published statistics from FRSS and unpublished data from the TFO.

e) Public Participation Meetings

Public participation meetings were also held at village level. Proposed project development strategies and options were discussed with fishermen and local people in relevant areas.

f) Sampling Programme

Five sampling sites were selected in the main floodplain area of the Gumti Phase II project area, which includes Zones B, C and D. Zone A was not sampled for capture fisheries due to the lack of suitable habitats, e.g. beels and floodplain, resulting from the unusually dry conditions that year. Field visits had a duration of 4 days during which information on fish catch was collected.

8.3.3 Methodology

a) Analysis for Estimating Impacts on Fish Production

The analysis of the potential impacts on the fisheries of the Gumti Phase II project area relied heavily on the results provided by the MIKE 11 hydraulic model, which provides a simulation of water levels and discharges at particular nodes in the schematisation of the river system in response to a set of boundary conditions which effectively comprise upstream flows and downstream water level controls.

For the analysis of fisheries impacts, the minimum water level in three values per decad (10 day period) was used. As the focus of the fisheries component was placed strongly on open water capture fisheries, i.e. the floodplain, it was decided to aggregate all water levels greater that the MPO Flood Phase F0 (30cm). The hydraulic model results were mapped to provide a spatial distribution to changes in the extent and duration of the floods in the Gumti Phase II area. Model runs were carried out for a 1 in 2 year flood (a mean or 'normal' year) over a 25 year period.

b) Calculation of Fish Production from Catch Data

Data resulting from this survey have been analyzed in more detail in order to attempt to estimate total fish production in the project area. To do this, actual catch observed on the sampled day per system (rivers, khals and beels) was analyzed in relation to fishing gears for each zone. In an attempt to reduce the margin of error, information on the catch reported over a 4-day period was not used, as it included recall data over the previous three days. The mean number of days that a particular fishing gear was used in the Gumti Phase II area was calculated from the catch assessment questionnaires and was used for the analysis.

In addition, it was decided to analyze the katta catches separately as they were extremely high. Katta catches were only recorded in Zone D and were further isolated and analyzed for the relevant gears. Results were incorporated to the estimated total catch for each zone. Catch figures for khals were incorporated into river figures as there were only two samples from this type of system.

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c) **Estimated Fish Production in Gumti Phase II**

Fish production in the project area was also calculated using national production levels (provided by FAP 17 based on DOF data, 1988-89) and compared with production levels calculated in this study.

Using national production levels, it can be seen that the estimated annual capture fisheries production in Gumti Phase II amounts to 10,179 MT; with an increasing production from Zone A towards Zone D. Pond production shows a different pattern with highest yields in Zone A (1,878 MT) and C (1,379), followed by Zone B (779 MT) and lastly, Zone D (398 MT). Overall estimated production including ponds amounts to 14,612 MT, which results in a production level of 115 Kg/ha.

Using the production levels estimated during this study for internal rivers/khals and beels, FAP 17's estimated production levels for floodplains (152 Kg/ha) (FAP 17, 1993), which include the commercial catch, and the average pond production levels reported by the TFO (1 760 Kg/ha), the results are quite different. The estimated total catch for the Gumti Phase II project area, including ponds, was 31,499 MT, in a total area of water bodies of 127,173 ha (including a portion of the Meghna River), resulting in a production level of 248 Kg/ha. However, if only the capture fisheries are considered, the resulting estimated total production in open waters is just over 24,100, with a production level of 196 Kg/ha, over an area of 122,971 ha. Both these production levels are comparable to fish production reported for other tropical countries (Lowe-McConnell, 1987).

d) **Catch Species Composition in Gumti Phase II**

Of the 260 species of freshwater fish reported for Bangladesh, approximately 47 (18%) were recorded in the study area. However, a preliminary list of species occurring in the area compiled from the catch surveys and fishermen's reports amounted to 90 species which represent 34.6% of the fish species reported for the country. Appendix F.IV in the Fishery Annex shows the preliminary list of fish and prawn species occurring in the Gumti Phase II Project Area.

In general, the catch species composition in each of the fishing systems per zone showed a similar number of species. In Zone B there were 17 species in rivers and 14 in beels, but only 4 species in the khals. However, this may be explained by the few samples taken from this type of system. In Zone C the difference was also small with 22 species caught in rivers and 27 in beels. In Zone D, the species composition in the three systems was remarkably similar, although actual catches were very different. The similarity in species composition has been interpreted as an indication of the ability of the various species to freely move within the floodplain area to reach different habitats in the floodplain, and of the importance of this area for all types of fish.

It should be remembered that these estimates refer only to the commercial catch, as far as it is known. The subsistence catch (i.e. that consumed directly which does not pass through the market) has not been taken into account in this analysis. Therefore the total value of the catch would be expected to be even higher than this estimate, although it is not known by how much.

It is thus clear that any proposed engineering intervention will need to take into account the loss of income to the members of the intricate local economic web such as the fishermen, market dealers, Jalmahal leaseholders, boat builders, net and trap makers, as well as those who benefit by supplying transport, ice and other services. It is granted that many fishermen would already have been performing several of these tasks themselves. However, any disruption to the fishing system and its dependent community will have serious consequences for the local and regional economy.

8.3.4 Estimation of Impact of Proposed Projects

The definition and description of the intervention strategies are dealt with in more detail in Section 8.5. The relevant strategies that were considered for fisheries impact analysis have been summarised as follows:

Strategy C: Intermediate Flood Response and Development

A mixed strategy including controlled flooding using submersible embankments, non-submersible embankments, small flood water exclusion polders and improved drainage.

The seven elements of this mixed strategy include the rehabilitation and rationalisation of existing embankments (particularly road embankments) and construction of new ones, possibly including submersibles, to allow flooding to be controlled and managed. In some cases, this will entail the complete exclusion of river flood water. In addition , a khal re-excavation programme will be carried out, aimed at improving drainage of flooding caused by local rainfall. There is also provision for a surface water source for irrigation in those areas where groundwater use is constrained by water quality. This is to be achieved by both pumping water into a deepened khal network and also by gravity flow into deepened khals from the Meghna River in the dry season.

Strategy D: Full Flood Control and Drainage

This strategy was suggested in the 1990 Report for the area. It excludes all external river flooding into the protected area by construction of full embankments. In addition, there was provision for improved drainage by khal excavation and a targeted programme to promote uptake of irrigation using groundwater sources.

The estimated fisheries impacts for each identified intervention are given in Table 8.5.

8.4 Modelling Interventions

For the purposes of assessing the relative merits of different options prior to the With Project model run, which will include the selected options, model runs over periods shorter than 25 years were carried out.

8.4.1 Initial Design Options

The initial design options were conceived by taking account of the diverse situations which occur in the Gumti Phase II Project Area. For the purpose of selecting design options it is convenient to split the project area into four zones of flooding and agricultural type; these zones are shown in Figure 8.3. It should be noted, however, that the zonal boundaries need not form a barrier to the boundaries of any scheme therein.

Figure 8.3

Planning Zones

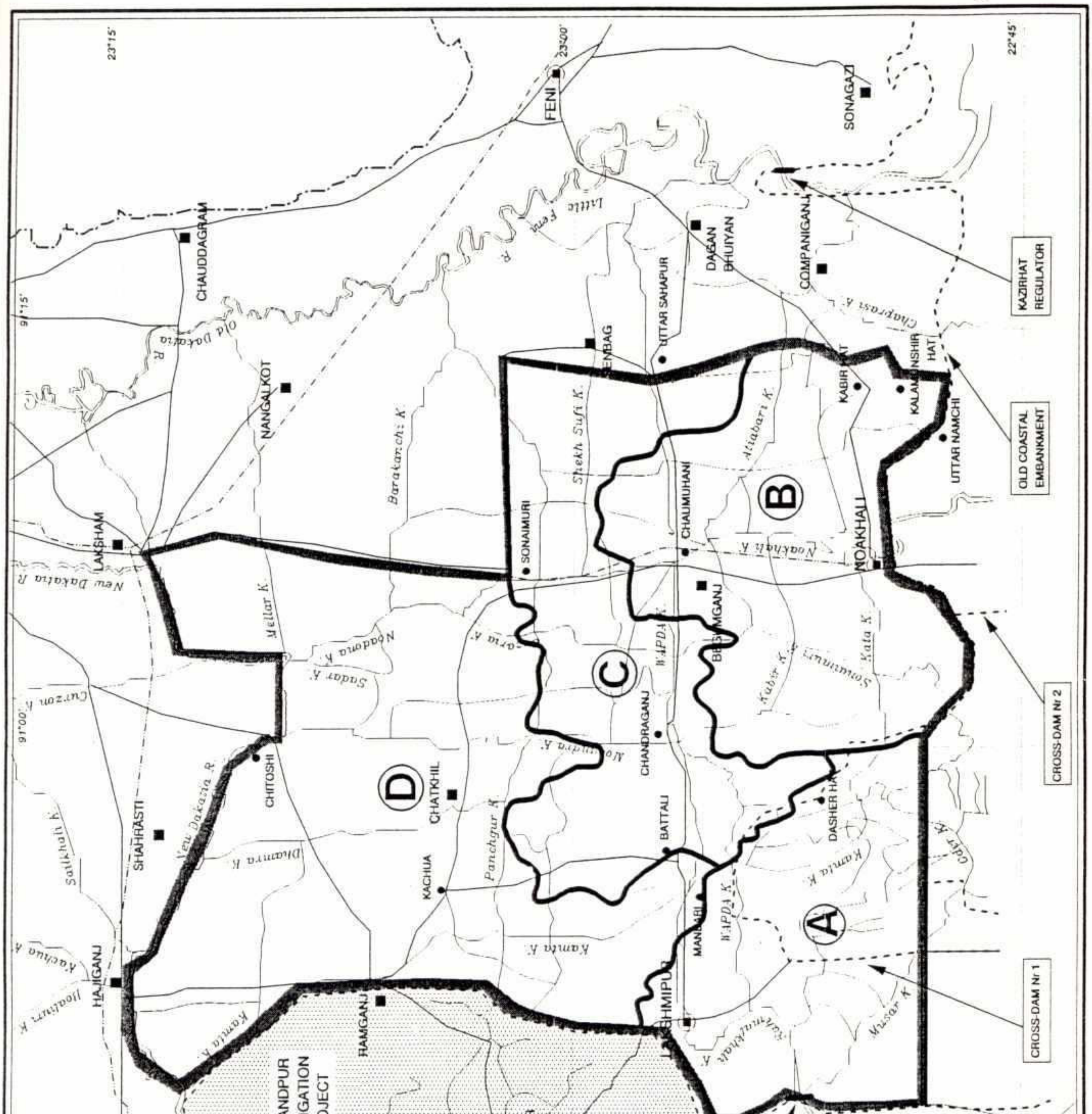

TABLE 8.5

Estimated Fisheries Impacts in Gumti Phase II Due to Strategy C by Interventions Without Mitigation and Management

		1	2	3	4	5	5	6A	6B	7
		(1)	(2.1)		(3.1)	(2.II)	(4.II)	(4.III)		
Gross Area (Ha)		23,400	5,000		10,459	823	1,560	1,060		
Systems										
Int Rivers/ Khals	NOW	276	59	7	156	10	18	12	1,111	
	WO Yr6	252	54	0	142	9	17	11	1,015	
	WI Yr6	244	39	7	150	6	24	11	1,374	
	Change (%)	-3.3	-26.9	0.0	5.6	-26.9	40.8	-6.1	35.4	
Beels	NOW	0	8.5	0	67	3	33	12	0	
	WO Yr6	0	8	0	61	3	30	11	0	
	Wi Yr6	0	3	0	26	1	12	5	0	
	Change (%)	0.0	-58.0	0.0	-56.8	-58.0	-58.0	-58.0	0	
Floodplain	NOW	2,293	760	0	1,590	125	237	161	0	
	WO Yr6	2,838	694	0	1,452	114	217	147	0	
	WI Yr6	525	203	0	145	33	91	62	0	
	Change(%)	-71.4	-70.7	0.0	-90.0	-70.7	-58.0	-58.0	0	
Ponds*	NOW	2,293	243	0	528	0	25	17	0	
	WO Yr6	2,986	316	0	688	0	33	23	0	
	WI Yr6	2,986	316	0	688	0	33	23	0	
	Change (%)	0	0	0	0	0	0	0	0	
										Total
TOTAL	NOW	4,582	1,070	0	2,340	138	313	203	1,111	
	WO Yr6	5,077	1,072	0	2,343	126	296	192	1,015	9,758
	WI Yr6	3,755	562	0	1,009	41	160	99	1,374	
	Change	-1321	-510	0	-1334	-85	-136	-92	359	10,120
	(MT)	-26.0	-47.5	0	-56.9	-67.4	-45.9	-48.1	35.4	
	Change (%)									7,001
										-
										3119
										- 30.8

* Includes cultured ponds only

The proposed developments, determined mainly from public participation meetings, are presented below zone by zone and summarised in Table 8.6. Figure 8.4 is a schematic diagram showing the initial design options.

Zone A

As a result of design option simulations A1 to A4 it was concluded that the following were the best developments for Zone A:

- an embankment on the left bank of the Ghungur which only allows drainage from area A1
- an embankment on the right bank of the Buri Nadi which only allows drainage from area A1
- excavation of the bed high point upstream of the Buri Nadi confluence
- excavation of the bed high point downstream of the Buri Nadi confluence

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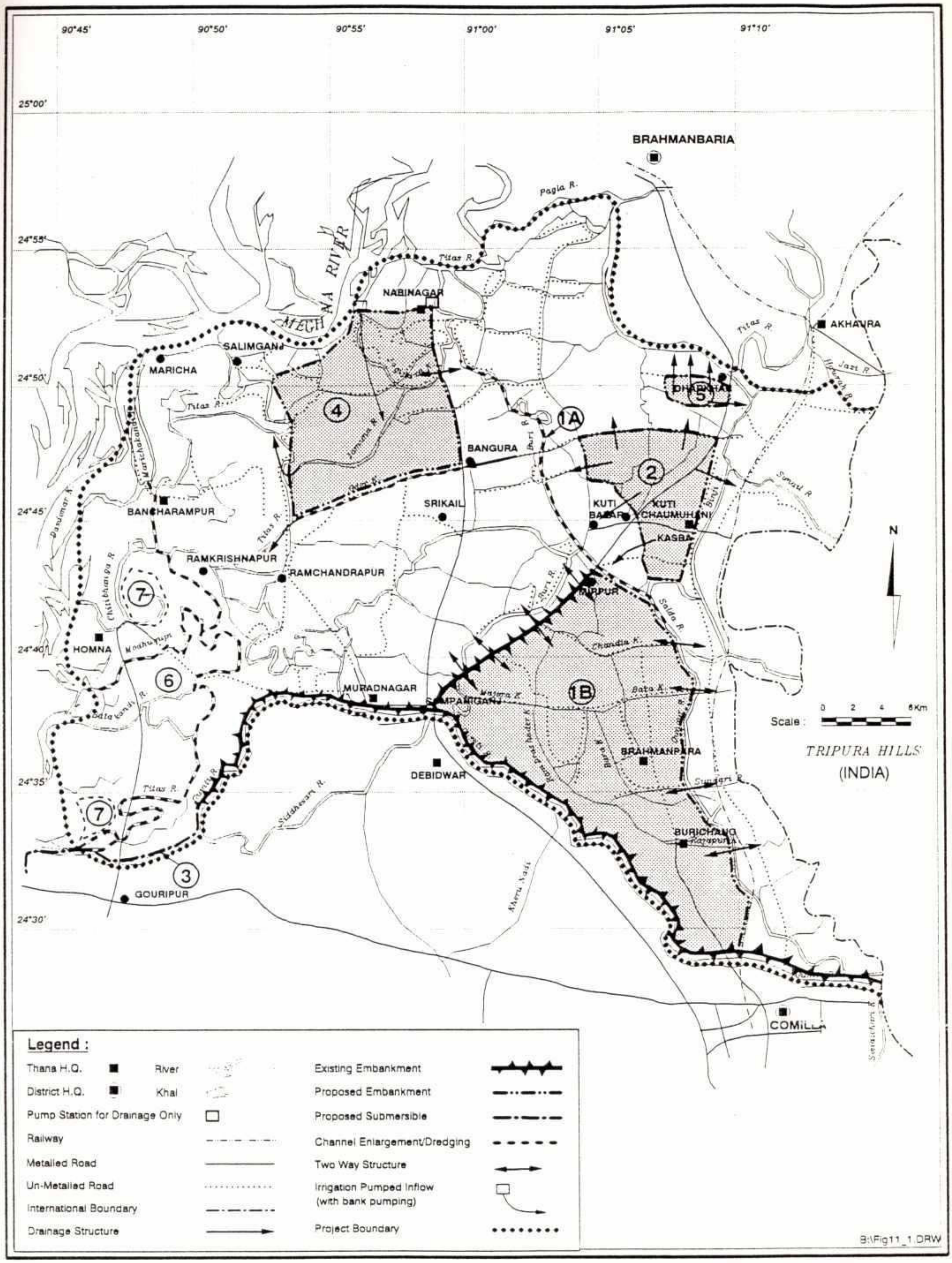
Figure 8.4

Layout of Developments



These developments result in a significant reduction in the flooding depth in area A1. This is in part offset by a flooding depth on the right bank of the Ghungur which is slightly higher than presently occurs.

Zones B, C and D

As a result of design option simulation B1 it was concluded that the following developments were recommended for Zone B:

- Village roads will be upgraded to form a flood embankment surrounding Unit II. Structures for rainfall-runoff drainage will be provided in the embankment.

- The ring road which encircles part of Unit III will be improved for full flood control with gated structures at the locations of existing bridges to facilitate rainfall-runoff drainage.

These developments result in a significant reduction in the flooding depth in poldered areas.

The construction of the embankments to create the poldered areas does not result in any rises in external water levels.

As a result of design option simulations C1 to C3 the following developments were put forward for Zone C:

- The part of this zone to the west of the Nabinagar - Muradnagar road and the North of the Oder Khal will be poldered. The polder will extend as far as the Meghna in the north. Structures will be provided on the Jamuna Khal at the western boundary of the polder and on the Jamuna Khal at the eastern boundary of the polder for controlling drainage.

- The part of this zone to the west of the Nabinagar - Muradnagar road and the south of the Oder Khal will be poldered. The polder will extend as far as the Gumti in the south. Drainage structures will be provided on the Jogidara, Arsi, Zia and Chapitala Khals under the Companiganj - Nabinagar road at the eastern boundary of the polder. Structures are also provided at the outfalls of the Roachala, Arsi and the khal to the south of the Roachala, for controlled drainage.

- The use of the irrigation pumps for pumped drainage could greatly reduce the flooding depth in the northern poldered area of Zone C.

These developments result in a reduction in flood levels in the poldered areas.

Model simulation D1 showed that the extension of the Gumti right embankment results in a reduction in flood depth in the area adjacent to the river; this reduction is most pronounced in the pre- and early monsoon seasons.

TABLE 8.6

Summary of Gumti Phase II Initial Design Options

	A1	A2	A3	A4	B1	C1	C2	C3	D1
Embankment on Ghungur left bank upstream of Buri Nadi confluence	X	X	X	X	X	X	X	X	X
Embankment of Buri Nadi right bank upstream of Ghungur confluence	X	X	X	X	X	X	X	X	X
Excavation in Ghungur upstream of Buri Nadi confluence		X	X		X	X	X	X	X
Excavation in Ghungur downstream of Buri Nadi confluence			X	X	X	X	X	X	X
Flow through Ghungur left embankment				X					
Embankment surrounding area B1					X	X	X	X	X
Embankment surrounding area B2					X	X	X	X	X
Embankment surrounding area C1						X	X	X	X
Embankment surrounding area C2						X	X	X	X
Excavation in Oder Khal							X	X	X
Pumped drainage from area C2								X	
Extension of Gumti right embankment to Meghna confluence									X

8.4.2 Final Design Option Simulations

A scheme which included all the above features formed the basis for the final design option simulations. This simulation did not included pumped drainage from the poldered area in the northern part of Zone C. The final design option simulation was run for the full 25 year period between 1965 and 1989 and complete post-processing analysis was carried out on the model results.

The simulated developments result in a reduction in flooding depth in all the poldered areas. The changes in the polders in Zone B and the southern polder in Zone C are significant. The improvements in the polder in Zone A and the northern polder in Zone C are much smaller. The improvements in the northern polder of Zone C could be greatly enhanced by pumped drainage.

Conditions in the un-poldered areas of Zones A, B and C are made worse by the proposed developments. Conditions in the southern part of Zone D are improved slightly by the extension of the Gumti right embankment; those in the northern part of Zone D are unchanged.

It was observed in the Without Project simulation that flow from the south east of the area passes through the drainage channels in the southern part of Zone C to the Meghna throughout the wet season. Once the external rivers rise in May and June, flow passes through this area from the Meghna in the vicinity of Nabinagar to the Meghna a short distance upstream of Daudkandi.

The polder in the southern part of Zone C blocks this flow path and results in the negative impacts in the un-poldered parts of Zones A, B and C, and a reduction of improvement in the poldered part of Zone A.

The improvements in flooding conditions in the southern part of Zone C are at the expense of a worsening situation in the areas upstream since the embankment blocks flow from these areas. This, together with the fact that the southern part of Zone C is very important for fish production, led to the conclusion that the polder in the southern part of Zone C should not be included as one of the recommended developments for the Gumti Phase II area.

Based on the results of the final design option simulation it was concluded that all the developments included in this simulation should be included in the With Project simulation with the exception of the polder in the southern part of Zone C. It was decided that the With Project simulation should test the situation where pumped irrigation was not included in the northern part of Zone C; initial design option C3 indicated the benefits that could be gained from pumped drainage in this area.

8.5 Options for Development

8.5.1 General

The basic objectives of any proposed development in the area is one for economic improvements. This encompasses the maximization of the net present value of aggregate of consumption benefits and employment generation. With the current Government policy of attempting to reduce public sector expenditure the encouragement of investment by the private sector becomes an important criterion.

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The project area has been divided into different zones, as shown in Figure 8.3, each of which has a characteristic set of problems and hence potential development solutions. Because of these heterogeneous characteristics, it is considered important to approach the study in this context rather than to treat the area as a whole. There are interventions which will affect more than one zone, but this is easily accommodated within the analysis approach.

The planning steps taken in order to arrive at a set of interventions were extensive and are described in the Feasibility study reports. The final set of proposed interventions are illustrated together in Figure 8.4 These interventions were tested using the MIKE 11 hydraulic model, to see their effect on agriculture and the environment.

8.5.2 No Project Development

There are three main arguments why there should be no project agricultural developments in the Gumti Phase II project area.

The first is that the project area is one of the highest floodplain fish production areas in Bangladesh. This means that any attempt to polder off any portion of the existing floodplain will involve heavy fishery losses.

The second is that there is a heavy sediment load coming annually into the east of the area from the Tripura hills, in India. This makes annual maintenance of khal excavation in the area expensive.

The third reason is that despite gas and salinity constraints, it is technically feasible to irrigate the entire net cultivable area to ensure winter crops, including boro, using tubewell technology. Therefore schemes which require two stage pumped irrigation are unlikely to be economic.

However, it should also be noted that the population density has increased significantly in the area and additional food and employment is greatly required. People's participation meetings highlighted many specific problems in each part of the project area and also gave possible solutions to these problems.

It was therefore concluded that despite the constraints of fisheries, sedimentation and the natural growth in "without project" irrigation, agricultural development was still important in the area. However, a viable scheme would have to be sympathetic to environmental considerations and should specifically address local water related problems.

8.5.3 Basic and Intermediate Flood Response Project

a) The Zone A Scheme

The initial model run showed that the peak water level in the unprotected area, to the east of Gunghur River, rose significantly when the Ghungur left embankment was in place. Further runs showed that if controlled discharge (40% of peak flow) was allowed into the protected area then this would reduce the additional rise but would also adversely affect the agricultural benefits caused by the embankment.

However, excavation of the Salda and Buri Nadi showed a considerable mitigation. With no discharge entering the protected area of Zone A, the peak (1987 and 1988) water levels showed an increase of only 30 cm. If a very severe flood did occur and the villages in the unprotected were being threatened, then opening Ghungur embankment gates would further reduce the water level by 10 cm. As the villages in the area are not particularly flood prone at the moment, it is unlikely that the additional rise will cause significant problems.

The model showed that in consequence of the rise in water levels, the flood phasing in the unprotected area is a little worse, this is further discussed in Chapter 10. However, it should be noted that the increase of water level is limited to the peak monsoon period and area of dis-benefits is very much smaller than the benefitted area, to the west of the Gunghur River. However, because the additional excavation has such a significant effect on pre-monsoon flows, there appears to be no additional damage to the boro crop in the unprotected area.

In addition to the Ghungur left bank, the proposal for Zone A included a left embankment along the Salda River, up to the Comilla-Sylhet road. In order to protect the whole zone from monsoon floods, it was also proposed to seal the Comilla-Sylhet road to form the north-west boundary. Four regulators will replace road structures so that the area may be effectively drained. Also, the khals within the protected area leading to the regulators are to be re-excavated.

In order to minimise khal and floodplain fisheries losses, the regulators under the Comilla-Sylhet road will be fish friendly.

b) The Zone B Schemes

Figure 8.4 shows that two embankment schemes have been considered in Zone B, a small scheme in the north and a larger one in the south. Both schemes use existing roads to the maximum possible extent.

Model runs showed that very little agricultural benefit was achieved in the smaller northern scheme. This was because the topography of the area was relatively low and it could not release the pre-monsoon rainfall adequately under gravity. However, large improvements were shown in the higher, southern area. The drainage of the southern area was also much improved by the proposed excavation in the Buri Nadi.

The required excavation of the Buri Nadi River will also have an additional benefit. At present, in a 1 in 5 dry year, LLP irrigation can take place in the Buri Nadi to 5 km south of Nabinagar. However, with the proposed excavation, an additional 14 km length will have full supply during a 1 in 5 dry year. This will therefore supply an additional 2800 Ha which can be served by LLP.

The schemes in Zone B and Zone A are therefore linked by their common need for re-excavation in the Buri River. Because of this, they are to be considered as one scheme in the economic analysis.

c) The Zone C Schemes

The initial proposal for Zone C was to have two embanked schemes either side of the Oder Khal. Each with pumped irrigation supply to the khal and river network. A distribution canal, along the line of borrow pits for the Muradnagar-Nabinagar road, was to be excavated. Also, re-excavation was required in the existing khals.

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The hydraulic model runs showed that in the present situation, pre-monsoon flow generated in the Tripura hills flowed into the Buri Nadi, which conveyed it north into the Titas River, by Nabinagar. When the monsoon arrived, water levels in the Titas backed up, with the rise of the Meghna levels. Instead of going north, the direction of flow changed to the west, passing through the khal and floodplain system north of Muradnagar to discharge into the Meghna between Homna and Daudkandi.

By effectively blocking this route with the southern embankment scheme, the water was restricted to flowing through the Oder khal. This caused congestion which had an adverse effect on the area to the east of the Muradnagar-Nabinagar road, including drainage from the schemes in Zones A and B.

These adverse effects meant that the southern embankment had to be abandoned. Model runs without the southern embankment, but with the khal excavation, brought the water levels back to the without project situation.

The proposed intervention for Zone C therefore consists of an embankment for the northern area. In addition, 8 cumecs of pumped irrigation will be provided to the northern area and 14 cumecs for irrigation to the southern area. The southern area will not have any flood control. Both of the pump stations will be reversible and both pump stations will be used for pumped drainage of the northern embankment. Because the full 22 cumec capacity will be used for the 10460 ha protected area, the percentage of F0 land will increase from 7% to 73%, which will give a very large rise in the amount of T aman which could be grown. The disadvantage, of course will be the destructive effect to the floodplain fisheries in the area.

d) The Zone D Schemes

i) Khal Re-excavation

The most effective intervention for the Gumti Phase II area is re-excavation of khals in Zone D. This intervention can be carried out with no negative effect. This is because fisheries will incur no floodplain losses but will achieve some gains. Also, drainage of the area will be improved. Maintenance costs will not be so high because of the sediment content of the Meghna is relatively low.

The proposed locations for khal re-excavation are given in Figure 8.4. At present, about 4000 ha can be irrigated by LLP during a 1 in 5 dry year. This value will increase to approximately 14000 ha with the recommended re-excavation. It should be noted that farmers are generally willing to invest in LLPs even if the guaranteed availability is less than a 1 in 5 year return period. The present and future areas are therefore likely to be greater than 4000 ha and 14000 ha, respectively, with a greater element of risk involved.

At present, JICA is carrying out khal re-excavation in the area, however, the scale of their proposed work is small compared to the proposed requirements.

ii) Submersible Embankment Schemes

Two submersible embankment schemes were identified and are indicated in Figure 8.4.

i) Dari Char Area to the north east of Homna.

This area was chosen as ground levels are low, indicating that HYV boro damage would occur in the pre-monsoon period. Also, the area may effectively be encircled by road developments proposed under the JICA/LGED rural improvement programme. A single drainage regulator would be able to control the inflow/outflow regime.

ii) Motopi Area just to the north west of Gouripur.

Again, in this area, ground levels are low, indicating that HYV boro damage would occur in the pre-monsoon period. A single drainage regulator would be able to control the inflow/outflow regime.

It was concluded that it was not possible to include a fish gate into the design. This was because any viable fish gate would let an unacceptable amount of water into the protected area before the boro crop could be harvested. The submersible embankment schemes were therefore considered to incur heavy fish losses (50%) because of lack of access to fish and spawn in the months of April and May. This value is consistent with the losses incurred in the existing Satdona beel scheme.

A further disadvantage of the concept, was that when water is allowed into the protected area, the rate of rise of water level was much higher (10 cm per day) than the normal Meghna level rise (5 cm per day). This means that if B aman is to grow, a faster growing but inferior yielding variety will be required.

In order to properly assess the benefit of the scheme, the Agriculturalist visited the two areas in question. The farmers stated that they did not generally incur damage to their boro crop, as they tended to plant very early. The crop could therefore be harvested early, prior to natural flooding. The farmers also stated that they did not wish to risk growing the B aman crop as water levels were very high and also B aman was often incompatible with the boro crop.

These arguments and the analysis formed the conclusion that at present it was not cost effective to provide submersible embankment schemes in Zone D. It must be noted, however, that this situation could change.

FAP 6 are presently considering interventions which could affect the timing of Meghna floods in the Gumti project area. Unfortunately, the FAP 6 "with Project" Modelling results are not yet ready, so the downstream effect is not yet known. If the time of flood is brought forward, then the boro crops in the submersible embankment areas will suffer damage. In this case, the submersible embankment schemes should be taken up as mitigation schemes for FAP 6.

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8.5.4 Full Flood Protection, Drainage and Irrigation

These options were proposed during the 1990 study and were reexamined for the present study.

Owing to changed perceptions concerning environmental issues including fisheries and to changes in irrigation development since the original study started these proposals no longer seem appropriate and are not considered in the regional plan.

iii) Extension to Gumti North Embankment

Local people, during the course of the study, expressed a strong desire for protection against River Gumti pre-monsoon flash flooding, on the northern side, downstream of the existing embankment.

A dwarf embankment should therefore be constructed between the existing embankment on the north side of Gumti River and Gouripur. The purpose of this embankment is to prevent flash floods from affecting the boro crops of the area between the Gouripur-Homna road and the River Gumti. Two flushing sluices have been included to maintain present irrigation supplies. A small (submersible) embankment has been selected as it is not considered worthwhile to protect the area against monsoon floods, when high monsoon water levels will come from the Meghna River anyway. After the month of June, the Meghna related water levels will rise in the Gumti and Titas Rivers, so the embankment will be submerged.

In addition to protecting the area from flash flooding in the boro season, the embankment will also prevent sand from coming into the area, thereby reducing the required maintenance cost for re-excavation the Lower Titas River in the area. Extension of the embankment from Gouripur to the River Meghna was considered, but this would have to include a large structure at the Lower Titas outfall to the River Gumti, which would be very expensive. The computer model is not sophisticated enough to accurately predict the effect this extension will have on the area downstream of Gouripur. However, the area is already effected by flash floods and the Matia and Lower Titas beds are being excavated, which will improved drainage in the area. Should the situation show that despite the improved drainage, boro crops are being regularly damaged, then the Motopi area submersible embankment scheme could be incorporated.

8.6 Environmental Impact Assessment

8.6.1 Introduction

Environmental Impact Assessment for proposed development programmes attempts to place the considered interventions within a context of environmentally sound and sustainable development. The aim of the environmental component to the Gumti Phase II study was to provide a broad and integrated view of the likely implications of proposed interventions, so that these could be used as one criteria for judging if it was worth taking these to more detailed further study. A comparative assessment (including looking at a predicted without project situation) was carried out for a wide range of water and land development strategies being considered for the area. As a result of this assessment recommendations were made as to the detailed interventions that were favoured, on broad environmental grounds, for further study. An assessment was then carried out of these and conclusions drawn from the analysis which allowed recommendations to be made as to which of the interventions should be studied to greater detail in the next phase of the work.

Environmental assessment considers both the natural environment and the human environment, their interaction and how this is likely to change as a result of proposed interventions. The range of issues that was considered important was drawn up as a result of the early baseline assessment work in the study area. The predicted outcomes of interventions include a wide range of issues and these can be rated in terms of perceived and policy priorities. The likely nature and severity of impact, both positive and negative, needs to be considered in terms of which particular social groups of people will be effected, where and when. The impacts can be judged in relative terms and, if the data exists or can be collected, quantified and if appropriate valued, either in relative or economic terms. However many of the impacts are difficult to quantity let alone value and in any case they need to be judged against policy priorities, both nationally and regionally, along with an indication as to how these are to be interpreted locally.

8.6.2 Development Proposals and Impact Assessment Methodology

a) Development Options and Strategies

The drawing up of a preliminary range of intervention strategies was carried out and given in the Second Progress Report. This included five differing degrees and types of intervention and they were broadly appraised relative to each other from an integrated environmental perspective. This then allowed environmental considerations to be borne in mind when drawing up an agreed intervention strategy for the area which was then studied in greater detail leading to recommendations being made as to which components of this were thought to be beneficial in overall terms.

Five possible broad policy strategies, labelled A-E (based on the TOR item 4) with A being a without intervention option, were drawn up for comparative consideration. Strategy C was a mixed strategy which took into consideration the study areas great diversity, looking at different interventions in the various planning zones based upon proposed interventions suggested in the public participation exercise. Strategies D and E were those suggested in the 1990 Report.

b) Proposed Detailed Interventions

As a result of the preliminary assessment the following detailed interventions were proposed for further study These were essentially drawn up as a result of the public participation programme. These interventions are shown in Figure 8.4. It should be noted that some of these cross planning zone boundaries are considered to depend, or be conditional upon, others, both for mitigation of induced negative impacts and also for economic feasibility. They are summarised by reference number:

1A Khal depending of the Buri/Salda River system justified in its own right but considered a conditional requirement of intervention 1B.

1B Controlled flooding of the western part of Zone A. This allows limited managed in-flow into the area via 4 gated structures in the north west which uses an existing road embankment as one side of the protected are and four in the east placed within a new embankment on the east bank of the Salda River.

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2 A medium sized polder in Zone B using existing road embankments which prevents all surface water in-flow to the area.

3 Extension of the Gumti right bank embankment westwards to Gouripur.

4 An enclosed medium sized polder in the north of Zone C and part of Zone B. This includes complete exclusion of all surface water in-flow and also has monsoon pumped drainage and pumped dry season surface irrigation using deepened khals. In addition the construction of the southern embankment will allow the Oder khal to be enlarged. The provision of pumping also allows the unprotected area south of this to be irrigated using gravity surface means along deepened khals and drains.

5 A small polder in Zone B using remodelled existing road embankments and excluding all external surface flow into the area.

6A6B Submersible embankments in Zone A similar to those recently completed in the north-west part of the study area.

7 A major khal deepening programme throughout the study area. In Zone A this is intended to allow the khals to remain full of water in the dry season for surface irrigation to take place. In the unprotected part of Zone C this would be for dry season pumped irrigation conveyance. Throughout the rest of the study area this is intended to improve drainage.

8.6.3 Hydraulic Modelling of Detailed Interventions

The proposed detailed interventions that have been incorporated into the hydraulic model are shown in Figure 8.4. The effects on the rising and falling flood pattern for a 1 in 2 year of all seven interventions were constructed. The differentials in flood extents for the with and without detailed interventions by each 10 day period were analysed. The broad conclusion of this analysis is that intervention 3 is partially effective in preventing the early flooding due to downstream impacts of previous upstream Gumti River embanking. Intervention 1B is effective in delaying flash flooding into the protected part of Zone A and throughout a normal year reduces the mean extent of flooding on the protected area by some 30%. The induced flooding effects of this on surrounding land are nearly all mitigated for by intervention 1A. Intervention 2, the medium sized polder, results in an internal mean annual flood plain loss, whereas the intervention 4 pumped polder is very effective indeed and the most of the floodplain remains flooded to a depth of less than 0.30 m all the year. According to the model, intervention 5 has little effect on the extent of 0.30 m flooding but this may be due to the insensitivity of the model, the small size of the polder and the coarseness of the contours. The interventions have in effect been optimised to ensure that there is very little increased extent of flooding as a result of interventions. Overall, the changes in flood plain extent as a result of the interventions are surprisingly small. For a 1 in 5 high normal flood there is even less difference.

8.6.4 Detailed Impact Assessment Matrix

The environmental rating matrix for each of the seven interventions is shown in Table 8.7. These are on a scale of +5 to -5 and like the strategy ranking matrix uses a six year period for impact assessment. It aims to give an indication of what are the important issues for each intervention so that more detailed and targeted data collection can be carried. Like the previous matrix it is not weighted by priority, instead an indication is given of those issues which are felt to be important. The principal negative impacts identified in the matrix are discussed in order of overall severity in Section 8.6.5 below.

8.6.5 Principal Negative Impacts for Detailed Proposed Interventions under Strategy C

The resources made available to the study to address such a complex area and which have required a wide ranging review of possible intervention strategies and options, have proved inadequate to carry out anything like a full environmental assessment. Consequently it has been decided to concentrate on the most serious negative impacts with the aim of identifying these and where possible undertaking sufficient work to quantify and value the most serious issues. Considerable additional work would be required to bring the environmental component up to the level of a fully integrated assessment with full quantification, mitigation arrangements and an Environmental Management Plan.

a) Changes in Flood risk and Timing

The results of the hydraulic modelling with all the seven detailed interventions were interpreted using the differential flood mapping. The conclusion from this is that the reduction in area of flood plain due to the interventions is not very great, but it is likely that the most serious effect of the interventions, especially on the fisheries system, are likely as a result of the barrier effects of closed embankments upon fish migration.

b) Losses to Fisheries

The estimated losses for each of the 7 detailed interventions are given in Table 8.5 The figure for overall loss due to all seven components of Strategy C being implemented is 11%. Overall, the predicted benefits from increased dry season water availability due to khal deepening can only mitigate for some 20% of the predicted floodplain losses.

The overall changes in fish production, including those from ponds over the first six years after construction is completed, are estimated to be 3122 t for strategy C. This is assuming overall national trends of a 1.5% per annum decrease in all fisheries systems except ponds which have been predicted to rise by 4.5%. There is some evidence that these figures, which are based upon pre- FAP 17 checking of PRSS data, may not be appropriate, and especially not to the Gumti area. However in view of the lack of any other data there appears to be no choice but to use them and it does at least have the advantage of being consistent with the work carried out for the FAP 3.1 fisheries work. In any case the differentials are what is more important in doing such a comparative assessment and these are not greatly affected by this assumption.

TABLE 8.7

Environmental Rating Matrix of Proposed Detailed Interventions

ISSUES	P	1	2	3	4	5	6	7	MP	MC
THE NATURAL ENVIRONMENT										
Hydrology										
Surface										
Flooding Damage to Land	*	+5	+3	+4	+4	+2	+1	0		
Drainage Problems	*	+3	-1	0	+5	-1	-1	+2		
Surface-Water Availability		-3	-2	-1	+4	-1	0	+3		
Groundwater Irrigation		+4	+4	0	+2	+2	0	0		
Domestic Water Supply	*	-1	-1	0	+1	-1	0	+2		
Erosion										
Meghna		0	0	0	0	0	0	0		
Cross Drainage		0	0	0	0	0	0	0		
Sedimentation										
Meghna		0	0	0	0	0	0	0		
Side Drainage	*	+2	+1	+3	+2	+1	0	+4		
Within Project Area		+2	+1	+3	+2	+1	0	+4		
Clogging/Smothering		+3	+2	+2	+2	+2	+1	+3		
Soil Fertility		-1	-1	0	-2	-1	-1	-1		
Navigation	*	-2	-2	-2	-3	-2	-2	+3		
Water Quality										
Domestic Water Quality		-1	-1	0	-1	-1	-1	0		

Agriculture Water Quality		-1	-1	0	+1	-1	-1	+1		
Land Resources										
Soil										
Quality/Chemistry		-1	-1	0	-2	-1	-1	0		
Waterlogging		0	+1	+1	+2	+1	+2	+1		
Erosion		0	0	0	0	0	0	0		
Ecology										
Flora		-1	-1	0	-2	-1	-1	-2		
Fauna		-1	-1	-1	-2	-1	-1	-2		
Fish	*	-2	-4	0	-5	-4	-4	+3	N	
Seismic Activity (*1)										
THE HUMAN ENVIRONMENT	P	1	2	3	4	5	6	7	MP	MC
Economic Livelihoods										
Risk		+3	+2	+3	+3	+1	-2	+3		
Settlement		+2	+2	+3	+2	+1	+1	0		
Land Tenure										
Scarcity		-1	-2	-2	-3	-2	-2	-2		
Land Values		+2	+2	+3	+3	+1	+1	+2		
Common Resource Rights										
Fish	*	-2	-4	0	-5	-4	-4	+2	VD	
Fuelwood		-2	-2	0	-3	-2	-1	-1		
Grazing		-2	-2	0	-3	-2	-1	-1		
Fodder		-2	-2	0	-3	-2	-1	-1		
Agricultural Output		+2	+4	+1	+5	+2	+2	+4		
Fishing ("Professional")	*	-2	-3	0	-5	-3	-4	+3	PO	CO
Forestry and Fuelwood		-2	-2	0	-3	-2	-1	-1		
Livestock		-2	-2	0	-3	-2	-1	-1		

Wage Paid Employment	*	+3	+3	0	+4	+3	+1	+5		
Industry		+2	+2	0	+3	+2	0	+2		
Drinking Water Availability	*	-1	-1	0	+2	-1	0	+2		
Human Health										
Waterborne Diseases										
Diarrhoea	*	-3	-2	-1	-2	-2	-1	-1		
Cholera	*	-3	-2	-1	-2	-2	-1	-1		
Insect Borne Diseases										
Malaria	*	0	0	0	-1	0	-1	-1		
Kala-azar		0	-1	0	0	-1	0	0		
Drinking Water Quality	*	0	0	0	-1	0	-1	0		
Sanitation		-1	-1	0	-1	-1	-1	-1		
Nutrition	*	-2	-4	0	-5	-4	-4	+2	VD	
Mental Health		+1	+1	+2	+1	+1	0	0		
Access and Transport Infrastructure										
Waterborne										
Meghna		0	0	-1	-1	0	-1	0		
Side Rivers	*	+1	-1	0	-1	-1	-1	+2		
Within Project Area		-3	-3	-3	-3	-3	-3	+3	PO	
Railway		+1	0	0	0	0	0	+1		
Road		+2	+2	+1	+2	+1	+1	0		
Archaeology and Cultural Sites		0	-1	0	0	0	0	0		
EXTERNAL FACTORS WITHIN STUDY AREA	P	1	2	3	4	5	6	7	MP	MC
Upstream Back-up Flooding	*	-3	-3	0	-1	-3	-2	+3	MI	
Downstream Knock-on Flooding		-1	-1	-1	+1	-1	0	-2		
EXTERNAL FACTORS OUTSIDE STUDY AREA										
-UPSTREAM CONSTRAINTS										
Increased FAP 6 Flooding	?	0	0	0	?	0	?	?		

Indian Dams on Upper Meghna	?	0	0	0	?	0	?	?		
Gumti River Hydro Dam		+1	0	+3	0	0	0	0		
Upstream Sediment In-flow	*	+3	+2	+3	+1	+1	0	+3		
-UPSTREAM IMPACTS										
Peak Back-Up Flooding		-1	-1	?	-1	-1	0	+2		
-DOWNSTREAM CONSTRAINTS										
Meghna River Water Levels	*	+1	+1	-2	+5	+1	+1	0		
-DOWNSTREAM IMPACTS										
Knock-on Flooding	*	-1	-1	-2	-1	-1	0	0		

LEGEND

RATING OF IMPACT

- -5 Severe Irreversible Negative Impact
- -4 Significant Negative Impact
- -3 Moderate Negative Impact
- -2 Slight Negative Impact
- -1 Very Slight Negative Impact
- 0 Present Baseline Situation and No Change
- +1 Very Slight Positive Impact
- +2 Slight Positive Impact
- +3 Moderate Positive Impact
- +4 Significant Positive Impact
- +5 Very Significant Positive Impact
- MI = Mitigation is Addressed Intrinsically
- VD = Mitigation Very Difficult
- PO = Mitigation Possible
- CO = Mitigation Costly
- PC = Mitigation Prohibitively Costly
- N = Mitigation Not Possible

ABBREVIATIONS/HEADINGS

- P = Expert Priority Issues
- 1 = Intervention 1
- 2 = Intervention 2
- 3 = Intervention 3
- 4 = Intervention 4
- 5 = Intervention 5
- 6 = Intervention 6
- 7 = Intervention 7
- MC = Mitigation Possible?
- MC = Mitigation Costly?
- (+1) = A Constraint not an Impact
- * = Major Issues
- F = In Times of Flood
- LF = In Low Flows
- PF = In Peak Floods
- ? = Insufficient Data to Assess

Note: The predicted impacts are assumed to be those some six years after completion of construction of the proposed interventions.

The procedures for valuation of the fisheries resources are given the feasibility study and have been incorporated into the financial analysis of each strategy and the individual detailed interventions for Strategy C. These use cash valuation based on market price and it must be remembered that the fisheries work covers only the fish caught by full time and part time fishermen and excludes occasional fishermen who in some zones are far more numerous. This is especially the case in Zone D where 66% of the households catch-fish-occasionally for self consumption. Even so, 40% of all households in the study area carry out occasional fishing and according to the nutritional studies this accounts for by far the greatest source of protein intake, being way above Dhal and meat. In terms of livelihood loss, an average of 6% of households are full time fishermen and 12% are part time, i.e. they both catch fish for sale, part timers having a primary occupation that they rate as being a more valuable contribution to their economic livelihood.

There are also likely to be significant socio-economic benefits offered by construction works, provided this is an intrinsic consideration in the planning of the construction programme. If appropriately phased and using labour intensive construction techniques this could greatly increase the demand for wage paid labour at a time of the year and in locations where it is in short supply, particularly for specifically vulnerable social groups.

c) Hazard Risk and Sustainability

The whole question of physical sustainability of embankments, particularly those which carry flash floods from the Indian hills needs to be carefully reviewed, particularly in the light of over 300 years experience with this on the Gumti river. There have been continuous failures of the Gumti embankment over at least the last 200 years. These have caused serious concentrated damage at such places of failure, probably for more so than if the embankment had not existed. This is made particularly serious in the case of the Gumti by the high levels of sedimentation which have resulted in the embankments heights having to be continuously raised to counteract river bed rise. This result is that the bed level of the river is now higher than the surrounding general ground level and the consequences of a catastrophic failure are likely to be very serious indeed. The requirement for dredging the Salda and Buri Rivers will require an open-ended programme of dredging and maintenance, which will entail continuous investment. At present there appears to be no institutional arrangement to raise capital from beneficiaries to do this.

It must also be pointed that the area is in a medium risk seismic zone having experienced two severe events in the last 200 years. Such events have occurred during monsoon times when the river has been full and resulted in embankment failure due to liquefaction. Contemporary accounts of this indicated that this could be a severe if statistically infrequent occurrence and the consequences should not be underestimated.

There are a whole group of social impacts, particularly those at individual household level which have implications for risk levels to socio-economic livelihoods. Some of these are dealt with in the Social Impact Assessment in Chapter 5 of this report and in Annex G. Others, particularly those concerning livelihood loss to full-time and part-time fishermen and boat owners, operations and builders, have been mentioned above. The real difficulty is that it is impossible to assess these realistically at the moment as there is insufficient data made worse by the fact that the 1991 BBS census work is still unavailable. A major detailed social impact assessment component will be required in any follow-up work to the study.

A major issue in terms of economic sustainability is how any intervention programme is to be funded, be it a grant or a loan, and how this is to be paid back and what better alternative use this money could have put to. This needs to be considered at an early stage in planning and within the framework of national, regional and local economic planning and selection of priorities.

8.6.6 Impact Mitigation and Environmental Management Plan

The preliminary economic analysis of the detailed interventions under Strategy C has included consideration of the major negative impact of fisheries resource loss. This has concluded that interventions 4, 5, 5A and 6B are not presently viable, a major factor being that the agricultural benefits offered are either limited and/or can not overcome the likely losses to fisheries production to produce the economic return demanded by the funding agencies. Of the interventions which are considered to have an adequate rate of return, the most favoured of these by ranking using broad environmental grounds are interventions 7, 3, 1A, 1B and 2.

Of these intervention number 2 (the medium sized polder in Zone B) is considered to have serious fisheries losses which require it to be carefully considered. However it also has a high potential for agricultural benefit and it thus comes down to a political decision as to if it is worth foregoing fisheries production for agricultural production in this particular area, although there may be places outside the study area where it is more justifiable to do this.

The multi-criteria analysis, which should include environmental mitigation and management planning, thus needs to be carried out only on these four interventions.

8.6.7 Impact Mitigation

The aim of impact mitigation is to design the interventions to be as environmentally friendly as possible by minimising environmental dis-benefits and maximising benefits. In addition there should be targeted programmes to tackle specific negative impacts in defined places or amongst particular social groups. Another aspect is to design the operation of the intervention to allow identified environmental issues to be addressed. In the case of fisheries losses in intervention 1B (controlled flooding to Zone A) some mitigation is possible depending upon the water management priorities for controlled flooding as opposed to recruitment of migratory fish species.

Mitigation considerations should also feature heavily in tackling construction issues, especially for intervention 7 (khal deepening) and the extension of the Gumti right embankment. Of the four recommended interventions the most serious negative impacts are likely to be in the medium sized polder in Zone B (intervention 2). Unfortunately due to specific locational factors, particularly topography, and the philosophy of the intervention being an enclosed polder which excludes all external inflow, the possibilities for mitigation are very limited indeed. It is thus a straight policy decision as to the justification of promoting agricultural benefits with resulting fisheries losses.

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8.6.8 Environmental Management Plan

It is not possible at the moment to even begin to draw up an Environmental Management Plan (EMP) for the intervention and would not normally be considered justifiable until a firm commitment has been given to taking the recommended interventions to further study. This would be required to be done if the study is to be continued. The outline notes for a future work programme indicate what sort of data collection requirements are need to allow such an EMP to be drawn up.

8.6.9 Impact Timing

As explained previously, a 6 year period has been used for assessment of the likely impacts of the interventions as indicated on the matrices. For the medium and longer term impacts a baseline data collection and monitoring programme is needed. This would specifically need to address the issues of soil chemistry and structure change, medium and longer ecological impacts and also possible socio-economic issues that may arise.

8.6.10 Residual Impacts for recommended interventions

Table 8.8 gives a summary of the major negative environmental issues for the recommended interventions, quantification and valuation if presently possible and an indication of the mitigation possibilities. The residual impacts that are likely to be impossible or very difficult to mitigate for are shown in the final column. The most significant residual impact would seem to be the nutritional implications of fisheries losses to occasional fishermen, particularly for intervention 2 in Zone B.

8.6.11 Conclusions and Recommendations

a) Conclusions

The environmental component to the study has concentrated on providing a continuous environmental perspective to the evolution of an appropriate and environmentally sensitive water and land development strategy planning for the area. This included consideration and re-evaluation of two alternative strategies proposed by the previous Feasibility Study along with a "do nothing" strategy with two intermediate levels of intervention of a flood-proofing based programme and a highly mixed, extensive but small scale approach. The latter was deemed to be the most appropriate to the area and was refined to address the issues identified by local people in the participation component of the study. This takes in the very varied conditions found throughout the study area and also recognises that large scale embanking of the area fails to address the issues of flood protection and drainage, the hydraulic model demonstrating that if anything such measures make the situation worse than they are at present.

TABLE 8.8

Residual Impacts for Recommended Aggregated Interventions 7, 3, 1A, 1B and 2

Principal Negative Impacts By Priority	Quantitification	Valuation	Mitigation Possibilities of Costs	Residual Impacts
Fisheries				
- Lost Cash Resource	- 1472 tones		- Some possible	- Some in 1B, Significant in 2
- Livelihood Losses	- 5% of households	- Possible	- Some possible	- Some
- Nutritional Consequences	- Not yet possible more data needed	- Possible but difficult	- Limited possibilities	- Significant for poor people
Increase in Waterborne Diseases	Not yet possible Monitoring data needed	Very difficult but possible	Possible	A little
Internal Navigation - Network and use - Livelihoods	- Not yet possible - Data needed	Possible but difficult	Partly possible	Some livelihood loss
Soil Fertility	Monitoring of data needed	Not yet possible	Management needed	Very little if careful
Decline in Flora and Fauna	Detailed basehead monitoring data needed	Not normally possible	Limited possibilities	Yes, depends on priorities
Fuelwood/Grazing/Fodder (Fertilizers, water quality)	Data needed	Possible but difficult	Possible	None

The assessment of the seven major detailed interventions has shown that the levels of fisheries losses are such that they undermine what relatively limited agricultural benefits there are to be had by small scale polderization. There is potential for encouraging surface water irrigation by khal depending and this also has social benefits during the construction period provided implementation is tackled in a sensitive and labour intensive manner. There would seem to be direct benefits from extending the Gumti River right bank embankment as this should help solve the long term problem of downstream aggravated flooding that partially embanking the river has caused for many years. The intervention of controlled flooding in Zone A addresses the problem of early flash flooding from the Indian hills but needs to be combined with downstream khal deepening if induced downstream and upstream flooding is to be avoided.

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h) **Recommendations**

The following three interventions would seem to be justified in environmental terms and seem to offer significant benefits in order of priority:

* Intervention 7 - Khal deepening.

* Intervention 3 - extension of Gumti right bank embankment.

* Intervention 1A and 1B - Deepening and remodelling of the Salda river and controlled flooding in part of Zone A.

However the economic analysis indicates that the latter pair of interventions (1A and 1B) are not economic unless their cost is shared by Intervention 2 (the larger of the exclusion polders in Zone B), as the latter has significant agricultural benefits. However this intervention has significant fisheries losses in this area, with socio-economic and nutritional loss implications, especially to occasional fishermen (37% of the population) and also to the 4% of full-time fishing households and some of the 6% of the part-time ones. It thus becomes a political decision as to if it is considered that the fisheries losses in the Intervention 2 area can be justified by the agricultural benefits along with the controlled flooding programme in part of Zone A and deepening of the Salda River system. Due to the fact that the economic analysis places so much store on the agricultural benefits of Intervention 2 were unjustifiable. When presented in this manner there would seem to be a very strong case indeed for allowing Intervention 2 to go ahead even though the basic philosophy of promoting agricultural production at the expense of fisheries is regrettable within the Gumti area, which is so rich in fish. If it is wished to promote a policy of increasing agricultural production through increased irrigation and flood control provision then the Gumti Phase II area is not a suitable place to do this irrespective of the question of environmental suitability, the economic losses to the fisheries resources amply demonstrate this to be the case, there are likely to be more suitable places within Bangladesh to pursue this type of policy.

8.7 Implementation

8.7.1 Pre-Design Stage

The future work programme covering environmental aspects should be started at the outset and should be completed before the design of the schemes is completed. The BWDB should be responsible for letting the contracts to Consultants.

It is proposed that the cadastral land area surveys in the line of embankment construction should be carried out at the same time as the topographic surveys. The cadastral maps can then be handed to the land registration office for land ownership identification. Once the design is complete, then the full land requirement will be known and compensation paid. NGOs could be involved in land acquisition, which should be undertaken by the Land Acquisition Officer. The Land Acquisition Officer normally works under the Deputy Commissioner, but in this case will be under the Project Authority. Compensation given for the land to be acquired should be fair and the valuation of land should be done at current market prices. Compensation for land in village areas included an enhanced rate for land acquisition as well as 12,000 taka per family to meet reconstruction cost.

Geotechnical surveys should also be carried out at the same time as the topographical and cadastral surveys. These too will be contracts let by the BWDB.

8.7.2 Design Stage

The contract for scheme design will be let by BWDB. The Consultants should be ready to start work as soon as the results of the first surveys are ready.

As stated in Chapter 10, additional computer modelling will be required for optimisation at the design stage. It is therefore likely that the Surface Water Modelling Centre will be required to assist.

8.7.3 Implementation Stage

During the implementation phase there may be two levels of management. The project level committee (PCC) involving the local MPs, BWDB officials, district and thana officials and NGO's. A local professional (eg a teacher or a doctor) may also be invited. It should be noted that the MPs have been included as the GOB are presently considering a proposal that MPs should lead Thana development activities.

The PCC have the full responsibility of the project management. As recommended by FAP 15, the committee could be chaired by a local MP, with the Executive Engineer, BWDB as Secretary. The Committee should monitor the over all progress of works and solve various bottlenecks towards the implementation of the project. Day to day works and other technical and financial responsibilities will remain with the Executive Engineer, BWDB as per the present practice. He will be the executive officer for the project. Representation of groups who could be adversely affected by the project or who are underprivileged (eg landless, fishermen or women) may be represented by NGOs.

Units of farmers who are to pay for maintenance of the works, discussed in Section 13.6, should ensure adequate control of funds and quality of works, but through the award of maintenance contracts similar to those used by SRP.

The Project Coordination Committee (PCC) will continue during the O&M stage with full responsibility for mediation in any matter concerning O & M between staff, beneficiaries and other groups.

The Executive Engineer, O&M, BWDB will remain the executive officer of the project. Representatives from DAE, DOF and other thana officials will remain responsible for their relevant fields.

For operation of all the regulators, a local committee for each of the structures could be formed. The committee may be formed involving the chairman of a Union Council, NGOs, beneficiaries, BWDB Section Officer. The U.C. Chairman may be the chairman of the committee and the Section Officer, BWDB, the Secretary. The committee will work in consultation with the Executive Engineer and as per the operation manual. The committee will be accountable to the PCC.

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8.7.4 Implementation Schedule

a) Schemes Recommended for Immediate Implementation

The six possible schemes for implementation are defined, three of these schemes are recommended for immediate implementation.

The design of Scheme A should include further model studies in order to optimise the excavation in the Salda and Buri Nadi Rivers along with the effects on the area to the east of the Gunghur River. In addition the design should address the possible use of compartmentalisation in thee Zone A protected area, to further optimise water distribution.

The design of Scheme B should also include a detailed sub model of the area, which will be able to accurately predict the effects of embanking the remainder of the Gumti River, towards thee Meghna River.

It should be noted that JICA, with LGED and BRDB, are already carrying out khal excavation and supply of LLPs in the Homna and Daudkandi areas. Although the khals this project has selected do not include those planned for excavation by JICA, it is quite possible that JICA may wish to take up Scheme C under it's present project, or an extension to it.

b) Project Costs

The costs for each of the recommended interventions are given in Table 8.9 to 8.13.

8.8 Operation & Maintenance

8.8.1 General

Effective operation and maintenance has been correctly identified as a major problem in achieving the expected benefits from flood control investments. The problems and recent developments have been fully addressed by the FAP 13 Study.

There are two major problems relating to the O & M of a water resources project. The first is the operation of the project, particularly its structures. The second relates to the maintenance of the major works, mainly khal re-excavation and embankments. In addition to these two fundamental requirements, monitoring and continued data collection should also be carried out. The data collected should be hydrological, socio-economic and environmental (including fisheries). This data will be extremely useful not only for Gumti Phase II but also for future similar projects.

The above problems are underlain by further questions, relating to institutional issues. Which agency or institution is to be responsible for O & M and how will the O & M be funded.

TABLE 8.9

Costs for Scheme A (Interventions 1A and 1B)

Zone A Capital Costs
Zone Area – 31 976 ha gross, 24 506 ha NCA
Protected Area – 23 400 ha gross, 17 933 ha NCA

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk,000)
1.	Flood embankment				
	– Clearing, Grubbing & Stripping	sq.m	648,000	3	1,944
	– Channel Excav. and Formation of Emb. (Manual Excav./Mechanical Comp.)	cu.m	988,000	42	41,496
	– Turfing	sq.m	680,000	3	2,040
2.	Channel excavation & Spreading				
	– Manual (transport 50 m)	cu.m	2,230,000	28	62,440
	– Mini–Dredger (transport 500 m)	cu.m	688,000	50	34,400
3.	New regulators				
	1 – Vent 3.5m X 3.0m fish–friendly	Vent 2*1		8,500,000	17,000
	3 – Vent 3.5m X 3.0m fish–friendly	Vent 2*3		4,700,000	28,200
	1 – Vent 1.82m X 1.52m	Vent 4*1		2,000,000	8,000
4.	Buildings	Existing facilities at Comilla			
5.	Vehicles	Nr	1	1,000,000	1,000
6.	Land Acquisition				
	– Agricultural	ha	100	375,000	37,500
	– Homestead	ha	1.7	1,617,800	2,750
	Sub–Total				236,770
	Physical contingencies 15%				35,516
	Sub–Total including contingencies				272,286
	Engineering service cost 12%				32,674
	Total Project Cost				304,960

TABLE 8.10

Costs for Scheme A (Intervention 2)

Zone B Capital Costs
Zone Area – 26 782 ha gross, 22 412 ha NCA
Protected Area – 5 000 ha gross, 4 184 ha NCA

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk ,000)
1.	Flood embankment				
	– Clearing Grubbing & Stripping	sq.m	631,300	3	1,894
	– Channel Excav. and Formation of Emb. (Manual Excav./Mechanical Comp.)	cu.m	713,650	42	29,973
	– Turfing	sq.m	63,900	3	192
2.	Channel excavation & Spreading				
	– Manual (transport 50 m)	cu.m	90,500	28	2,534
3.	New Drainage/Flushing Sluices				
	2 – Vent 1.82m X 1.52m	Vent 1*2		1,700,000	3,400
	1 – Vent 1.22m X 1.52m	Vent 2*1		1,600,000	3,200
	1 – Vent 1.82m X 1.52m	Vent 3*1		2,000,000	6,000
4.	Buildings	Existing facilities at Brahmanbaria			
5.	Vehicles	Nr	1	1,000,000	1,000
6.	Land Acquisition				
	– Agricultural	ha	34.3	375,000	12,863
	– Homestead	ha	0.61	1,617,800	987
	Sub–Total				62,042
	Physical contingencies 15%				9,306
	Sub–Total including contingencies				71,349
	Engineering service cost 12%				8,562
	Total Cost for Intervention 2				79,910
	Total Cost for Interventions 1A and 1B (from Table 13.1)				304,960
	Overall Cost for Scheme A				**384,870**

TABLE 8.11

Costs for Scheme B (Intervention 3)

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk 000)
1.	Submersible embankment (Gumti R. Bank)				
	– Clearing Grubbing & Stripping	sq.m	83,471	3	250
	– Channel Excav. and Formation of Emb. (Manual Excav./Mechanical Comp.)	cu.m	75,447	42	3,169
	– Turfing	sq.m	88,707	3	266
2.	Drainage/flushing sluices (Gumti R. Bank)				
	1 – Vent 1.82m X 1.52m	Vent	2*1	2,000,000	4,000
3.	Irrigation Inlet Structure (Gumti Right Emb.)				
	6 inch dia PVC Pipe with Dist. Box	Nr	15	50,000	750
4.	Buildings : Existing facilities	Nr	0	6,000	0
5.	Vehicles	Sum		500,000	500
6.	Land Acquisition				
	– Agricultural	ha	8.35	375,000	3,131
	– Homestead	ha	0	1,617,800	0
	Sub–Total				12,067
	Physical contingencies 15%				1,810
	Sub–Total including contingencies				13,877
	Engineering service cost				1,665
	Total Project Cost				**15,542**

TABLE 8.12

Costs for Scheme C (Intervention 6)

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk 000)
1.	Channel excavation & Spreading				
	– Manual excavation (transport 50 m)	cu.m	677,000	28	18,956
	– Mini–Dredger (transport 500 m)	cu.m	677,000	50	33,850
2.	Buildings : Existing facilities	Nr	0	6,000	0
3.	Vehicles	Sum		500,000	500
	Sub–Total				53,306
	Physical contingencies 15%				7,996
	Sub–Total including contingencies				61,302
	Engineering service cost				7,356
	Total Project Cost				68,658

TABLE 8.13

Costs for Scheme D (Intervention 4)

Zone C Area – 41 400 ha gross, 35 040 ha NCA
FCDI Area – 10 459 ha gross, 8 852 ha NCA
Add. Irrig. Area – 11 887 ha gross, 9820 ha NCA

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk ,000)
1.	Flood embankment				
	– Clearing Grubbing & Stripping	sq.m	593,890	3	1,782
	– Channel Excav. and Formation of Emb. (Manual Excav./Mechanical Comp.)	cu.m	1,219,943	42	51,238
	– Turfing	sq.m	807,500	3	2,423
2.	Channel excavation & Spreading				
	– Manual excavation (transport 50m)	cu.m	914,967	28	25,619
3.	New regulators				
	2 – Vent 3.5m X 3.0m fish–friendly + flume	Vent	1*2	7,000,000	14,000
	2 – Vent 2.0m X 3.0m check/navigation	Vent	5*2	600,000	6,000
	2 – Vent 1.82m X 1.52m check/head gate	Vent	1*2	550,000	1,100
	2 – Vent 3.5m X 3.0m fish–friendly	Vent	1*2	6,600,000	13,200
	1 – Vent 1.82m X 1.52m	Vent	3*1	2,000,000	6,000
	2 – Vent 1.82m X 1.52m chute drop	Vent	1*2	2,000,000	4,000
4.	Pump Stations				
	Nr 1 (Q = 3 @ 2.52 = 7.56 cu.m/sec)				
	Civil Works	sum		39,441,630	39,442
	Electrical & Mechanical Works	sum		41,271,600	41,272
	Nr 2 (Q = 4 @ 3.655 = 14.62 cu.m/sec)				
	Civil Works	sum		58,235,000	58,235
	Electrical & Mechanical Works	sum		91,637,671	91,638
5.	Buildings	sq.m	900	6,000	5,400
6.	Vehicles	Nr	4	1,000,000	4,000
7.	Land Acquisition				
	– Agricultural	ha	43.50	375,000	16,313
	– Homestead	ha	2.33	1,617,800	3,769
	Sub–Total				385,429
	Physical contingencies 15%				57,814
	Sub–Total including contingencies				443,243
	Engineering service cost 12%				53,189
	Total Project Cost				**496,432**

8.8.2 Funds

Necessary funds for O&M of the project have to be realized from the beneficiaries. This however depends on the following:

- reliability of the project,
- public acceptance of the project and
- public participation

To make the project reliable and acceptable to the public, O&M during the initial period after completion of the project may have to be carried out by the GOB (BWDB) as was conceived in FAP 13. FAP 13 recommended two years O&M after completion of a project. During the period the major drawbacks of the planning and design should also be rectified.

Involvement and motivation of the public during the planning, design and implementation stages will make it easier to make the project acceptable to them. Payments may be levied to realise adequate funds for O&M according to the findings of the BWDB Systems Rehabilitation Project. This is discussed in Chapter 13.

8.8.3 Specific O&M Requirements

Preparation of O&M manuals will be taken up during the design stage. A general outline for O&M of different infrastructure for the proposed projects are discussed below:

8.8.4 O & M Costs

The costs for Operation and Maintenance were prepared according to the FPCO Guideline for Project Assessment. This cost includes the cost of:

- technical staff, department overheads, labour and materials
- operation and maintenance of vehicles and instruments
- estimate of annual repairs by contract
- periodic replacement of pumps, motors etc, subject to wear and tear
- cost of strengthening the government departments, e.g. extension systems

The maintenance costs of the schemes required for the Gumti phase II Project are taken as:

Embankments	6%
Drainage channels	6%
Structures	3%
Irrigation Structures	3%
Pump Stations (maintenance)	2%
Pump Stations (operation)	Sum
Vehicles	4%

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The costs of annual re-excavation in the Salda and Buri Nadi Rivers is expected to be high. Calculations were carried out assuming an annual silt and sand load of approximately 110,000 tonnes per annum. This heavy requirement was however balanced with the far lower maintenance costs for khal re-excavation within the protected areas of Zone A and Zone B. Calculations showed that the combined re-excavation costs inside and outside the protected areas arrived at approximately 6%. This value was therefore adopted.

The operation of pump station costs were based on full irrigation requirements and 70 days (at 18 hours/day) of drainage pumping. The costs used were based on electricity supply at standard agricultural rates and amounted to approximately 3.4 million Taka a year.

8.9 Economics

8.9.1 Methodology

The methodology used to evaluate project interventions is based on FPCO Guidelines for Project Appraisal. The economic analysis is based on 1991 constant prices whereas the financial analysis uses 1992 prices. Economic prices have been calculated by applying FPCO conversion factors to 1991 financial prices, which were either estimated from secondary data, market prices for example, or taken from previous reports (i.e. labour rates).

8.9.2 Benefits

Benefits resulting from project interventions are described below but in general include the following:

- increased agricultural production resulting from either improved flooding regimes or from the provision of flood protection to crops

- avoidance of flood damage by the provision of protection to housing, livestock, fish ponds, and Government property.

Dis-benefits (or costs) to capture fisheries arise as a result of changed flooding regimes, where there is a direct conflict of interest between agriculture (which benefits from reduced flooding depths) and fisheries which suffer.

8.9.3 Capital Costs

Capital costs are summarised in the previous section of this chapter.

8.9.4 Economic Evaluation

i) Zones A and B

Proposals for Zones A and B are for the construction of two embankments surrounding 17933 ha (NCA) in Zone A and 4182 ha in Zone B. Benefits are expected to include increased cropping of aman in the monsoon season, and a small increase in T aus areas, as well as the provision of flood protection. Capture fishery losses of 1831 tonnes are forecast.

The results of the economic analysis for Zones A and B are presented in Tables 8.14 to 8.16 which cover the following:

- summary of benefits in financial prices
- summary of cropping pattern changes
- summary of result and sensitivity analysis

As can be seen in Tables 8.16 the project produces an IRR of 14.9%. The project returns are particularly sensitive to delays in either completion or the achievement of benefits. Given that a construction schedule of five year is proposed, it is not anticipated that these will occur.

Sensitivity to both fishery losses and reduced flood damage are similar. Inspection of the Cash flow (Table 15.8) illustrates the relative importance of different costs and benefits. Incremental Crop income is the largest but is still only twice the fishery losses. In percentage terms the increase in crop income between the "with" and "without" situations is small, less than seven per cent. The importance of flood damage benefits, especially protection against flash floods is evident.

Implementation of the project should increase rice production by seven per cent. Employment is not increased significantly mainly because the increase in demand for agricultural labour is offset by the loss of employment in fisheries.

A multi criteria analysis which reviews the overall impact of the proposals for Zones A and B is presented in Annex H and in Chapter 12. Apart from the impact on capture fisheries the project is not expected to generate any serious environmental degradation. It may increase flooding depths in the monsoon in the area to the east of the Zone A embankment by small amounts, although this will be counteracted to some extent by the improvement expected in the control of flash flooding through deepening and enlarging the Rivers Salda, and Buri Nadi.

ii) Zone C.

This proposal is described in Section 8.5. The difficulty in analysing the proposed interventions in Zone C concern the rate and extent to which groundwater can be expected to be exploited in the "future without" project situation. This is because shallow tubewells are hampered by the presence of underground gas reserves which break suction in the pump when the gas passes through the system. Alternative force mode technology for either shallow or deep wells should overcome the problem but application of such technologies have been constrained by their cost and novelty (in the case of the shallow force mode tubewell). At economic prices both shallow and deep force mode wells are cheaper than the alternative of pumping water from the River Meghna into Khals and out of Khals onto the land with low lift pumps. A comparison of costs, based on the proposed pumping stations for Zone C, which are designed for an irrigation duty of 9800 ha has been made with both shallow and deep force mode tubewells, and the present value of providing one hectare of irrigation over 30 years at 12% calculated:

Pump station and LLPs	P (12%) per ha =	Tk. 30 180
Shallow force Mode tubewell	P (12%) per ha =	Tk. 15 000
Deep tubewell	P (12%) per ha =	Tk. 17 800

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TABLE 8.14

Summary of Benefits

ZONES A & B	Unit	Project Year 1	Future Without (1)	Future Without (2)	Future With (1)	Future wtih (2)	% increment (1)	% increment (2)
Net Cultivated Area	'000 hectares	46.9	46.9	46.9	46.9	46.9	0	0
Irrigated Area	'000 hectares	30.5	35.2	35.2	35.2	35.2	0	0
Labour Requirement (ag & fish)	million man days	15.7	15.9	15.9	16.0	16.0	1	1
Paddy Production	'000 tonnes	276	291	291	307	307	5	5
Cropping Intensity (excl. orchard) %	NCA	186%	182%	182%	189%	189%	4	4
Irrigated area	% NCA	65%	75%	75%	75%	75%	0	0
Net Crop Income	million Taka	933	969	969	1,029	1,029	6	6
Crop fishery income	million Taka	42	41	41	9	9		
Crop Flood loss reduction	million Taka				28	28		
Non-agric. floed loss reduction	million Taka				5	10		

Notes:

Project Year 1	:	assumed 1994/95
Future Without (1)	:	Future Without Project Conditions, 5 years after project would have been completed
Future Without(2)	:	Future Without Project Conditions, year 30
Future With(1)	:	Future With Project Ccondition, 5 years after project completion
Future With(2)	:	Future With Project Conditions, Year 30
% Increment(1)	:	% difference FW(1) over FWO(1)
% Increment(2)	:	% difference FW(2) over FWO(2)

Flood losses refer to average annual losses that will be eliminated by the project.
Values in 1992 financial prices

TABLE 8.15

Summary of Cropping Pattern Changes

					(% of NCA)
	Year 1	Future without(1)	Future Withou(2)	Futrue Without(1)	Future With(2)
B Aus, local	4.2%	2.^%	2.6%	2.6%	2.6%
B Aus, HYV	1.5%	1.5%	1.5%	1.5%	1.5%
T Aus, local	2.6%	1.1%	1.1%	1.1%	1.1%
T Aus, HYV irri	3.0%	2.7%	2.7%	3.4%	3.4%
T Aus, HYV n-r	8.9%	8.1%	8.1%	9.2%	9.2%
Mixed aus/aman	1.7%	1.7%	1.7%	2.0%	2.0%
B Aman local dw	15.5%	9.5%	9.5%	6.3%	6.3%
T Aman local dw	7.0%	7.0%	7.0%	8.0%	8.0%
T Aman, local	20.9%	20.9%	20.9%	13.6%	13.6%
T Aman HYV irri	3.2%	3.2%	3.2%	4.4%	4.4%
T Aman HYV n-ir	17.8%	17.8%	17.8%	30.2%	30.2%
Boro, local	0.7%	0.7%	0.7%	0.7%	0.7%
Boro, HYV irrig	64.1%	74.3%	74.3%	74.3%	74.3%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.7%	1.5%	1.5%	1.5%	1.5%
Wheat unirrig	7.9%	6.4%	6.4%	6.4%	6.4%
Potato irrig.	2.3%	2.3%	2.3%	2.3%	2.3%
Potato unirrig	2.1%	2.1%	2.1%	2.1%	2.1%
Jute	3.7%	3.7%	2.7%	2.7%	2.7%
Pulses : ave.	3.6%	2.7%	2.7%	2.7%	2.7%
Mustard	11.0%	9.2%	9.2%	10.3%	10.3%
Spices (chilli)	0.8%	0.8%	0.8%	0.8%	0.8%
Veg. (brinjal)	1.9%	1.9%	1.9%	1.9%	1.9%
Total	186.2%	181.6%	181.6%	188.8%	188.8%

TABLE 8.16

Summary of Results and Sensitivity Analysis

	ZONES A & B		
Capital Cost	234.1 Tk.m.	construciton	4 years
Annual O&M Cost	7.5 Tk.m.	(economic prices)	
Net Present Value @12%			46.8 Taka milli (economic prices)
Economic Internal Rate of Return			14.9 %
Sensitivity Analyses			Economic IRR(%) Change in Variable

Variable	Base Case	+10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	14.9	13.8	12.3	10.5	16.1	18.5	24.4	29.15
O&M Costs	14.9	14.6	14.3	13.7	15.1	15.4	16.0	124.27
Fisheries Losses	14.9	14.0	12.6	10.3	15.7	17.0	19.2	31.58
Reduced flood losses	14.9	15.7	17.0	19.1	14.0	12.6	10.3	31.91
Total Benefits	14.9	17.1	20.2	24.9	12.5	8.4	-1.7	11.90
Incremental Net Crop Income	14.9	16.2	18.2	21.1	13.4	11.0	6.2	18.98
Delay in full benefits								
2 years	11.6							
	10.1							
4 years								
Delays in Completion								
	12.1							
2 years	10.8							
4 years								

(Present values assume the pump station takes four years to build and that investment in secondary pumping occurs in year 5. LLPs are 20 L/S, irrigating 10 ha with an operational life of 5 years. SFMTWs are 15 L/S, command 7.5 ha with an operational life of 10 years. DTWs are 30 L/S, irrigate 15 ha with an operational life of 10 L/S).

Thus it may be concluded that if only irrigation is considered, exploiting groundwater will be cheaper, in economic prices at least. In financial prices the outcome is far less clearcut because:

1) electricity for irrigation is subsidised whereas gas oil is taxed

2) both shallow force mode and deep tubewells are expensive and it is likely that farmers would be reluctant to invest such large sums even if credit were easier to obtain than it is at present.

As a consequence it is by no means certain that investment in groundwater will occur without an official intervention to encourage its development (as for example the National Minor Irrigation Development Project). For these reasons three alternative analyses of Zone C proposals have been undertaken which are all based on different "without project" developments. Thus in each case the "future with" remains the construction of the northern polder, with irrigation supplies sufficient for 9800 ha supplied by surface water and pumped drainage of the polder in the wet season, while the "future without" comprises:

1) no further development of ground water

2) a rapid development of groundwater such that 75% of NCA is irrigated by year 10 (with the balance of irrigation required in the "with project" also supplied by groundwater

Tables 8.17 and 8.18 shown the results for analyses 1 and 2 above.

With no "future without" groundwater development the proposal produces an IRR of 18%, benefitting from both increased irrigation areas and substantial drainage benefits within the polder (where F0 land increases from 7 to 73% NCA). With "future without" groundwater development the project loses its irrigation benefits and the IRR falls to less than 12%. As a result the scheme cannot be recommended for implementation until the practical applicability of shallow force mode tubewells is established or disproved. In the event of the latter, the scheme looks attractive as an economic investment even though there are substantial fisheries losses and environmental costs associated with its development.

iii) Zone D

Two proposals for Zone D are evaluated here:

1) the re-excavation of khals to improve the irrigation supply

2) the extension of the River Gumti embankment to provide protection to areas currently prone to flash flooding.

a) Re-excavation of Khals

The re-excavation of Khals should increase the area able to be irrigated with low lift pumps by approximately 10 000 ha.

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TABLE 8.17

Zone C(no further groundwater development)
Summary of Results and Sensitivity Analyses

Capital cost	323.3 Tk.m.	Construction period	5 years
Annual O&M cost	25.9 Tk.m. (economic prices)		

Net Present Value @12%	157.8 Taka million (economic prices)
Economic Internal Rate of Return	18.34 %

Sensitivity Analyses — Economic IRR (%)

Variable	Base Case	Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	18.3	17.2	15.6	13.6	19.7	22.2	28.4	74.09
O&M Costs	18.3	17.9	17.2	16.1	18.8	19.4	20.5	136.69
Fisheries Losses	18.3	18.1	17.7	17.0	18.6	19.0	19.7	218.32
Reduced flood losses	18.3	18.4	18.5	18.7	18.3	18.2	18.0	572.22
Total Benefits	18.3	20.2	22.9	26.8	16.3	12.8	5.2	28.25
Incremental Net Crop Income	18.3	20.2	22.7	26.5	16.4	13.1	5.9	29.33
Delay in full benefits								
2 years	15.0							
4 years	13.5							
Delays in completion								
2 years	14.9							
4 years	13.3							

TABLE 8.18

Zone C(10 year FWO groundwater development)
Summary of Results and Sensitivity Analyses

Capital cost	323.3 Tk.m.	Construction period	5 years
Annual O&M cost	25.9 Tk.m.	(economic prices)	

Net Present Value @12%	-64.0 Taka million (economic prices)
Economic Internal Rate of Return	9.15 %

Sensitivity Analyses   Economic IRR (%)

Variable	Base Case	+10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
		Change in Variable						
Capital Costs	9.1	8.4	7.4	6.1	10.0	11.4	14.8	30.05
O&M Costs	9.1	8.6	7.8	6.3	9.7	10.5	11.7	55.44
Fisheries Losses	9.1	8.8	8.3	7.4	9.5	10.0	10.8	88.55
Reduced flood losses	9.1	9.2	9.3	9.5	9.1	8.9	8.7	372.24
Total Benefits	9.1	10.7	12.8	15.8	7.4	4.2	-5.2	19.01
Incremental Net Crop Income	9.1	10.6	12.6	15.5	7.5	4.5	-3.7	20.12
Delay in full benefits								
2 years	8.6							
4 years	7.5							
Delays in completion								
2 years	7.7							
4 years	6.9							

With an increase of 10 000 ha the IRR = 28% and an IRR of 12% is obtained with an increase in irrigated area of 5200 ha, or just over half of what is expected.

Assumptions made for this analysis were:

1) LLPs and STWs are replaced every 5 years
2) LLPs command an area of 10 hectares, with a discharge of 20 l/s.
3) STWs command an area of 4.5 hectares with a discharge of 8 l/s.

Costs for LLPs and STWs are presented in Annex IX.

CHAPTER 9

NORTHERN SUB-REGION - DEVELOPMENT PROPOSALS

9.1 Introduction

The previous chapter has discussed the largest planning unit in this sub-region separately since it has been studied at feasibility level.

The other planning units in this sub-region are as follows:-

Gumti Phase I	-	Planning	Unit	10
Ashuganj	-	,,	,,	12
Titas	-	,,	,,	13.

These three units have or had much in common with the Gumti Phase II area and some of the information obtained during the Gumti II feasibility study has been used to update and reconsider proposals previously under for these units.

Unfortunately the SERM does not cover the areas of planning units 12 and 13 and therefore it has not been possible to quantify the benefits of flood protection to these areas in the same way as for other units. However, since these areas have high value fisheries it is unlikely that flood protection could be economically viable unless the FAP 6 proposals induce a greatly increased liability to boro damage. This is effectively tested in the option studied for the Titas area (planning unit 13).

9.2 Gumti I Planning Unit 10

This planning unit was the subject of the now completed Gumti Phase I flood control and drainage project. This project, protects the whole planning unit from flooding from the Meghna and Gumti Rivers. Although one or two offtakes are provided from the Gumti River for surface water irrigation large scale irrigation was deleted from the project, in expectation of supplies being made available from the Gumti Phase II project but this is not now expected to happen.

The planning unit is bounded on the south by the Daudkandi-Comilla road and the west, north and east by the Gumti River, from which it is fully protected by an embankment. The gross area is 31 486 ha, and the net cultivable area (NCA) 26 139 ha. The thanas included, in whole or in part, are Daudkandi, Muradnagar, Debidwar and Burichang, all in Comilla District.

Like the Dhonagoda planning unit, the Gumti Phase I planning unit may be considered in two parts:

- the generally low lying Meghna flood plain, with limited groundwater potential, because of salinity and gas constraints,
- the higher land in the east rising to the Lalmai Hills, with high groundwater potential but scarce surface water.

Unlike the Dhonagoda planning unit, the only flood hazard (barring breaches of the Gumti embankment) is from the accumulation of rainfall with in the polder. It has been suggested that the embanking of the Gumti River without the provision of surface water for irrigation may have had a net negative impact in some areas, with less water available from the minor khals during the dry season.

9.2.1 Previous Studies

(i) Master Plan (International Engineering Co, December 1964)

The Master Plan envisaged a single Comilla-Noakhali project of 336 000 ha gross covering the whole of the Noakhali North, Dakatia, Dhonagoda and Gumti Phase I planning units, with the exception of the south west portion of the Dhonagoda planning unit; this was treated as the North Unit of the Chandpur Project which, like the Meghna-Dhonagoda Project, was treated as a separate project. The Gumti Phase I planning unit lies within the North Area as designated in the Master Plan. It was proposed to provide full flood protection with pumped drainage initially, followed by surface water irrigation from the Lower Meghna River. About 5 000 ha, in the east of the planning unit were also expected to receive irrigation water pumped from the Gumti River under the separate Gumti River Project. The Gumti River Project also included the provision of new flood embankments to the Gumti River for about 30 km downstream of the Indian border.

(ii) Planning Report on Development of Gumti River for Irrigation. (International Engineering Co, December 1966)

This report follows up the Gumti River Project in the 1964 Master Plan, and concludes that the water available is insufficient to irrigate the originally anticipated area. No irrigation from the Gumti River was thus envisaged within the Gumti Phase I planning unit.

(iii) Meghna-Muhuri Water Transfer. Draft Planning Report (International Engineering Co/Rahaman & Associates, September 1972)

The present planning unit formed a component (as the Gumti South Project) of Phase IV of the water transfer scheme proposals, although irrigation water was to be abstracted separately form the Meghna River, and not via the main water transfer channel. Development was anticipated in two stages.

Stage I

Surface water irrigation, by means of a primary pump station on the lower reaches of the Gumti River near Gouripur, raising water into Barkamta Khal, and thence into subsidiary khals, for delivery to the tertiary system by LLP. A relift pump station was to be provided for the higher land in the east. Barkamta Khal and its two main distributaries were to be embanked to retain irrigation water. Gouripur pump station was to be reversible, for pumped drainage.

Stage II

Flood control and drainage. The southern embankment of the Gumti River would be completed to Daudkandi, and additional pumped drainage capacity provided. Flooding from the south was already to have been prevented by embanking the Daudkandi-Comilla road and closing drainage crossings under the proposals for the Dhonagoda Project.

(iv) Draft Feasibility Report on the Gumti-South Project. (BWDB/Netherlands Engineering Consultants (NEDECO), January 1984)

This study, under the Drainage and Flood Control III Project, examined the provision of flood control, drainage and irrigation to an area more or less corresponding with the Gumti Phase I planning unit. Under the recommended option, embankments along the Gumti left bank were to be raised to above high flood level, and continued along the north bank of Barkamta Khal, thus leaving the latter open for navigation. Further embankment works were also recommended on the Gumti right bank, to prevent flood depth increasing as a result of the project in the area to the north of the Gumti River. Drainage was to be entirely by gravity.

Irrigation water for 2 300 ha in the east of the area was to be provided by an offtake diverting 2 m^3/s from the Gumti River (out of a total of 6.7 m^3/s available near Comilla) during the dry season. A further 8 400 ha in the west was to be brought under irrigation from a primary pump station on the Meghna River at Daudkandi, via a 15km feeder channel (the option of pumping from the Gumti River near Gouripur was considered vulnerable to siltation in the lower reaches of the Gumti River).

(v) Third Flood Control and Drainage Project. Inception Report (Engineering and Planning Consultants/Sir William Halcrow and Partners, August 1986).

This Inception Report relates to a consultancy for the planning, implementation, design and construction monitoring of three sub-projects, one of which was the Gumti Phase I project, as defined in the 1984 Feasibility Report on the Gumti-South Project (see (iv) above). The irrigation component via a pump station at Daudkandi was still being considered at this stage, although the Feasibility Study proposal to use the Daudkandi-Comilla road borrow pit for the feeder canal alignment was "considered to be uneconomic and physically difficult to attain", and other alignments were being sought.

(vi) Supplementary Feasibility Study for the Provision of Irrigation Supplies to the Gumti Phase I Sub-Project (Bureau of Consulting Engineers/Sir William Halcrow and Partners, March 1990).

This study is supplementary to that prepared for the Gumti Phase II area (Gumti Phase II Sub-Project Feasibility Study, Bureau of Consulting Engineers/Sir William Halcrow and Partners, March 1990). It examines the provision of irrigation water for 12 100 ha within the Gumti Phase I area from the Nabinagar pump stations proposed under Gumti Phase II (suitably enlarged via a siphon beneath the Gumti River at its intersection with the Buri River. The report gives the background concerning the previous proposals for irrigation of the Gumti Phase I area, and notes that as design work proceeded under the Third Flood Control and Drainage Project (see (v) above) "doubts were raised as to the financial and economic viability of this pumping scheme, which would only be capable of supplying irrigation water to some 10 650 ha in the lower part of the project area.

Eventually in mid 1989 it was decided to abandon the pumping proposals". The report also observes that the dry season flow of the Gumti River is largely committed to the Sonaichari Irrigation Project upstream, and reliable supplies are unlikely to be available for the Gumti Phase I area.

(viii) Hydrological and Morphological Studies. Gumti-Titas and Atrai Basins.(Howard Humphreys/Hydraulics Research, April 1990).

These studies were a component of the Third Flood Control and Drainage Project. The section on the Gumti - Titas basin is primarily concerned with the computer simulation of the fully embanked Gumti River. Construction of the embankments was already well advanced at the time of presentation of the report, on the basis of designs prepared by EPC/Halcrow (see (v) above), which gave a generally lower crest level than that proposed by NEDECO (see (iv) above). The report concluded that the embankment under construction would be overtopped by about 20 cm about 30km from the Indian border in a 1:20 year Gumti flood, and the freeboard in most reaches would be minimal, whilst in the lower reaches a 1:20 year Meghna flood would overtop both EPC/Halcrow and NEDECO design embankments by about 1m. (The overtopping in the downstream reach is probably of no consequence in the absence of full embankments to the Meghna River, eg under the Gumti Phase II Project. It is understood that no decision has been taken to raise the embankments in the upstream reaches.)

(ix) The Master Plan Study on the Model Rural Development Project Phase II for Kachua, Nabinagar, Bancharampur and Debidwar Thanas (JICA, February 1991).

This study includes Debidwar thana within the planning unit. Proposals are divided into priority projects, targeted for completion in 1995, and a longer term programme with an 18 years implementation period.

For Debidwar thanas, the following items are included in the irrigation drainage and flood control sector.

	Priority (1993-1995)	Overall (1993-2010)
Low capacity (0.5 to 0.75 cusec) fractional pumps for supplemental irrigation of upland winter crops from ponds etc.	50 Nr pumps 250 ha command area	150 pumps 750 ha command area

The programme also includes components for the re-excavation and embankment of fish ponds and the provision of extension and credit for semi-intensive fish culture.

9.2.2 Groundwater Development Potential

The recently completed Gumti Phase II feasibility study has increased the level of knowledge concerning groundwater constraints not only within planning unit 11 but also within this unit. Although the groundwater mapping was not been produced for planning unit 10 it can be reasonably deduced that much of the western part of the unit suffers from two constraints as follows:

- the deep aquifer is largely saline with EC values exceeding 2000 μs/cm thus precluding D.T.W development

- the shallow aquifer produces gas in many wells which tends to give problems with suction mode wells (STWs) which lose suction and makes this type of development unreliable.

Therefore in this part of the unit the only type of groundwater development feasible is SFMTWs. This is relatively new and untired in Bangladesh and it also requires higher investments from farmers than they have previously been accustomed to provide.

However the eastern part of the unit has better condition with neither of the above mentioned constraints. The potential for the unit is thus estimated as shown below:

	Potential (ha)	Existing (ha)
STW/DSSTW	5 100	1 991
FMTW	3 400	2 675

It has been assumed that groundwater would be eventually used to its full potential whatever other developments are made.

9.2.3 Surface Water Potential

The previous section has indicated that groundwater potential is limited to the eastern half of the planning unit.

The existing surface water irrigation combined with the existing and potential groundwater development is estimated to provide about 47% of the 26139 ha NCA with irrigation supplies as shown below:

Irrigation Mode	Existing Development	Future Development	Total
LLP	3,336	* -	3,356
STW	1,991	3,109	5,100
DTW	2,675	725	3,400
Traditional	478	-	478
	8,500	3,834	12,334

* Assumes no public intervention

The existing supply to many of the LLPs has been made more difficult by the construction of the Gumti lift embankment.

The proposals studied for this unit both in the interim report and in the draft regional plan showed poor returns. Also the development of the Gugrajola scheme and the Model Rural Development project in Daudkandi thana make this proposal even less attractive.

The river surveys undertaken for the Gumti Phase II study have indicated that the present river bed level is low enough to permit water to enter all the way back to a point 12 km downstream of the Buri Nadi offtake and the indications are that this situation is improving.

The Gumti Phase II study has suggested that the use of back flow in the Gumti river as a source of irrigation water for planning unit 10 could be reconsidered (it has been discounted in previous studies).

Therefore it is suggested that the principal khals leading to the main drainage structure at the western end of the present scheme (Siddeswari regulator) are deepened as much as possible within the existing bank top width to allow the maximum volume of water back into the scheme during the dry season.

As already demonstrated for other planning units khal deepening produces good rates of return and provided the river section downstream of the Siddeswari regulator has appropriate section the additional potential in this western part of the scheme would be of the order of 1,000 ha. This would increase the total irrigated area to 51% of the NCA of the planning unit. The present design of the Siddeswari regulator will probably not permit adequate flows into the system in the dry season and consideration could be given to additional low levels gates to allow such flows.

The only other possibility for increased surface water development is for ,additional LLP's pumping directly over the Gumti embankment.

9.2.4 Fisheries in Gumti Phase I Planning Unit

There are about 6 000 ponds with an area of about 650 ha and the total production obtained is 1 000 tonnes. Culture fisheries are expected to improve gradually as this area is within the reach of Comilla area. In Muradnagar itself, the fishermen were seen producing fish seed using traditional methods but with quite good results.

Capture Fisheries in this area will suffer due to the implementation of the FCD project and requires attention from the DOF to improve the capture fisheries but in particular to develop culture fisheries in lands where flooding is reduced, the number of ponds in this area is relatively low.

The proposed development of irrigation could increase culture fisheries in ponds and culture-based capture fisheries in the khals and creeks.

9.2.5 Long Term Development

The discussion in section 9.2.2 identified that groundwater development of the shallow aquifer in the western part of the Gumti I area is constrained by gas for suction mode wells. It would seem appropriate that this area could be considered for pilot development of SFMTWs which could be highly successful under the prevailing conditions. It is an area which could merit the attention of the NMIDP to promote such development.

9.3 Ashuganj - Planning Unit 12

9.3.1 General Description and Constraints

The Ashuganj Planning Unit lies in the northern part of the study area, bounded on the west by the Meghna River and the north, east and south by a loop of the Titas River. Its gross area is 28 913 ha and net cultivable area (NCA) 25 919 ha, including in whole or in part the thanas of Ashuganj, Sarail, Brahmanbaria and Nabinagar, all in Brahmanbaria District.

The area is generally Meghna flood plain, and an extension of the greater Sylhet haor area. During the monsoon season, the aman crop is susceptible to flood damage from the Meghna and Titas Rivers, whilst winter crops generally require irrigation. About 15% of the planning unit is regularly (more than four years out of five) flooded before the boro harvest is complete (31 May). See sub unit 1 below.

As stated above, most of the unit is currently at a level which does not suffer flooding which damages the boro crop and for this reason submersible embankments are not considered appropriate. In addition the area which does flood early is a long narrow strip which would be relatively expensive to protect. Thirdly this low area is a prime fishing area which would severely affect the viability of any flood control option.

However when FAP 6 has reported on its proposals for the North East Region (NER) it will be important to identify any likely change in the early and peak monsoon flood levels which the proposals for the north-east may cause in this area. Any such increase could be due to the diversion downstream of volumes of water to be excluded by increased areas protected by submersible embankments in the NER. FAP 6 will need to take this into account when framing their proposals since any induced damage or costs would need to be added to the cost of the developments in the NER.

At the time of writing no information on the likely effects of the NER proposals are available.

The 720 megawatt Ashuganj Power Station lies within the planning unit, and draws cooling water from the Meghna River, discharging it again with a temperature rise of 6 or 7 degrees Celsius. About 3 270 ha are at present irrigated from this water under the auspices of Ashuganj Sabuj Prakalpa, which is an autonomous body set up by the government for this purpose. The maximum discharge available now that the power station is up to full capacity is 37.5 m^3/s, with a reliable minimum of 21 m^3/s, of which only 5.7 m^3/s is being used at present for irrigation.

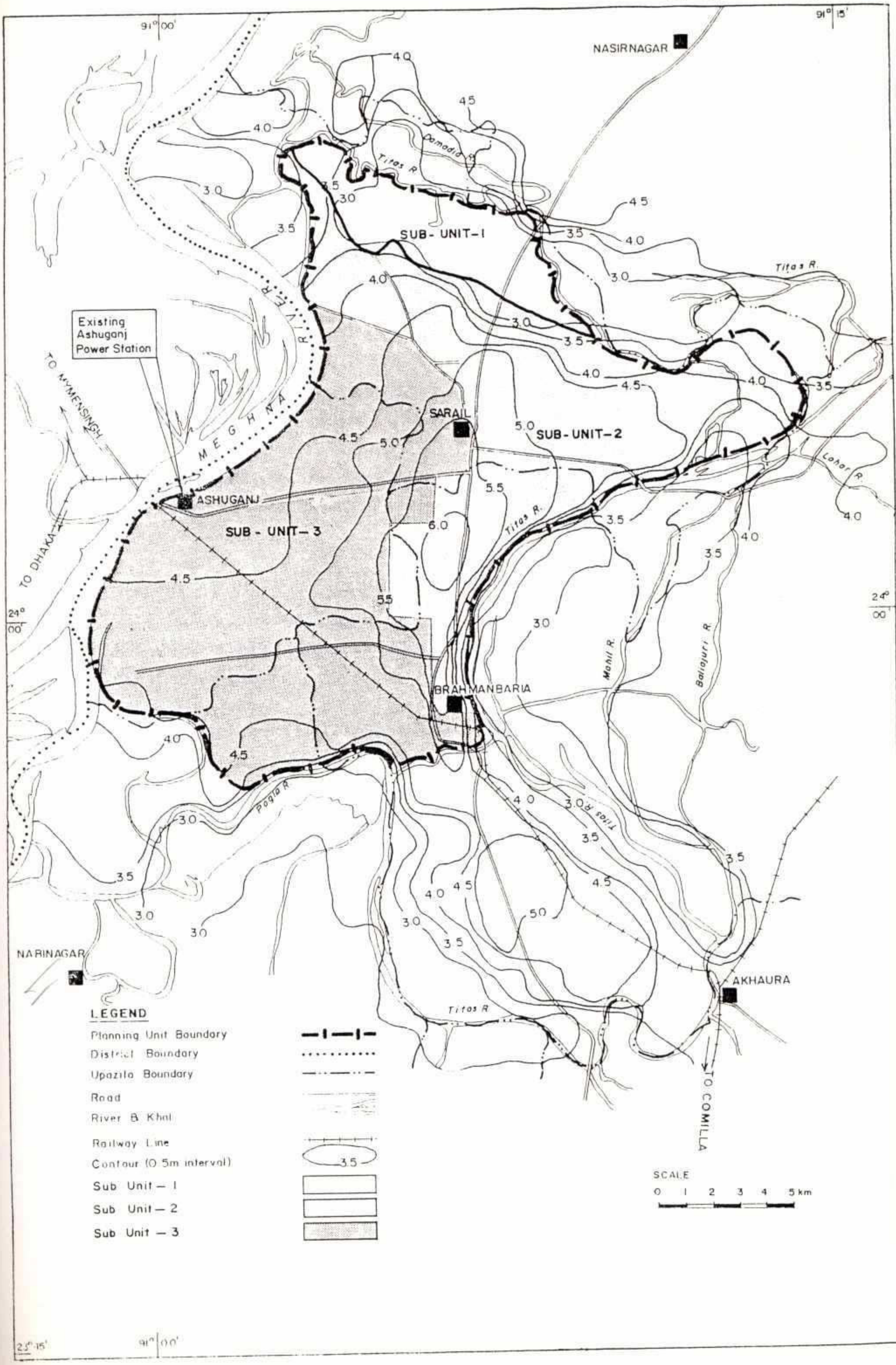
For the purpose of this study, the planning unit has been divided into three sub-units, as in Figure 9.1.

(a) Sub-unit 1 (Gross area 3 300 ha, NCA 2 960 ha)

This sub-unit, adjacent to the Titas river, is largely below 3.0 m above Public Works Datum (PWD) and is not recommended for intensive agricultural development. Irrigated boro is vulnerable to early floods, but flood control is considered unlikely to be effective because of the difficulty in evacuating internal drainage water. It is therefore thought prudent to leave the area open, with the possibility of further natural land development through silt deposition.

Figure 9.1

Ashuganj Planning Unit



(b) **Sub-unit 2 (Gross area 11 613 ha, NCA 10 459 ha)**

This sub-unit has mixed topography, but it is generally (4 years out of 5) flood-free until after 31 May, and hence a boro crop can be safely harvested without a need for submersible embankments. Groundwater potential is good, and the area is already intensively irrigated. Full flood control to permit an HYV aman crop would almost certainly require pumped drainage and is unlikely to be economic.

(c) **Sub-unit 3 (Gross area 14 000 ha, NCA 12 500 ha)**

This sub-unit has less groundwater potential than sub-unit 2, but is within relatively easy reach of a plentiful surface water supply from Ashuganj Power Station. Its flooding characteristics are similar to those of sub-unit 2.

9.3.2 Previous Studies

(i) Ashuganj and Palash Agro-Irrigation Project - Project Proforma (Bangladesh Agricultural Development Corporation (BADC), May 1990).

This Project Proforma considers the development of irrigation in the Ashuganj planning unit as a package with a similar scheme (Palash Irrigation Project) using cooling water from Ghorashal Power Station. The works within the Ashuganj area include

17 km of lined distribution channel
15 km of earthen distribution channel
20 km excavation and re-excavation of other channels
25 km of embankment
47 km of feeder roads
93 Nr syphons/sluices/regulators/bridges/culverts
300 Nr field outlets.

The total cost is given as about Tk 148 million. Part of the area was to be irrigated by gravity distribution and part by secondary lifting with LLP. The actual areas served are not specified for the individual schemes (combined Ashuganj and Palash irrigation areas - 19 830 ha), but only a portion of the planning unit appears to be covered.

(ii) Ashuganj-Sabuj Prakalpa in Thana Brahmanbaria Sadar and Sarail in the District Brahmanbaria. Project Proposal for inclusion in the 1990-91 Programme under IFAD (BWDB, September 1990).

This proposal aims to provide full flood control, drainage and irrigation to a gross area of 24 300 ha (NCA 19 500 ha), or the bulk of the planning unit. Again, cooling water from Ashuganj Power Station is to be used for irrigation, and in addition pumped drainage is provided. The proposed works include:

45 km of channel re-excavation
90 km of embankment
2 Nr drainage pump stations
78 Nr sluices/regulators/bridges

The total cost is given as about Tk 351 million.

In a later modified form of the proposals, the works have been phased. The Phase I area, serving a gross area of 8 500 ha (NCA 7 287 ha) to the south and west of the Ashuganj-Sarail-Brahmanbaria road, includes the following proposed works:

- 45 km of channel re-excavation
- 25 km of embankment
- 1 Nr drainage pump station
- 28 Nr sluices/regulators/bridges

The total cost is given as Tk 131 million.

9.3.3 Groundwater Development Potential.

No salinity constraint has been reported in this planning unit. On the basis of the studies described in Annex V, the potential for groundwater irrigation within each of the three sub-units, assuming a net irrigation requirement of 625 mm for a boro crop, is given in Table 9.1 together with the existing areas irrigated.

TABLE 9.1

Ashuganj - Groundwater Development

	Sub-Unit 1 Mode 1 (ha)	Sub-Unit 2 Mode 4 (ha)	Sub-Unit 3 Mode 2 (ha)	Total (ha)
STW/DSSTW				
Existing	0	2 172	307	2 479
Potential	855	0	424	1 279
FMTW				
Existing	0	2 596	32	2 628
Potential	0	8 429	1 646	10 075
Total				
Existing	0	4 768	339	5 107
Potential	855	8 429	2 070	11 354

Different groundwater development modes have been considered appropriate to each sub-unit. For the deeply flooded sub-unit 1 the only viable development is by STW/DSSTW and even this is considered unlikely to be realised, because of the vulnerability of the mature boro crop to flooding. Sub-unit 2 is already intensively irrigated and is dependent upon groundwater for further development. This can only occur if STW/DSSTW are phased out and DTW allowed to reach their full potential. In sub-unit 3 it is considered unlikely that farmers will invest heavily in DTW, because of the proximity of a surface water supply from Ashuganj Power Station. The combined STW/DSSTW/SMFTW mode of groundwater development is considered more appropriate here. If a surface water distribution system is constructed, groundwater irrigation may be totally superseded apart from a small area (estimated at 100 ha) which may be difficult to command by surface water, and remain dependent upon DTW.

9.3.4 Fisheries in Ashuganj Planning Unit

The Planning Unit, is important from a fisheries point of view. It has a total of about 5 000 ponds with an area of 450 ha and production of about 800 tons. Standing water and rivers are also substantial in the area; the number of full time and subsistence fishermen shows the importance of open water fishery of the area. Hatchery and nursery technologies are not as developed as elsewhere. There are three hatcheries in Brahmanbaria area and one each in Sarial and Nabinagar. The openwater capture fisheries production was not available form any secondary sources; however, if national average for the openwater production is considered the amount stands at about 14 000 tonns (DOF, 1988-89 data).

The importance of the capture fishery of the unit is emphasised by the existence of a substantial proportion of F_3 and F_4 land in the unit which allows early dispersal of fish. Such lands are adjacent to rivers, or other depressions and form part of the jalmahal which serve as the breeding and feeding grounds of the inland shallow water fish that reside in the jalmahal during the dry periods of the year.l The culture fisheries situation will be expected to change gradually with the diffusion of acquacultural technology packages related to hatchery, nursery and pond rearing methodologies, a large part of the pond areas within the genuine deeper areas would take a long time to come under culture, simply because of flood risks.

The floodplain fishery or the capture fishery in the inland water of rivers and F_3 lands has a major conflict with the cultivation of boro, as the latter must have to be harvested before the early monsoon season when most of the low lying areas are submerged and the majority of the species residing in the enclosed waters must disperse in the rivers or in the adjacent flooded areas. Under such a situation, provision of even a submersible embankment would do little to sustain flood plain fishery. The proposition of having no submersible embankment in the deeper areas of the planning unit, would add to the sustence of the existing capture fishery.

Ashugonj Sabuz Prakalpa falls in the sub-unit 3 of the Planning Unit and the proposal to use power plant cooling water for irrigation would also provide increased opportunities for culture fisheries in the area.l The very slight rise in temperature of the cooling water in the winter (five degrees C) might be of considerable benefit to fish. As irrigation water will be available throughout the dry season, the culture will be easier. The main irrigation canal can be stocked with small fish species like Tilapia and Rajpunti by partitioning the canal into small production units.

9.3.5 Project Options

The only intervention proposed is the extension of the surface irrigation system in sub-unit 3, using the cooling water from Ashuganj Power Station. Sub-units 1 and 2 would be left to natural/private development. The proposed scheme substantially follows that prepared by BADC (see section 9.3.2 above), and details of structures etc have been taken from the Project Proforma. However, the proposal to extend the area commanded by gravity distribution has been dropped, because from consultations in the field it was apparent that farmers were not prepared to give up land for the required elevated canals. It is understood that a proportion of the existing irrigated area is under gravity command, but this has been treated as served by LLP in the present analysis; since it will remain unchanged in the with and without project conditions the EIRR should not be significantly affected.

The dependable minimum cooling water discharge of 21 m^3/s is adequate for a total irrigated area of about 16 800 ha, and is therefore not a limitation. The raised temperature of the water does not seem to be a problem, with no apparent ill effects in the area presently irrigated.

The assumed irrigated areas by mode in the present, future without project and future with project conditions are given in Table 9.2.

TABLE 9.2

Ashuganj Sub-Unit 3 - Irrigated Area by Mode

Irrigation Mode	Present (ha)	Future without Project (ha)	Future with Project (ha)
Low Lift-Pump	1 717	1 717	8 670
Shallow/Deep Set Shallow Tubewell	307	424	0
Deep Tubewell	32	740	85
Traditional	1 245	1 245	1 245
Total Irrigated	3 301	4 126	10 000
Non-Irrigated	9 199	8 374	2 500
Net Cultivated Area	12 500	12 500	12 500

9.3.6 Implementation

This is a relatively small scheme (capital cost Tk 162 million) and no special phasing is necessary, apart from starting with the areas which will give the quickest benefit, nearest to the water source.

Both BADC and BWDB have prepared proposals for execution of the project but BADC is further advanced, with approval in principle from the Executive Committee for the National Economic Council (ECNEC) and the Project Proforma in the final stages of approval. BADC also has a previous involvement in the scheme. It would therefore make sense for BADC to continue its involvement, subject to government policy on its future as a project implementation agency.

9.3.7 Quantities and Costs

The engineering quantities and costs are summarised in Table 9.3

TABLE 9.3

Ashuganj Sub-Unit 3
Engineering Quantities and Costs (1991 Prices)

Item Nr	Description	Unit	Unit Rate (Tk '000)	Quantity	Capital Cost (Tk '000)	O & M % of Cap.Cost	Annual O&M Cost (Tk'000)
1	Head Regulators	Nr	3 000	2	6 000	3	180
2	Check Structures	Nr	2 000	10	20 000	3	600
3	Outlets	Nr	10	300	3 000	3	90
4	Syphons	Nr	3 000	2	6 000	3	180
5	Escapes	Nr	1 000	10	10 000	3	300
6	Minor Irrigation Channels						
	Extension Area	ha	1.2	6 730	8 076	6	485
	Existing Area	ha	0.6	3 269	1 961	6	118
7	Vehicles	Nr	1 000	5	5 000	4	550
8	Buildings			12 500	12 500	6	750
9	Land Acquisition	ha	400	100	40 000		
	Total Base Cost				112 537		3 252
	Engineering, Administration & Overhead (15%)				21 101		0
	Physical contingency 25%				28 134		813
	Total				161 772		4 065

9.3.8 Benefits

The changes in cropping pattern in sub-unit 3 resulting from the proposals are summarised in Table 9.4.

Agricultural benefits are summarised in Table 9.5

9.3.9 Economic Evaluation

The results of the economic analysis are presented in Table 9.6 The EIRR is good at 20% and the project has already been taken up for development since the draft plan report are published.

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TABLE 9.5

Summary of Cropping Pattern Changes

(% of NCA

Planning Unit 12. Ashuganj Project

Planning unit only

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus	8	8	8	2	2
T Aus, HYV	0	0	0	1	1
B Aman	24	24	23	20	20
LT Aman	10	10	10	8	8
HYV Aman	2	2	2	2	2
L Boro	7	7	8	11	11
HYV Boro	21	22	25	64	64
Wheat irrig.	1	1	1	2	2
Wheat unirrig.	3	3	3	1	1
Potato irrig.	0	0	0	0	0
Potato unirrig.	1	1	1	0	0
Jute	9	8	8	2	2
Sugarcane	0	0	0	0	0
Pulses	4	4	4	1	1
Oilseeds	12	12	11	3	3
Spices	1	1	0	0	0
Veg. irrig.	0	0	0	1	1
Veg. unirrig.	2	2	2	0	0
Total	105	106	107	120	120

TABLE 9.6

Summary of Benefits

Planning Unit 12, Ashuganj Project

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	12.5	12.5	12.5	12.5	12.5	0	0
Irrigated Area	'000 hectares	3.6	3.8	4.3	9.9	9.9	161	130
Labour Requirement	million man day	2.2	2.2	2.3	2.7	2.7	21	19
Paddy Production	'000 tonnes	27	27	30	53	53	94	80
Cropping Intensity (excluding orchard)	% NCA	105	106	107	120	120	14	12
Irrigated area	% NCA	29%	30%	34%	79%	79%	161	130
Net Crop Income	million Taka	97	98	103	153	153	55	48
Crop flood loss reduction	million Taka				0	0		
Non-agric. flood loss reduction	million Taka				0	0		
Fish catch reduction	million Taka				0	0		

Notes:

Project Year 1: assumed 1994/95

Future Without (1): Future Without Project Conditions, 5 years after project would have been completed

Future Without (2): Future Without Project Conditions, Year 30

Future With (1): Future With Project Conditions, 5 years after project completion

Future With (2): Future With Project Conditions, Year 30

% Increment (1): % difference FW (1) over FWO (1)

% Increment (2): % difference FW (2) over FWO (2)

Flood losses refer to average annual losses that will be eliminated by the project.

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TABLE 9.7

Summary of Results and Sensitivity Analyses

Planning Unit 12, Ashuganj Project

Capital cost 90.4 Tk.m. Construction period 5 years

Annual O&M cost 3.0 Tk.m. (economic prices)

Net Present Value @12% 72.13 Taka million (economic prices)

Economic Internal Rate of Return 20.27 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable						Switching Value (%)
		+10%	+25%	+50%	-10%	-25%	-50%	
Capital Costs	20.3	19.1	17.6	15.5	21.6	24.0	30.0	110.63
O&M Costs	20.3	20.1	19.9	19.6	20.4	20.6	20.9	536.57
Fisheries Losses	20.3	20.3	20.3	20.3	20.3	20.3	20.3	ERR
Reduced flood losses	20.3	20.3	20.3	20.3	20.3	20.3	20.3	ERR
Total Benefits	20.3	21.6	23.5	26.3	18.8	16.4	11.5	47.84
Incremental Net								
Crop Income	20.3	21.6	23.5	26.3	18.8	16.4	11.5	47.84
Delay in full benefits								
2 years	18.3							
4 years	17.0							
Delays in completion								
2 years	17.8							
4 years	15.9							

9.3.10 Qualitative Impacts

This is a fairly minor project with no flood control component, and the impacts are correspondingly minor. The provision of irrigation water in the dry season should have a positive impact upon capture fisheries. As elsewhere general increases in agricultural production tend to alleviate poverty and lead to enhanced property values and investment opportunities, but the landless poor do not benefit to the same extent as landholders. Qualitative impacts are summarised in Table 9.8.

TABLE 9.8

Ashuganj Sub Unit 3 - Qualitative Impacts
(Ranked from - 5to + 5)

Impact	Rating
Physical	
Morphology (erosion and sedimentation)	0
Surface Water Quality	0
Ecological	
Biodiversity - Aquatic (Non-Fish)	0
Capture Fisheries	0
Culture Fisheries	0
Socio-Economic	
Displacement	0
Social Conflicts	0
Investment Opportunities	+ 1
Income Distribution	- 1
Poverty Alleviation	+ 1
Quality of Life	
Housing and Public Buildings	0
Nutrition	0
Transport Systems	0
Public Health, Diseases and Vectors	0

9.4 Titas - Planning Unit 13

9.4.1 General Characteristics

Titas Planning Unit (Figure 9.2) is in Brahmanbaria, Nasirnagar, Sarail, Nabinagar and Akhaura thanas of the Brahmanbaria district and the Madhabpur thana of Habiganj district. The gross area is about 101 510 ha and NCA is about 90 000 ha.

A narrow strip on the eastern part of the Unit is an extension of the piedmond soil from the Tippera Hills while the western part is the deeply flooded old Meghna estuarine flood plain.

Flooding in this area is mainly from the Meghna and the Titas on the western part and flash floods from the eastern rivers like Sonai, Boalia, Lohar etc. coming from the Tippera Hills which may cause serious local flood damage, especially during the pre-monsoon periods. Two small areas on the eastern border one on the north of Akhaura and the other on the south-east of Madhabpur are flood free.

About 53% of NCA of the planning unit is now under irrigation (Table 9.9); the main mode is LLP (42%) followed by traditional (23%), STW (20%) and DTW (15%).

9.4.2 Development Opportunities

For development the planning unit may be divided into three sub-units (Figure 9.2).

i) Sub-Unit 1 Gross area 31 400 ha, NCA 28 300 ha

Sub-Unit 1 lies in the northern part of the unit in the thanas of Nabinagar and Madhabpur. Most of the area is moderately to deeply flooded (71%). The western part, west of Khasti river, suffers from the Meghna-Titas floods while the eastern part suffers from flash flood during early monsoon and mixed floods during the peak stages.

ii) Sub-Unit 2, Gross area 8 250 ha, NCA 7 400 ha.

The area is confined by the Titas in the east, south and west and the Anderson Khal in the north. The area may be further divided into two parts. The central part, confined by the railway, the Titas river and the Comilla-Brahmanbaria highway (gross area 2 420 ha) has the highest elevation. HYV boro and T aman are major crops in this area. Full flood control may be achieved utilizing the existing railway and the road embankments and construction of a new embankment on the bank of the Titas in the south. The bridges under the highway and railway would be closed and provided with drainage sluices wherever required. Re-excavation of drainage channels may also be required.

The second part (gross area 5 830 ha) lying on the periphery of the first part, is comparatively low covering moderately or deeply flooded land. Full flood control in this area may not be feasible. Partial flood control by submersible embankment may be beneficial for protecting the boro crops and to grow second crop B aman after harvesting boro.

Figure 9.2

Titas Planning Unit

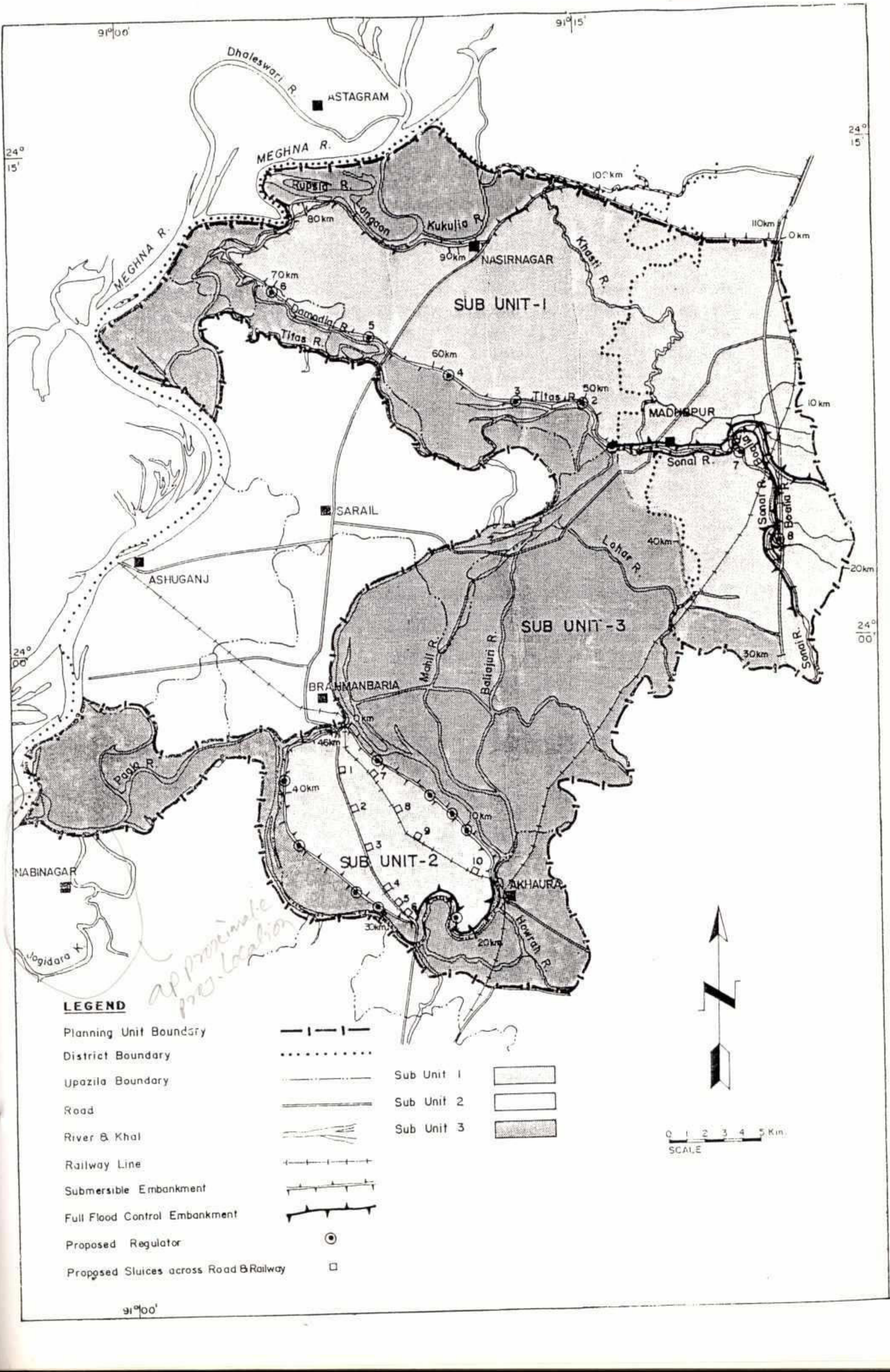

TABLE 9.9

Present Irrigated Area by Mode
(ha)

Units	Irrigation modes	F_0	F_1	F_2	F_3	Total
Sub-Unit 1						
	LLP			2 000	2 199	4 199
	STW		1 000	1 407		2 407
	DTW	1 000	408			1 408
	Traditional			1 095	2 600	3 695
	Total irrigated	1 000	1 408	4 502	4 799	11 709
	Non-irrigated	3 066	2 742	5 979	5 805	16 591
	NCA	4 066	4 150	9 481	10 604	28 300
	Gross Area	4 511	4 605	10 520	11 766	31 400
Sub-Unit 2						
	LLP			700	750	1 450
	STW		486	500		986
	DTW	500	373			873
	Traditional			423	500	923
	Total irrigated	500	859	1 623	1 250	4 232
	Non-irrigated	563	226	856	1 523	3 168
	NCA	1 063	1 085	2 479	2 773	7 400
	Gross Area	1 185	1 210	2 764	3 091	8 250
Sub-Unit 3						
	LLP			6 000	8 594	14 528
	STW		3 000	3 109		6 088
	DTW	3 000	1 852			4 849
	Traditional			3 000	3 603	6 580
	Total irrigated	3 000	4 852	12 109	12 197	32 045
	Non-irrigated	4 797	3 108	6 074	8 140	22 232
	NCA	7 797	7 960	18 183	20 337	54 277
	Gross Area	8 886	9 072	20 723	23 179	61 860
Unit Totals:						
	LLP	0	0	8 700	11 543	20 177
	STW	0	4 486	5 016	0	9 481
	DTW	4 500	2 633	0	0	7 130
	Traditional	0	0	4 518	6 703	11 198
	Total irrigated	4 500	7 119	18 234	18 246	47 986
	Non-irrigated	8 426	6 076	11 909	15 468	41 991
	NCA	12 926	13 195	30 143	33 714	89 977
	Gross Area	14 583	14 886	34 007	38 035	101 510

Source: (a) Spot Images 1989, Land Resources Inventory and AST Minor Irrigation Data 1991.

(b) SERWRDP.

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ii) **Sub-Unit 3, Gross area 61 860 ha, NCA 54 278 ha.**

A narrow strip along the Meghna and the Titas in the north of the Sub-Unit is quite low. As discussed under the Ashuganj Planning Unit, flood embankment on this deeply flooded land may not be economically feasible. On the other hand construction of any embankment may deprive the area from further natural development. The area may therefore, be left for natural development until a reasonable level is attained in course of time.

The area between the Titas and the Baliajuri rivers in the south, though low, appears to be more active. This is revealed from a comparison of the Irrigation maps of 1963 and the SPOT imagery of 1989. There appears to be significant siltation in this area. The source may be the neighbouring hills in the east. There is a number of parallel channels in this area which carry the silt from the hills in addition to the cross country flow. Any embankment in this area may have adverse effect on the natural process of land development. Therefore no FCD development in this area may be recommended unless there is adequate land development in course of time.

The area on the eastern side is comparatively high. Part of the area suffers from flash floods and the other part is the piedmond extension above flood level. It is not economic to extend any flood control measure on the large number of flashy channels to protect only a narrow strip of land in this area.

iv) **Summary**

The same comments as those made for planning unit 12 in section 9.3.1 also apply to this unit and the effects of interventions proposed by FAP 6 will require careful consideration in terms of the additional damage which could be caused to large areas of boro crops in this unit if flood levels were to rise earlier. Full flood protection from Meghna floods is unlikely to be viable in this area for the same reasons as those discussed in the previous section and for zone D in Gumti II planning unit.

9.4.3 Groundwater Development

The groundwater potential as shown in Table 9.10 appears to be encouraging though the potential for STW/DSSTW is quite low. FMTW can command about 74% of the NCA with the sub-unit variations as follows:

Sub-Unit	% of NCA
Sub-Unit 1	59%
Sub-Unit 2	77%
Sub-Unit 3	81%
Planning Unit	74%

Existing irrigated areas by sub-units are shown in Table 9.9. The total development potential by Sub-Units and thana under different mode is summarised in Table 9.10. All of the area may be commanded by the available resources (existing and future) assuming that the irrigable area is about 75% of the NCA. If the existing LLP development is taken into account over 70% of the NCA can be developed in each sub-unit without using any surface water. Since, generally, the south-east region tends to be short of water in the dry season no further surface water should be developed in this unit where groundwater is plentiful. Indeed it may be that in the future some traditional surface irrigation is replaced by groundwater systems.

TABLE 9.10

Titas Planning Unit
Groundwater Development Potential
(ha)

Sub unit	Thana	Gross Area	NCA	DSSTW	FMTW
Sub unit 1					
	Nasirnagar	16 040	14 456	3 336	10 753
	Madhabpur	15 360	13 844	2 482	12 263
	Sub-total	31 400	28 300	5 818	23 017
Sub unit 2					
	Brahmanbaria				
	Full FCD	2 420	2 148	360	2 412
	Part FCD	5 830	5 252	868	5 811
	Sub-total	8 250	7 400	1 228	8 224
Sub unit 3					
	Brahmanbaria	27 496	24 285	4 091	27 408
	Nasirnagar	12 358	10 716	2 570	8 285
	Madhabpur	4 648	3 891	751	3 711
	Sarail	6 883	6 101	1 784	7 896
	Nabinagar	5 979	5 300	1 177	6 754
	Akhaura	4 496	3 985	1 295	5 330
	Sub-total	61 860	54 278	11 669	59 384
	Unit Total:	**101 510**	**89 978**	**18 715**	**90 625**

Source: Annex V - Hydrogeology

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9.4.4 Fisheries in the Titas Planning Unit

The culture fishery is rich in this unit being represented by a total of about 17 000 ponds of about 1 600 ha. The production from pond culture is about 3 000 tonnes. The area has vast standing waters and river resources with areas covering 175 and 350 hectares respectively. Production figures from such openwaters were not available. The number of full time and subsistence fishermen are 20 000 and 66 000 respectively. There are 77 fishermen's cooperatives, 4 hatcheries and 37 nurseries. These numbers indicate that the floodplain fishery in this unit is probably as valuable and productive as that in the Gumti area or the Ashuganj unit and there would be similar problems for the development of submersible embankments.

9.4.5 Sub-Unit 1

Despite the reservations expressed in section 9.4.2 one option was tested for Sub-Unit 1. A submersible embankment along the Titas and the Meghna on the western boundary as shown in Figure 9.2. The embankment excludes the extremely low lying areas by the side of the Titas-Meghna to allow the existing uninterrupted natural process of land development and also to avoid extra height of embankment with little additional benefit. The submersible embankment would help to protect some of the boro crop from flood damage and could encourage a second crop, B aman, after harvesting boro in the moderately and deeply flooded areas. Drainage regulators would be provided on the peripheral submersible embankments.

Apart from the normal floods from the Meghna-Titas, flash floods from the prominent rivers like the Sonai and the Boalia would be controlled by embankments on both sides of the rivers as shown in Figure 9.2. Flash floods in other small rivers in this area would be controlled by improving the channel sections. Internal channels outside the flash flood area would also be re-excavated as required for the removal of excess run-off during the early monsoon (before the submergence of the embankment) and also to facilitate the late monsoon drainage.

Irrigation facilities may be extended from the groundwater sources by the privately owned tubewells, using FMTW techniques. Also as a result of the construction of the submersible embankments it would be expected that new LLPs could be developed in areas presently exposed to early flooding (F_3 land).

9.4.6 Costs

The works would compromise:

- Submersible embankment along the Meghna-Titas.

  The embankment is designed to protect the area from floods up to the end of May during 1:5 years. With an average height of 2.5 m and a total length of 51 km. The land area to be acquired would be 240 ha.

- Re-sectioning the road connecting Nasirnagar with the Dhaka-Sylhet Highway, 13 km long.

- Embankments on both sides of Sonai and Boalia rivers.

  The embankments are designed as per the EPC's proposal in their Feasibility Study Report for the Madhabpur Drainage and Flood Control Project 1986 for protection against flash floods. They will be 38 km long and designed for a flood with a return period of 20 years, 200 ha of land must be acquired.

- Drainage Regulators, (9 No).

- Channel excavation including structures.

  Allowance has been made for this work on the basis of standard costing per unit area, over a gross area of 31 400 ha.

Costs are summarised in Table 9.11.

9.4.7 Economic Evaluation Option 1

The economic analysis has been carried out using the standard method, in this case the loss due to capture fisheries has been taken as similar to that experienced in Satdona Beel (Gumti) since if submersible embankments are to be effective they will keep out fish at a critical time.

With submersible embankments there is no saving in non agricultural flood damage.

The economic analyses assumed that there were annual 15% benefits to the existing planted boro crop with submersible embankments and that about 3500 ha of additional LLPs would occur on the protected areas given the topography and the known early monsoon flood levels this seems reasonable but, as stated earlier, cannot be confirmed by the SERM in this area.

The rate of return is very poor and examination of the sensitivity and cash flows suggests that unless the FAP 6 proposals have a very significant effect on early flood levels (May) then submersible embankments will be very difficult to justify in this area.

A summary of the cropping patterns used is given in Table 9.12. Present and future irrigated area by flood phases with and without project are given in Table 9.13. The summary of benefits is given in Table 9.14. The economic sensitivity analysis is given is Table 9.15. The main features of the project are the Capital Cost, Tk 761 million, annual O&M costs of Tk 29.5 million, EIRR of -6.0% and NPV at 12% of Tk -301 million.

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TABLE 9.11

Titas Planning Unit
(Sub Unit 1)
Capital and O&M Cost (1991 Price)
(Partial FCD Scheme)

GROSS AREA : 31 400 ha
NCA : 28 300 ha

Sl Nr	Description	Unit	Unit Rate (000 Tk)	Quantity	Capital Cost (000 Tk)	% of Cap.Cost	O&M Cost (000 Tk)
1.	Submersible Embankment	km	2 275	51	116 025	10	11 603
2.	Resectioning of Embankment (1)	km	680	13	8 500	10	850
3.	Flash Flood Embankment Along Sonai-Boalia Rivers	km	1 706	42	72 334	6	4 340
4.	Regulators: [2] Size						
	Q=32 m³/s (8-1.52mxOpen)	Vent	1 600	1	12 800	3	384
	Q=21 m³/s (5-1.52mxOpen)	Vent	1 750	1	8 750	3	263
	Q=15 m³/s (3-1.52mxOpen)	Vent	2 000	3	18 000	3	540
	Q=8 m³/s (2-1.52mxOpen)	Vent	2 250	1	4 500	3	135
	Q=10 m³/s (2-1.52mx1.83m)	Vent	2 250	2	9 000	3	270
	Q=0.90 m³/s (1-0.90m Dia.)	Vent	220	1	220	3	7
5.	Excavation of Minor Khals including Structures						
	Drainage Modulus : 50mm/day	ha	1.56	18 700	29 172	6	1 750
	: 40mm/day	ha	1.30	12 700	16 510	6	991
6.	R.C.C. Road Bridge	Nr	7 080	1	7 080	3	212
7.	Railway Bridge	Nr	15 800	2	31 600	3	948
8.	Vehicles	Nr	1 000	5	5 000	4	486
9.	3 Buildings	-	-	14 150	14 150	6	849
10.	Land Acquisition	ha	400	440	176 000	-	-
	Sub-Total				529 641		23 627
	Engineering, Administration & Overhead (15%)				99 308		
	Physical contingency 25%				132 410	5 907	
	Total				**761 359**	**29 534**	

Note: [1] 30% of normal unit rate has been considered for already existing roads.

[2] (1-1.52mXOpen): Vent nos.- Width X open channel sector.
(1-1.52mX1.83m): Vent nos.- Width X Height.

TABLE 9.12

Summary of Cropping Pattern Changes

(% of NCA)

Planning Unit 13, Titas Project: Sub-unit 1

Planning unit only

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus	13	6	6	6	6
T Aus, HYV	2	3	3	3	3
B Aman	25	24	24	26	26
LT Aman	11	14	14	14	14
HYV Aman	10	12	12	12	12
L Boro	4	4	4	4	4
HYV Boro	36	51	51	61	61
Wheat irrig.	4	7	7	7	7
Wheat unirrig.	5	3	3	2	2
Potato irrig.	1	1	1	1	1
Potato unirrig.	0	0	0	0	0
Jute	6	3	3	3	3
Sugarcane	0	0	0	0	0
Pulses	5	3	3	2	2
Oilseeds	11	9	9	7	7
Spices	1	1	1	1	1
Veg. irrig.	1	1	1	1	1
Veg. unirrig.	3	1	1	1	1
Total	137	142	142	152	152

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TABLE 9.13

Distribution of Land by Flood Phase/Irrigation (ha)

Planning Unit 13, Titas Project: Sub-unit 1

Gross area 31400

Net Cultivated Area (NCA) 27534 (excluding orchards)

Land Category	F0I0	F0Ir	F1I0	F1Ir	F2I0	F2Ir	F3I0	F3Ir	All I0	All Ir	All I0+Ir
Present											
Area (ha)	2300	1000	2742	1408	4978	4502	5805	4799	15825	11709	27534
% NCA	8	4	10	5	18	16	21	17	57	43	100
Project year 1											
Area (ha)	2061	1239	2515	1635	4978	4502	5805	4799	15359	12175	27534
%NCA	7	4	9	6	18	16	21	17	56	44	100
Future Without (1)											
Area (ha)	825	2475	1038	3113	2370	7110	5805	4799	10037	17496	27534
% NCA	3	9	4	11	9	26	21	17	36	64	100
Future Without (2)											
Area (ha)	825	2475	1038	3113	2370	7110	5805	4799	10037	17496	27534
% NCA	3	9	4	11	9	26	21	17	36	64	100
Future With (1)											
Area (ha)	825	2475	1038	3113	2370	7110	2651	7953	6883	20650	27534
% NCA	3	9	4	11	9	26	10	29	25	75	100
Future With (2)											
Area (ha)	825	2475	1038	3113	2370	7110	2651	7953	6883	20650	27534
% NCA	3	9	4	11	9	26	10	29	25	75	100

Note: F0I0 land excludes orchards

TABLE 9.14

Summary of Benefits

Planning Unit 13, Titas Project: Sub-unit 1

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	27.5	27.5	27.5	27.5	27.5	0	0
Irrigated Area	'000 hectares	12.4	17.6	17.6	20.4	20.4	16	16
Labour Requirement	million man day	6.4	6.9	6.9	7.4	7.4	7	7
Paddy Production	'000 tonnes	83	101	101	127	127	26	26
Cropping Intensity (excluding orchard)	% NCA	137	142	142	152	152	7	7
Irrigated area	% NCA	45%	64%	64%	74%	74%	16	16
Net Crop Income	million Taka	312	362	362	397	397	10	10
Crop flood loss reduction	million Taka				51	51		
Non-agric. flood loss reduction	million Taka				0	0		
Fish catch reduction	million Taka				57	57		

Notes:

Project Year 1: assumed 1994/95
Future Without (1): Future Without Project Conditions, 5 years after project would have been completed
Future Without (2): Future Without Project Conditions, Year 30
Future With (1): Future With Project Conditions, 5 years after project completion
Future With (2): Future With Project Conditions, Year 30
% Increment (1): % difference FW (1) over FWO (1)
% Increment (2): % difference FW (2) over FWO (2)
Flood losses refer to average annual losses that will be eliminated by the project.

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TABLE 9.15

Summary of Results and Sensitivity Analyses

Planning Unit 13, Titas Project: Sub-unit 1

Capital cost	416.8 Tk.m.	Construction period	5 years	
Annual O&M cost	20.8 Tk.m.	(economic prices)		
Net Present Value @12%	-301.29 Taka million (economic prices)			
Economic Internal Rate of Return	-6.01 %			
Sensitivity Analyses				

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	-6.0	-6.4	-7.0	-7.8	-5.5	-4.7	-2.9	100.27
O&M Costs	-6.0	-7.8	-12.1	**	-4.6	-2.9	-0.7	325.96
Fisheries Losses	-6.0	-13.4	**	**	-2.7	0.7	4.7	117.74
Reduced flood losses	-6.0	-3.0	0.1	3.8	-11.8	**	**	134.33
Total Benefits	-6.0	-1.5	2.6	7.1	**	**	-195.9	86.70
Incremental Net Crop Income	-6.0	-3.9	-1.6	1.2	-9.2	**	**	244.52
Delay in full benefits								
2 years	-7.8							
4 years	-8.1							
Delays in completion								
2 years	-6.7							
4 years	-7.4							

** - Large Negative

9.4.8 Quantitative Impacts

A summary of the quantitative impacts is given in Table 9.16. The project stands a slight risk due to sedimentation from the rivers. Transport may be adversely effected slightly by the impediment to navigation caused by the regulators. A major adverse sociological effect will be the large area of land to be acquired which is about 1.4% of the protected area.

The experience of the Gumti Phase II study suggests that submersible embankments could have a serious impact on the culture fisheries in this area and therefore both the economic analysis and the initial environmental assessment have been revised.

Both analyses suggest that this area is not appropriate for this type of development and it is therefore not recommended. However, as already stated, once the proposals for the FAP 6 area are known, their effects in this area should be carefully examined since substantial areas or boro not presently damaged by normal or high normal floods could become vulnerable if early monsoon flood levels are increased. This could radically affect the approach to flood control in this area.

TABLE 9.16

Qualitative Impacts Planning Units 13 Option 1
(Ranked from - 5 to + 5)

Impact	Rating
Physical	
Morphology (erosion etc.)	- 1
Surface Water Quality	0
Sedimentation	- 1
Ecological	
Wetlands Reduction	- 0
Biodiversity - Crop Species	- 1
Biodiversity - Aquatic (Non-Fish)	0
Capture Fisheries	- 3
Culture Fisheries	0
Socio-Economic	
Displacement	- 2
Social Conflicts	- 2
Investment Opportunities	0
Income Distribution	- 1
Poverty Alleviation	+ 1
Quality of Life	
Housing and Public Buildings	0
Nutrition	0
Diseases and Vectors	0
Transport Systems	+ 1
Health (sewage etc)	0

CHAPTER 10

REGIONAL WATER PLAN

10.1 Introduction

In Chapter 2 the basis of the regional strategy was set out and the components for a development plan described. Chapter 3 has described the methodology used to evaluate projects and Chapter 4 presented selected criteria to be used for comparison and ranking of developments. Chapters 5 through 9 have examined a range of possible projects in each planning unit and have also examined various options for some of them. As indicated in the planning unit summaries, each project has been assessed on the basis of information available at present, and the consultants have indicated that, at feasibility study stage, optimisation of some of the selected projects could improve their economic and environmental performance.

Thus, it must be emphasised that the values presented in the report are purely for ranking purposes within the subregion where all options are judged on the basis of the same criteria as developed in Chapter 3.

10.2 Objectives and Formulation of the Plan

The Regional Water Plan aims to provide the Government of Bangladesh and potential donors with a range of developments spread throughout the region to promote improved living conditions through flood control, drainage and irrigation, increased agricultural output and enhanced incomes in a balanced programme over an extended period of time. Most of the identified components of the plan will require studies at feasibility level followed by detailed design before construction can begin. However other activities have been identified which could proceed direct to design and implementation or are ongoing programmes under existing projects.

Feasibility studies may revise the scope and priority of projects identified here and therefore the plan must be flexible to allow for changing priorities.

However the regional plan is more than just a collection of projects and it must include a number of related programmes which will allow the regional strategy described in Chapter 2 to develop.

The strategy may be summarised as follows:-

a) Improved and secure potable water supplies for the population to have the highest priority in allocation of resources

b) Systems of drainage and flood control to be appropriate to each part of the region taking into account causes of flooding and existing users (e.g. farmers, fishermen, boat operators etc.).

c) Water Resources - This is discussed in more detail later but in principal the most important aspects to keep in mind are:-

i) Groundwater resources to be promoted in areas where fresh surface water is absent and where it will be difficult to develop.

ii) Surface water systems to be developed first in those areas where it can be most cost effectively utilised. This suggests that this will initially be in those areas where good quality and cheaply available groundwater is absent or in short supply.

d) Fisheries will be developed and exploited both capture and culture both with or without the plan. However research into the capture fisheries is still at an early stage (FAP 17) and new initiatives will need to be tested before definite development proposals can be included in national or regional plans.

Culture fisheries programmes are currently receiving much attention nationally and the fisheries section of Volume 1 (Chapter 7) has indicated that they are potentially highly profitable parts of the SER are already well developed in this respect through a combination of public and private initiatives. This is expected to continue but in consumptive water use terms it is not significantly different from irrigation requirements per unit area.

The fisheries component of the plan is therefore primarily a programme of practices and policies as measures to mitigate adverse impacts and to promote increased production.

e) Irrigation development of the tertiary level is now in the private sector for all types of development. Therefore, the approach of this regional plan has been to identify schemes which allow supplies to be delivered into existing distribution systems on a least cost basis. This will need to be combined with an intensive effort to registers all water users who abstract water from these systems so that they can be equitably treated in terms of guaranteed supplies (with established water rights) and in terms of accepting a need for payment to maintain those rights.

f) Other Water Users

The preceding paragraph (e) raises the issue of water rights use and abuse. There is a need to develop comprehensive systems to identify, register, charge and control the use and abuse of water resources not only for irrigation but also for and by industrial users.

The introduction of drainage charges for beneficiaries of flood control projects is already in the early stages of development under the SRP. However it will also be necessary to develop systems for monitoring and control of industries and large communities which discharge waste to water bodies (directly or indirectly) which are subsequently used by others or which contain fish which may be consumed by the population.

These are national not regional issues but are a vital component for successful implementation of any plan.

g) Other aspects discussed briefly in this chapter include navigation and flood proofing.

i) Navigation is generally tested as an impact for proposed interventions so that other sectors benefitting impose the minimum interference to important navigation routes. Where flood control or drainage makes land flood free then alternative transport systems (roads) will be consequently improved.

ii) Flood proofing is again a national rather than a regional consideration but it has been specifically considered where proposed interventions could cause other areas to be adversely impacted in terms of flooding.

The following sections of this chapter describe the ranking of interventions identified costed and evaluated in Chapters 5 through 9.

This ranking is discussed and refined in terms of a number of measured and subjective factors as follows:

- regional balance
- environment
- economics
- financial
- social equity
- sustainability

The regional water resources consequences of the various proposals are then examined and a tentative prioritisation and programming of project interventions and other complementary and supplementary policies and programmes is presented.

10.3 Project Ranking

The projects have been evaluated on the basis of the criteria identified in Chapter 4 and evaluated in Chapters 5 to 9. The results of these evaluations are now brought together in order to compile and rank projects on the basis of these results. The comparison for ranking is shown in Table 10.1, for both quantitative and qualitative criteria.

The consultants have substantially revised and improved the methodology for evaluation for the various options considered and they generally show better economic returns than previously. The principal reasons for this are as follows:

i) Although full economic account of fisheries loss was previously considered for each project it is now a value net of the cost of catching the fish and an attempt has been made to estimate disbenefit according to degree of obstruction and reduction of floodplain areas.

ii) all irrigated crop benefits are included (not only boro) and boro yields are higher as a result of the substantial primary data collection programme for two feasibility studies.

TABLE 10.1

Evaluated Project Interventions for Ranking

Planning unit - Ref		1	2		3&5	4,5,8&(9)			6	7		8			11				12	13	DTW
Proposal Description		Ramgat	South Sudhara		Noakhali	Dakatia-Little Feni Transfe			CIP	Meghna Dhonagoda		Dhonagoda			Gumti Phase II				Ashuganj	Titas	
		Irr	Dr	Dr	North	Irr 1	Irr 1+2	Reg	Embkmt	Embkmt	Distrib	FCD	FCD	Khals	Polder FCD	Embkmt	Khals	PolderI&D	Sub-	Sub-	
	Units		1	2	D&I	1	2	3	1	1	2	1	2	3	A (1&2)	B (3)	C (6)	D (4)	Unit 3	Unit 1	(i)
1 Economic criteria																					
Economic Internal Rate of Return	%	13.8	16.9	10.4	18.1	11.3	11.4	17.6	78.0	60.8	16.5	10.7	15.9	89.0	14.9	23.8	27.9	18.3	20.3	(6.0)	27.1
Net present value at 12 %	Tk m	36.0	190.7	(37.0)	851.0	(32.0)	(42.9)	114.8	0.0	815.9	3.7	(26.5)	56.7	113.6	46.8	6665.0	36633.0	157.8	72.1	(301)	0.2
EIRR for 25% increase in capital cost	%	11.6	14.4	8.5	15.6	9.3	9.4	14.8	65.0	54.5	13.3	8.8	13.6	78.2	12.3	19.1	22.1	15.6	17.6	(6.4)	20.7
EIRR for 25% increase in O&M cost	%	13.1	16.3	9.6	17.7	10.6	10.5	17.3	64.0	59.5	16.3	10.3	15.5	88.4	14.3	23.1	27.2	17.2	19.9	(7.8)	22.0
EIRR for 25% increase in fish loss	%	13.6	16.0	9.7	17.4	11.3	11.4	16.6	78.0	56.4	16.5	8.0	13.7	89.0	12.6	24.0	28.0	17.7	20.3	-ve	27.1
EIRR for 25% decrease in total benefit	%	9.9	12.2	6.2	13.7	7.9	7.8	12.6	46.0	45.4	12.2	4.6	9.9	74.7	8.4	17.2	-	12.8	16.4	-ve	13.4
EIRR for 25% decrease in incremental net crop income	%	10.6	16.1	9.6	14.1	7.9	7.8	15.4	51.0	48.7	12.2	8.9	14.2	74.7	11.0	17.2	-	13.1	16.4	-ve	13.4
EIRR for 25% increase in total benefit	%	17.0	20.7	13.7	21.7	13.9	14.2	21.9	0.0	71.8	20.4	15.1	20.5	101.6	20.2	29.9	-	22.9	23.5	1.8	39.7
2 Quantitive criteria																					
Increase in farm employment	Man-day (m)	0.9	0.0	0.0	3.4	1.1	2.1	0.7	n.a.	n.a.	n.a.	0.8	0.6	0.3	0.1	0.0	0.0	0.8	0.4	0.5	0.0
Increase in paddy production	T (000)	40	11.0	11	112	47	76	18	n.a	n.a.	n.a.	17	14	9	16	0.5	0	48	23	26	0.1
Reduction in capture fishery	Tk m	5.0	13.0	13	51	0	0	15	n.a.	n.a.	n.a.	45	30	0	32	0	0	16	0	57	0
Regional population benefitted.	(000)	84	847	847	2,312	1,650	2,880	1,180	806	257	257	1,579	1,449	175	387	18	149	287	94	316	n.a.
Land Acquisition	ha	68	47	77	76	27	48	66	49	16	0	70	12	0	137	8	0	46	100	440	0
3 Qualitative Criteria																					
Physical Environment																					
Sea level rise		1	2	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Morphology and sedimentation		-2	-3	-2	3	0	0	2	1	-2	-2	-2	0	0	2	1	1	1	0	0	0
Surface water quality		1	1	1	1	-1	-1	2	0	-1	0	0	0	0	-2	0	0	-1	0	0	0
Cyclones		1	2	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Salinity		1	2	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecological																					
Wetlands reduction		0	0	0	0	0	0	-3	0	-2	-1	0	0	0	-1	0	0	-1	0	-2	0
Biodiversity - crop species		-1	0	0	-2	-1	-1	-1	-1	-1	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1
Biodiversity - aquatic species (non-fish)		0	-1	-1	-2	0	0	0	-1	-1	0	0	0	0	-1	0	0	-2	0	-1	0
Capture fisheries		-2	-3	-3	-3	1	1	-2	1	-2	0	-4	-3	0	-3	0	0	-5	-1	-4	0
Culture fisheries.		1	1	1	1	1	1	2	0	1	0	0	0	1	1	1	1	1	1	0	1
Socio-Economic																					
Displacement		-2	-1	-1	-1	-1	-1	-1	-2	-2	0	-2	0	0	-1	-2	0	-3	-1	-3	0
Social conflicts		-3	-2	-2	0	0	0	0	-1	-2	0	0	-1	0	-1	-1	0	-1	0	-2	0
Investment opportunities		1	1	1	1	1	1	1	1	1	0	1	1	1	2	2	1	2	1	0	1
Income distribution		-1	-2	-2	-1	-1	-1	-1	1	1	1	-1	-1	-1	-1	0	-1	-1	0	-1	-1
Poverty alleviation		1	0	0	2	1	1	2	2	2	1	1	1	1	1	1	1	2	2	1	1
Quality of Life																					
Housing and public buildings		0	1	1	1	0	0	1	1	1	0	1	0	0	1	1	0	1	0	0	0
Nutrition		1	1	1	-1	-1	-1	1	1	0	0	0	0	0	-1	0	0	-1	-1	-1	0
Transport systems		0	1	1	1	-1	-1	0	0	-1	0	1	1	0	1	0	0	1	0	0	0
Health, diseases & vectors		1	0	0	-1	-1	-1	0	0	2	0	0	0	-1	-1	0	-1	-1	0	0	0
4 Financial																					
Capital cost	Tk m	383	296	493	1,261	839	1,324	363	63	202	18	395	237	12	385	16	69	323	162	761	0.4
O & M cost	Tk m	13.0	11.5	20.5	39.6	27.2	50.2	5.6	31.1	36.9	0.2	7.7	6.7	0.6	12.1	0.4	2.1	36.5	4.1	29.5	0.1

Note (i) Analysed for single 2-cusec DTW irrigating 24 ha of F1 land

Key to impacts	Nil	Minor	Notable	Major	Serious	Critical
Positive	0	1	2	3	4	5
Negative	0	-1	-2	-3	-4	-5

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iii) In appropriate circumstances without project yields are decreased for certain crops to allow for improvements in conditions directly resulting from a project intervention. This effectively gives different yields for with and without project conditions. In every case this has been identified in the analysis of each particular option. This is one reason why, all options considered for the final plan still appear in this volume.

The consultants were also criticised by one commentator for first sorting projects by economic criteria before considering the qualitative criteria but this is maintained for two reasons:

i) if a project has a very poor rate of return it will be unlikely to attract financial backing in which case the arguments for or against it on qualitative grounds become somewhat academic.

ii) Where commentators disagree with the economic rankings all the other parameters can be seen together and planners and decision makers can make up their own minds by refering back to the detailed evaluations to examine the sensitivity analyses and by examining Annex VIII they can view the different values of each item in the cash flow.

At this level of planning and analyses the qualitative criteria cannot be examined in detail but the consultants have tried to be as objective and consistent as possible in their treatment of options considered. No doubt there will be many other presentations which could be identified for some areas but the consultants believe that they have been able to identify the principal viable options.

Apart from the two areas already studied at feasibility level it has not ben possible to optimise costs or benefits of the schemes proposed for development. Both the feasibility studies have identified how in depth study and effective use of modelling techniques can produce improved rates of return compared with prefeasibility level studies.

For this reason the projects have been divided into two economic categories as follows:

i) Projects having a base case EIRR in excess of 12%

ii) Projects having a base case EIRR of less than 12% but greater than 9%.

Projects having returns of less than 9% have not been considered for ranking.

All projects are then compared in the light of their qualitative ranking to see if environmental aspects were significantly different for projects in the same priority classification. It should be noted here that projects which had severe environmental problems have been amended, if possible, during project evaluation to minimise such effects. However, many project options have regressive tendencies in terms of social equity or fisheries impact and this has been pointed out in the analyses..

Table 10.1 shows that there are 15 proposed projects or components with a base rate of return which exceeds 12% on present assumptions.

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Amongst there are a number of quite small components which are either already in the process of implementation or could be started quite quickly using funding sources already available (Group 1).

There are also a number of proposals which, whilst they require more time for implementation to allow for final planning and design stages, are nevertheless sufficiently well advanced and studied to be able to recommend them for implementation (Group 2).

The third group of projects comprise those which are: either a) marginal (9-12%) economically or b) there are definite concerns about environmental, social, or sustainability issues.

This later group include projects with quite good rates of return and if these are taken forward for further study such issues will require particular attention.

10.3.1 Group 1 Proposals

This group includes the following eight proposals.

- Planning Unit 6, Chandpur Irrigation Project, Retirement of embankment at Hanarchar and rehabilitation of the system. This is to be done under the Systems Rehabilitation Project.

- Planning Unit 7, Meghna Dhonagoda Irrigation Project (MDIP), Retirement of embankment, strengthening of eastern embankment and provision of navigation locks (or roads). This work is urgent and should proceed directly to the design stage.

- Planning Unit 7, MDIP, Rehabilitation of internal canals. This should be done as soon as possible to realise full benefits of the existing project, and it may be combined with the retirement of the embankment.

- Groundwater Development. Both STW and FMTW are economically viable and should be developed. This is to be one of the components to be supported by the NMIDP. This component can commence throughout most of the study area and in general is not dependant on other projects. However further studies are required for the southern part of the region and this is discussed later.

- Dhonagoda Khal Deepening (Option 3). This component could either be financial through the FFW programme or by extension / development of the Model Rural Development Plan (presently Japanese Funded). The proposals are described in Chapter 7.

- Similar Khal deepening programmes could be developed in Gumti Phase I area if the structural arrangements at Siddeswari regulator are satisfactory and possibly also in part of Ashuganj and Titas planning units. The latter would require survey work for confirmation since there is no data available within the SERM.

- Ashuganj Irrigation. It is understood that this project has already been taken up for development and therefore it is included in this group of proposals.

- Gumti Phase II khal deepening (Scheme C, intervention 6). Once again this intervention can be seen to be highly attractive even in competition with STW development and is a clear indicator of where surface water schemes could take preference. Again this scheme could be financed either through FFW programmes or through extension of the Japanese funded scheme which is already involved in this area (see chapter 8).

- Gumti Phase II Submersible Embankment. This relatively inexpensive proposal has clear benefits and is recommended for early implementation. It sensibly completes the Gumti right embankment as far as the Homna road embankment (See Chapter 8).

10.3.2 Group 2 Proposals

This group comprises two proposals which have been studied at feasibility level. These proposal are:

- The Noakhali North Drainage and Irrigation Project as described in Chapter 6.

- The Gumti Phase II Scheme A- interventions 1A, 1B and 2 which are described in Chapter 8.

Although they do have some negative effects, particularly as concerns fisheries impacts, they are nevertheless recommended to go forward for the next planning stage which should include the recommended additional surveys, studies and designs as set out in the feasibility studies. Draft terms of reference for the additional studies are included in Appendix H to the NNDIP study.

10.3.3 Group 3 Proposals.

This group comprises proposals for the following five areas:

- Planning Unit 1, polder 59/1a.

- Planning Unit 2, polder 59/3a 3b and 3c

- Dakatia / Little Feni Transfer (3 options) in planning units 3,4,8 and 9.

- Planning Unit 8, Dhonogoda flood control.

- Gumti Phase II scheme D intervention 4 which is an FCDI polder scheme involving pumped drainage.

All these schemes require further study at feasibility level before they can go forward for development and all except two of the Dakatia-Little Feni transfer options have environmental or social and sustainability concerns.

Because it has few of these concerns the Dakatia-Little Feni Transfer proposal has been singled out for further study as a matter of priority.

Although options 1 and 2 as described in section 3 of chapter 7 show marginal rates of return these are based on several quite conservative assumptions which suggest that, like the NNDIP scheme at the time of the draft regional plan report, there are strong possibilities for improvement of the rate of return through optimisation at the feasibility study stage when more data would be available which could quantify the possibilities concerning drainage improvements in the Sonaichari and Little Feni areas. In addition careful consideration could be needed in optimal sizing of the Dakatia regulator and at the regional planning level no account has been taken of any possible non-agricultural benefits which might accrue from using the structure to exclude exceptional high floods as to prove such benefits requires more detailed analysis than was possible at this stage.

Dakatia-Little Feni option 3 shows a good rate of return but needs further study to prove that it is sustainable in terms of downstream changes in sedimentation (although the consultants believe it to be so) ,and FAP 5B proposals could be critical in this respect.

The other four areas in this group all require further study and in some cases (planning units 1 and 2 particularly need to be considered in the context of FAP 5B findings and proposals and studies for these therefore, are scheduled slightly later.

Dhonogoda option 2 is preferred to option 1 both on environmental and economic grounds but would seem to provide protection from severe floods to a large area at a relatively low cost.

However, the fisheries aspect requires careful evaluation to ensure that the disbenefits are not likely to be more severe than estimated at the regional planning stage.

The Gumti Phase II scheme C polder scheme could also provide good benefits but it is in an environmentally sensitive area (fisheries) and there is the possibility of alternative modes of development (groundwater). It is therefore, sensible to delay this proposal to a later date.

10.4 Programming Criteria

Having selected a number of schemes for definite or possible inclusion in the plan it is necessary to consider how these projects might be scheduled to provide the Government of Bangladesh with a balanced programme and also one which allows the maximum flexibility for the later part of the programme. This flexibility is especially necessary when the environmental sensitivity of many of the possible development projects is taken into account and the outcome of future feasibility studies is uncertain. It is therefore important to identify the major factors which may have a bearing on the scheduling of projects.

There are three considerations to be taken into account:

- Financing
- Implementation capacity of BWDB
- Surface water allocations within the country and within the region.

10.4.1 Financing

One of the objectives of the FAP is to enable choices to be made between competing water resources development projects and programmes for different parts of Bangladesh, in accordance with their relative technical and economic viability. Until such time as the project pre-feasibility studies for all regions are complete, it is impossible to judge the priority which should be attached to projects in the south-east region, relative to competing projects elsewhere. However, for the purposes of this study it necessary to estimate the likely scale of public sector finance which might be available for projects in the south-east region, for comparison with the possible requirements for particular projects, or groups of projects. This has been investigated in Chapter 2, Section 2.2.2, and indicates a level of expenditure of about Tk 550 to 600 million per year (1991 prices) from about 1994 onwards. As has been pointed out, this estimate is necessarily arbitrary, but has been used as a guideline.

10.4.2 Implementation Capacity of BWDB

The implementation capacity of BWDB could to be improved but the scale of activity planned for the SER is based on recent findings with respect to investment and should not lead to a substantial increase in the planned rate of expenditure. There is a considerable need to improve the performance of some sections BWDB, but it is hoped that the comments on implementation experience given in Chapter 10 Part 1 of this report will be of some assistance. The capacity of BWDB will be tested not by developments in the SER but rather by the combined scope of projects on a national basis. This cannot be assessed by this study.

10.4.3 Regional Water Resources

As described in Chapter 2 of this report the primary physical constraint to irrigation development is the availability of water in the critical month of March which has the highest water demands and lower quantities available in the rivers and khals of the region.

The consultants have attempted to maximise the utilisation of available resources by recommending the development of substantial areas by the groundwater modes of STWs and FMTWs whilst acknowledging that there are practical problems which may limit this development below its theoretical potential. This constraint has been applied to a number of planning units as explained in chapters 5 through 9. The water resources implications of the present state of development and how surface resources would be utilised in the event that all components of the plan were implemented are shown in Table 10.2.

The consultants have taken note of, but not been restricted by the National Water Plan allocation of 204 m^3/s for the SER in March because at this stage of planning and when all regions of the country are being reassessed for their potential it is considered prudent merely to indicate the amounts which would be required if certain levels of development occur whether or not any particular allocation is exceeded. When the results of all the regional plans are available then a review of the allocations can be undertaken.

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a) **Groundwater**

The plan assumes a total increment in groundwater irrigation of approximately 49 800 ha. This total is spread throughout most of the region as shown in Table 10.3 below except in the coastal region, where a potential resource has been identified and it is recommended that under the plan this resource should be investigated to assess its potential and spatial extent. Primarily this will be for the planning units 1 and 2.

All the groundwater has been assumed to be developed by the private sector and therefore no cost would be borne by the Government. However if the most efficient use of water resources is to be achieved then FMTW technology will need to be encouraged and this may require some limited subsidy for FMTW to make them competitive with STWs. If this does not happen the groundwater resources will be under utilised and this would result in increased demand for surface water systems which are totally subsidised. This would place a greater burden on the Government's financial resources. Thus it appears that the presently proposed financial arrangements may produce both an inefficient utilisation of water resources and of available financial resources.

The consultants proposals have accepted some limitations on FMTW groundwater development but also anticipate a satisfactory resolution of this issue within the plan period. The smaller 0.5 or 1.0 cusec FMTWs proposed for the plan require no greater areas to be served than for many LLPs so the social problems associated with the old larger DTWs of 2 cusec capacity will be greatly diminished. Also the more competitively priced shallow FMTWs proposed look to be more competitive in price per ha with STWs and are more reliable since they will not run dry. However the initial investment is still much higher so credit could become a serious constraint to this type of development.

The proposal evaluations in chapters 5 and 6 have identified the need to introduce some degree of control over deep groundwater development in the southern part of the region so that the available resources can be reserved for those purposes and areas which are considered to have the highest priority.

As described in Chapter 2 the highest priority must be given to domestic water supply and it is expected that most of this will come from groundwater. Indeed all the groundwater calculations have been based on the assumption that all such requirements are met from the groundwater resource in the future and the resources stated to be available for irrigation are estimated net of water supply requirements.

However in planning units 1,2 and the southern parts of units 3 and 4 there are areas where development of groundwater is difficult and the extent of the saline-free deep aquifer needs to be better defined. Also it must be ensured that sufficient water from this resource is reserved for potable water supply so this may require a limit to be imposed on the areas developed for irrigation from this aquifer. At the present time such development is unlicensed and uncontrolled. Availability of potable water supplies have improved considerably in the last 10 years, in the one district for which the 1991 census data were available (Noakhali), and this programme will continue but the consultants consider that uncontrolled development of groundwater in this area should cease and a licensing system should be introduced.

TABLE 10.2

Planned Projects - Summary of Water Resources Demands

Ref No / Planning Unit	Net Cultivated Area (NCA)	Potential Irrigated Area Total 75% of NCA (i)	Potential Area Irrigable by Ground water	STW	FMTW	Balance needing Surface Water Irrigation (ii)	Net Surface Water Req.	Present Irrigated Area Total	Present Irrigated Area Ground water	Present Irrigated Area Surface	Future Irrigated Area without project (FWO) Total	FWO Ground water	FWO Surface	Planned Irrigated Area Total	Planned Ground water	Planned Surface New	Planned Surface FWO	Proposed Irrigation Percent of Potential Total	Proposed Irrigation Percent of Potential Ground water	Existing Gross Surface Water Req.	Existing Meghna Surface Water Req.	Future Gross Surface Water Req.	Future Meghna Surface Water Req.
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	m3/s	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(%)	(%)	m3/s	m3/s	m3/s	m3/s
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1 Polder 59/2 (iii)	26,500	19,875	0			19,875	27							8,500		8,500		43	0			11	11
2 South Sudharam (i	89,600	67,200	36			67,164	91	1,594	36	1,558	1,594	36	1,558	1,594	36		1,558	2	100	2		2	
3 Noakhali North	74,500	55,875	2,727	877	1,850	53,148	72	25,833	1,727	24,106	26,833	2,727	24,106	45,342	2,727	18,509	24,106	81	100	31	7	55	37
4 Little Feni (iv)	80,200	60,150	25,883	2,586	23,297	34,267	46	18,839	9,410	9,429	29,858	20,429	9,429	57,135	17,429	8,501	9,429	95	67	12		23	23
5 Dakatia	68,500	51,375	13,750	5,100	8,650	37,625	51	22,946	7,903	15,043	28,793	13,750	15,043	36,835	13,750	8,042	15,043	72	100	20	10	30	25
6 Chandpur	39,750	29,813	219			29,594	40	23,132	219	22,913	23,132	219	22,913	23,132	219		22,913	78	100	30	30	30	30
7 Meghna Dhonago	13,450	13,440	0			13,440	18	13,440		13,440	13,440		13,440	13,440			13,440	100	0	17	17	17	17
8 Dhonagoda (iv)	88,050	66,038	25,873	9,572	16,301	40,165	54	31,026	14,635	16,391	39,244	22,853	16,391	42,264	21,853	4,020	16,391	64	84	21	10	27	16
9 Sonaichari	15,950	11,165	11,165	2,346	8,819			9,757	8,022	1,735	10,425	8,690	1,735	11,960	8,690	1,535	1,735	100	78	2		4	
10 Gumti Phase I	26,150	18,305	8,483	5,105	3,378	9,822	13	8,500	4,666	3,834	12,316	8,482	3,834	13,316	8,482	1,000	3,834	73	100	5	4	6	5
11 Gumti Phase II	122,150	91,613	91,615	37,200	54,415			60,980	26,317	34,663	83,085	48,422	34,663	83,085	38,422	10,000	34,663	91	42	45	34	58	47
12 Ashuganj	25,900	20,720	11,354	1,279	10,075	9,366	13	14,767	5,108	9,659	14,767	5,108	9,659	19,681	5,054	4,968	9,659	95	45	13	13	19	19
13 Titas	90,000	67,500	32,833		32,833	34,667	47	47,987	16,611	31,376	56,200	24,824	31,376	56,200	24,824		31,376	83	76	41	41	41	41
Other areas (v)	18,200	13,650	4,073	4,073		9,577	13	7,251	1,098	6,153	10,226	4,073	6,153	10,226	4,073		6,153	75	100	8	8	8	8
Sub-total	778,900	586,718	228,011	68,138	159,618	358,709	484	286,052	95,752	190,300	349,913	159,613	190,300	422,710	145,559	65,075	190,300	72	64	247	174	332	279
Muhuri transfer (vi)		14,950				14,950	20									9,500		n.a.	n.a.			12	12
Total	778,900	601,663	228,011	68,138	159,618	373,659	504	286,052	95,752	190,300	349,913	159,613	190,300	422,710	145,559	74,575	190,300	72	64	247	174	344	291

Notes

(i) Potential area estimated as 75% of NCA except for Meghna Dhonagoda and Ashuganj

(ii) Potential area irrigated by surface water calculated from total potential area less groundwater potential

(iii) Groundwater potential requires investigation

(iv) Includes area between Kazirhhat and Musapur

(v) These areas are near the Meghna and Lower Meghna rivers

(vi) Muhuri additional irrigation area assumes gross crop water reqirement of 1.30 l/s/ha

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TABLE 10.3

Estimated Groundwater Development Potential

	Planning Unit	STW/DSSTW	FMTW	Total
1.	Polder 59/2	0	0	0
2.	South Sudharam	0	0	0
3.	Noakhali North	0	1000	1 000
4.	Little Feni River	0	8 020 *	8 020
5.	Dakatia	2 395	3 405	5 850
6.	Chandpur	0	0	0
7.	Meghna Dhonagoda	0	0	0
8.	Dhonagoda	3 715	3 505 *	7 220
9.	Sonaichari	0	670	670
10.	Gumti I	3 115	705	3 820
11.	Gumti II	5 100	7 000 *	12 100
12.	Ashuganj	- 50	0	- 50
13.	Titas	4 100	4 110 *	8 210
14.	Other Areas	2 970	-	2 970
	Total	21 345	28 466	49 810

*FMTW development constrained below theoretical potential.

b) Surface Water

Table 10.2 has identified a possible total additional 74,575 ha of surface water irrigation

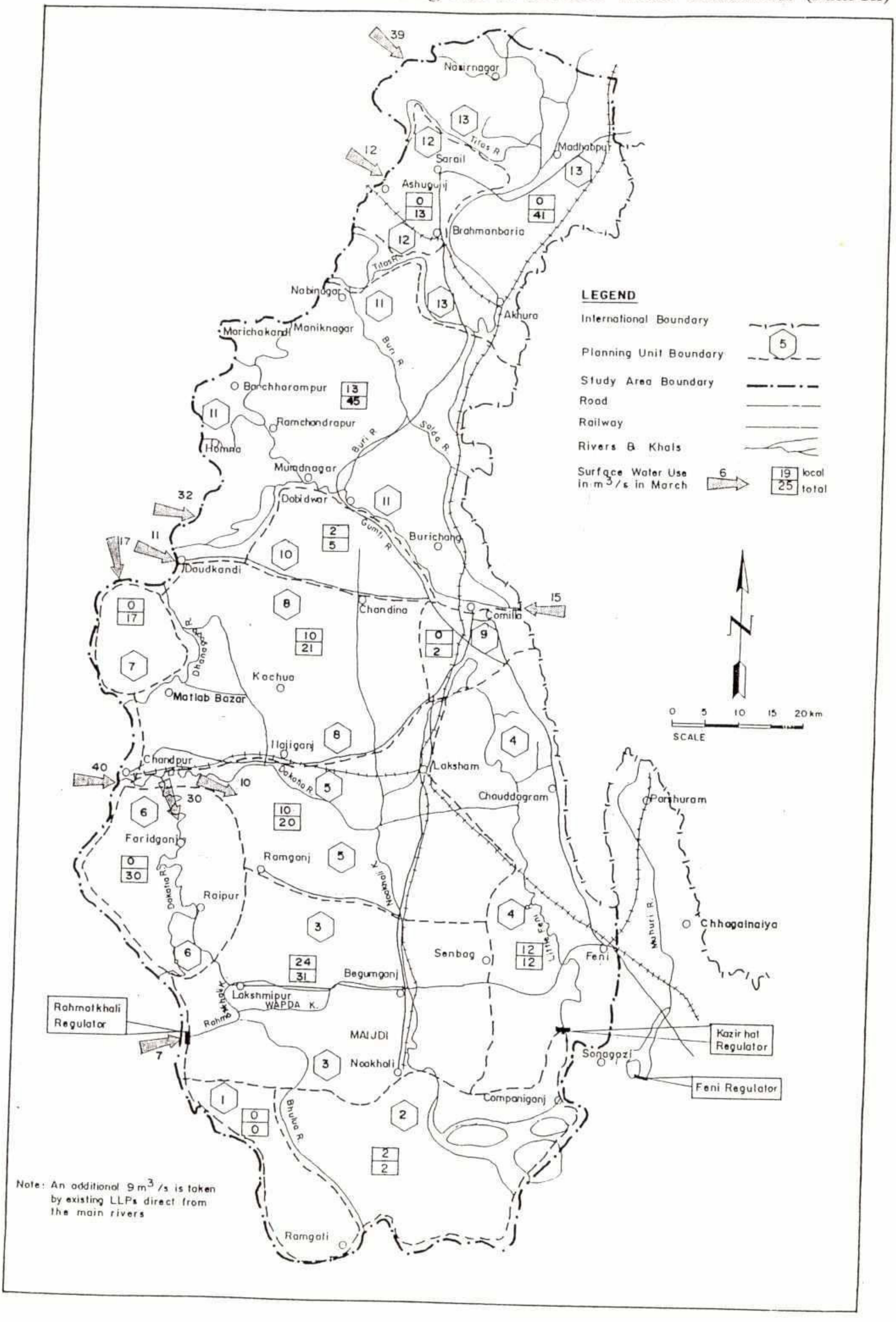
The existing utilisation of surface water resources is shown in columns 21 and 22 of Table 10.2. The difference between the two columns is the total presently utilised from tributaries such as the Gumti river and/or taken from locally stored rainfall. The distribution of present surface water resources is shown Figure 10.1.

All surface water requirements are based on a peak crop water requirement of 1.3 l/s/ha. This is less than that used for the NNDIP study but overall resource use is estimated to be less than design figures for individual projects.

The planned future utilisation of surface water is shown in columns 23 and 24 of Table 10.2 and the difference is again the locally available water. However it should be noted that in this case the locally available resources are diminished. This is because the more efficient drainage schemes in unit 3 and 5 (Noakhali North and Dakatia) will have removed some of the water which is currently stored on flooded land and used for local

Figure 10.1

Existing Use of Surface Water Resources (March)



irrigation. Thus in the "with plan" situation all the water required for the area of irrigation of Noakhali North served by the newly excavated khals and some of that for Dakatia/Little Feni transfer will have to be provided from the Lower Meghna. The distribution of planned future surface water resources is shown in Figure 10.2.

The total surface water requirement from the Lower Meghna if the full development is realised would be 279 m^3/s compared with a present requirement of 176 m^3/s. Even if only the present Noakhali North drainage and irrigation plus Ashuganj and khal deepening programmes were implemented the requirement would be increased to 230 m^3/s.

It is anticipated that over the plan period re-evaluation of proposals for, Dakatia and Little Feni will substantially increase this total requirement close to that suggested in Table 10.2. This total is much larger than was allocated to this region in the National Water Plan and thus priorities between regions and perhaps within the Region will have to be decided.

The prioritisation of projects between regions cannot be done by this report but some considerations could be given for prioritisation within the region.

It is considered that first priority should be given to schemes which require no primary pumping. In this plan the projects identified would be the khal deepening programmes in Dhonagoda, and Gumti II, the scheme in Noakhali North and the Ashuganj project Even these schemes would raise the Meghna water requirement to about 230 m^3/See.

However this would leave planning units 1 and 4 (Little Feni) without much prospect of further agricultural development given the groundwater constraints.

This report has also identified that an efficient transfer system could provide water for up to 9 500 ha of additional irrigation to the Muhuri catchment if the Dakatia-Little Feni transfer scheme were to be developed and a feasibility study for this scheme combined with study of the drainage problems of the Sonaichari, Dakatia and Little Feni catchments is proposed.

It is clear that unless the water allocation for the South East Region can be increased from that provided in the National Water Plan that difficult decisions will be required and that some areas within the region would suffer retarded development as a result.

10.5 Plan Formulation

The plan does not seek to place the various proposals in a definite order of priority.

It does include a number of proposals which are not included in this study but which nevertheless are concerned with the South East Region and therefore have an impact on the regional development of water resources. The plan includes eight proposals or projects which are concerned with Flood control, erosion and / or drainage, seven proposals concerning surface irrigation, and regional proposals for development of groundwater.

Figure 10.2

Maximum Planned Use of Surface Water Resources (March)

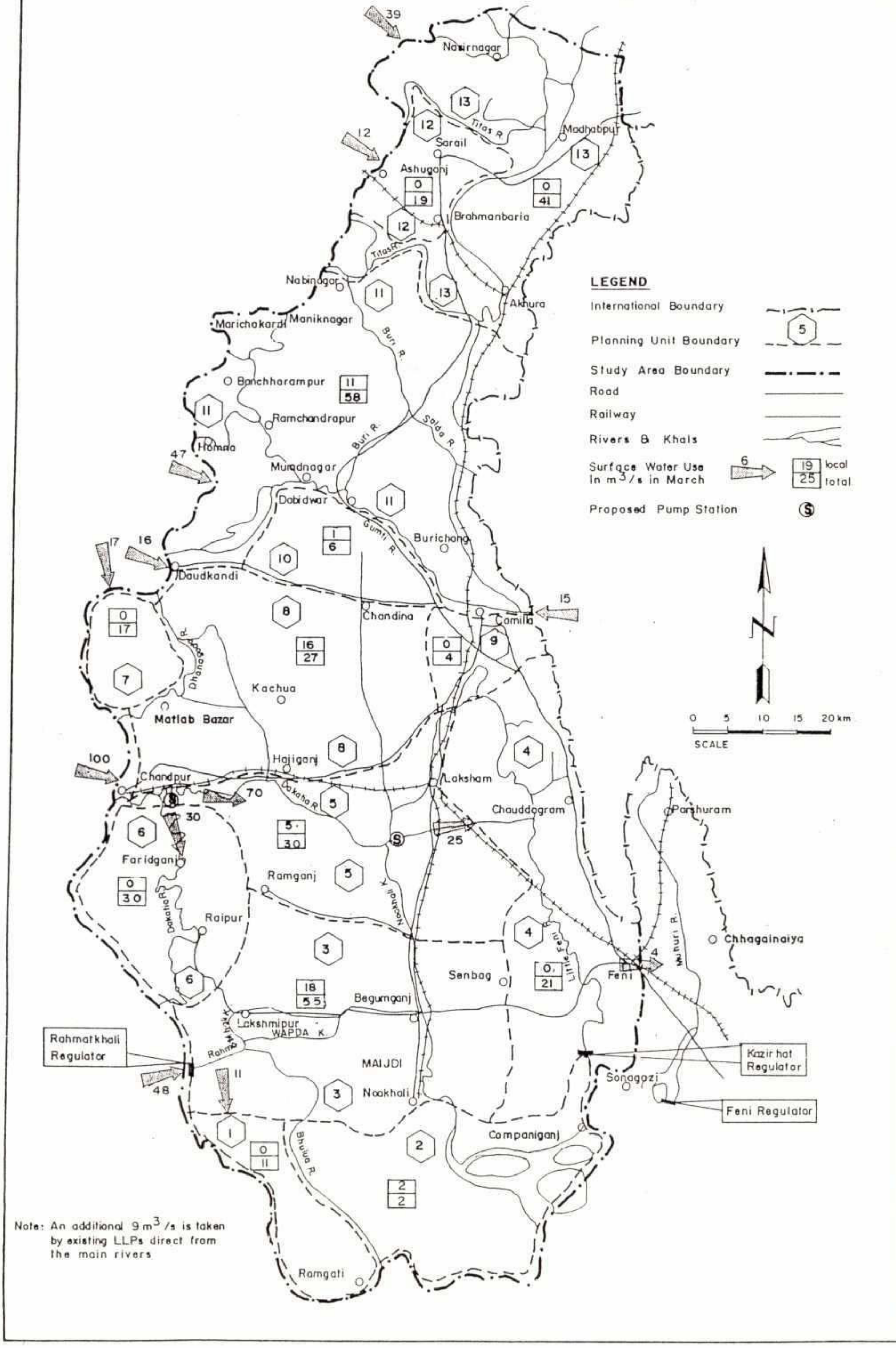
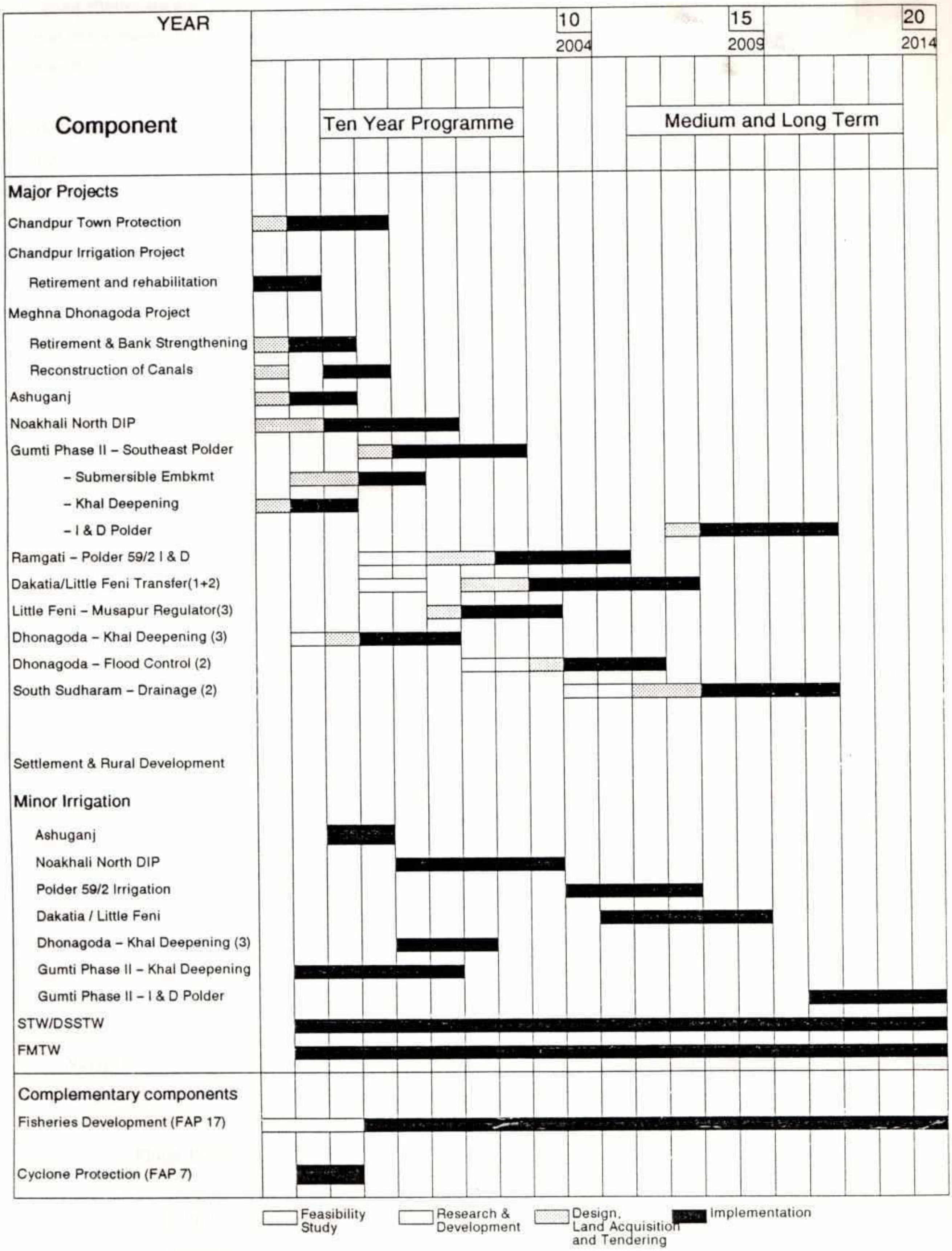


Figure 10.3

Regional Water Plan



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Two major studies are also proposed and both are concerned with improved water resource exploitation although one also has a major drainage component. All parts of the region are included in the plan under at least one component.

The plan gives priority to the rehabilitation and improvement of existing schemes this not only serves to protect existing investments but should lead to greater confidence of the people of the area that future projects will be maintained. Also such projects usually offer good returns to the investments made.

Development within the region will be a dynamic process. Both external and internal conditions are constantly changing and the relative merits of different modes of development will also change. The development plan must accommodate this dynamism and must be changed to take account of changing circumstances.

The plan developed here should allow this quite easily since, with one exception, there are no very large single stage proposals in the plan which generally comprises relatively small scale investments which will form the building blocks of regional water resources development and can be rearranged according to need since few of them are interdependent.

The outline plan is shown in Figure 10.3 and shows structural and complementary components which are discussed in the next section.

10.6 Complementary Components of Regional Development

There are a number of components and policies which will needed to be coordinated with the development of structural interventions and some of these will have their own structural measures. These are discussed in the following sections of this chapter.

However there is one aspect which is considered sufficiently important to merit separate chapters and the final two chapters of this report describe the ongoing requirement for environmental management and mitigation planning and the need for monitoring, training and future studies.

The components discussed in this chapter are:

- Floodproofing
- Fisheries
- Navigation
- Peoples Participation

10.7 Flood Proofing

The main alternative to full flood control schemes is known as flood proofing. The principals of and approach to flood proofing are described in Chapter 2 of this report and they are not repeated here.

Many provisions are already taken by most people and institutions and a normal flood does little or no damage, it is the exceptional floods which cause serious damage. Most houses are built above normal flood level and people already take simple precautions such as sealing earthen pots containing rice so that it will not be damaged. Other safeguards are taken such as storing firewood in trees. The proposals in this chapter are aimed at action to provide relief from exceptional events and to try to identify the requirements for the region.

Flood proofing has been studied under FAP 23 and this study has produced some guidelines for needed measures. FAP 10 is studying the flood warning requirements but these will be national in scale and not just related to the south-east region. FAP 7 has studied measures for cyclone protection which includes two units in the south-east region but the methods and costs of their proposals are not generally applicable elsewhere and are not considered here as flood proofing.

A number of the planning units in the south east-region are either fully protected from floods or are relatively free from serious flooding because they are remote from the Meghna river and flood depths are due to rainfall only and generally produce no serious problems for housing.

The southeast region is perhaps atypical in that there are not the large areas of unstable river char lands which occur in some other regions. Since the Brahmaputra changed its course to the Jamuna the river channels and charlands in the upper Meghna have become much more stable and the population is relatively settled and well established.

Proposals within the regional development plan will not lead to increased water levels for these char lands and existing levels of floodproofing are mostly adequate. The FAP 25 scenarios and the Gumti II feasibility study suggest that all possible action under FAP will be unlikely to have much effect on peak water levels in this area. However most of planning units 11.12 and 13 will remain exposed to Meghna floods and therefore, it is to this sub-region that any national programme should give most attention.

Further south the proposals in the plan will generally lower exceptional flood levels without constructing new embankments which should mean that existing flood proofing will become safer in the future.

In the extreme south the CERP is undertaking a programme of cyclone protection work which will reduce damage in the event of cyclones. However in this area there will continue to be a need to improve the degree of the flood proofing since flooding in the event of severe cyclones will be sudden and possibly catastrophic. In this particular area separate measures are being undertaken including cyclone shelters, disaster warning arrangements and relief systems.

Such systems and indeed all floodproofing arrangements are properly a national rather than a regional programme. The following sub-sections highlight the important components of floodproofing to provide viable support systems in the event of severe events.

a) **Transport Systems**

The three principal transport systems are roads, railways and waterways. Each system plays its parts in normal conditions but in monsoon periods the road system is greatly curtailed and water borne transport becomes dominant. Nevertheless the principal distribution networks of railways and roads are expected to function down to the thana headquarters level. This seems a realistic and achievable target and if all thana headquarters can

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be assured of normal transport/supply at times of exceptional flood events then the distribution of emergency supplies is made simpler and can be administered at the thana level. The south-east region is presently well served by its network of railways and national roads and these routes are generally already above the required levels. A number of these routes are presently in poor condition but they are currently being improved under internationally aided projects. Many of the thana roads are also already to the required level but the following roads still need raising to achieve the desired levels.

Nasirnagar to Sarail	10 Km
Bancharampur to Ramchandrapur	9 Km

It is believed that these roads are included in the programme for the ADB financed Flood Damage Restoration project but that this does not allow for raising the embankment levels.

b) Community Protection

This programme requires a logical and systematic sequence of activities which could be coordinated through the Ministry of Local Government, Rural Development and Cooperatives and could also make use of the knowledge and capabilities of NGOs active in the various parts of the region.

i) Dissemination of design flood levels to be protected against (1 in 50 years) for each thana/union. This information would be estimated from FAP 25/SWMC through WRPO under the Ministry of Irrigation, Water Development and Flood Control.

ii) Placement of Flood Warning Boards in each thana/union.

iii) Inventory of public buildings and services to identify their capacity for use as refuge and or temporary store. The inventory would include: Schools, Health Clinics, Public Water Supplies and Mosques.

iv) Delegation/organisation of Flood Warning Officers within each thana and union and definition of their responsibilities.

v) Assessment of populations at risk (Requiring shelter/assistance). This is a major task since it requires a detailed knowledge of housing conditions throughout the areas. This may be more easily achieved, in some areas, by prior identification of areas known to be safe and hence selection of risk populations by process of elimination.

vi) Evaluation of new and improved facilities required by comparing results of v) with the present status of facilities as in iii).

vii) Preparation of a detailed and costed programme.

The use of public buildings as emergency relief centres is a logical development since the programme could be integrated with the normal government programmes for schools, hospitals etc. It is the organisation and implementation of this integration which is likely to prove most difficult to achieve in practice.

At this stage of planning the consultants have assumed that emergency accommodation should have the highest priority. The provision of separate storage facilities is thought to be of less urgent consideration. The consultants believe that families moving during emergencies will take food supplies they have with them rather than permanently using central stores which would have to be managed and paid for. Local poor populations would be unlikely to use such stores under normal circumstances.

The consultants have seen estimates that storage facilities should be provided for 67 kg per head of population. This suggests a rice consumption of 0.5 kg/ha/day for 134 days (4.5 months). This seems rather high since peak floods generally occur in late August/early September some 2 to 2.5 months before the aman harvest. Whilst it is accepted that such harvest would be damaged the consultants believe that the additional cost of providing special storage for such rare events would produce poor returns to investments. On the other hand if the accommodation facilities provided in public buildings allowed for each family to bring two months minimum supplies with them (180 kg/family) then the accommodation and limited storage provision could be provided at less overall cost and without the need for permanent management of stores.

It is suggested that the size of facilities should be arranged to suit the various sizes of community and perhaps the smallest unit might accommodate up to 600 persons (100 families). This would be more appropriate to the provision of dual purpose facilities that are well used in normal times.

10.8 Fisheries Development and Mitigation Measures

10.8.1 Flood Plain

Ideally, there should be a compromise between the cultivation of HYV boro and aman and sustainability of floodplain fishery in a deeply flooded area. However, it has become increasingly clear that such a compromise may be extremely difficult, if not impossible to find. Losses to the floodplain fisheries are not easy to mitigate and substantial expense usually has to occur before benefits, can be accrued from replacement culture fisheries. In a deeply flooded area, for cultivation of T aman and HYV boro to be possible, flood protection must be guaranteed and in this protection situation, keeping only the main khals, rivers and beels full of water would drastically reduce the open water fishery, even if there were provisions for fish passes in the embankment/regulators. Under such conditions proposals can be made for controlled flooding at the expense of the fishery. This would mean allowing a sub-normal flood situation, in such a way that, in a sub-normal flood situation, there would be controlled flooding instead of full flood control. If the purpose is to let the F_3 and F_4 land to be flooded, then the regulators have to be kept open until at least the middle of May, or until such time the F_3 and F_4 areas inside the project are flooded. The gates shall have to be kept open again from September onward. This would permit, up to a reasonable level, the migration, spawning and feeding and dispersal of the major carp and the flood plain resident species. The migration of juveniles of the fresh water prawn would be affected under the situation as their migration starts from the middle of June and end in September and the gates would be kept shut during this time. Hilsa migration is restricted to the Meghna River proper and their activities may not be affected by the flood protection embankments in the area. However, detailed hydraulic models for specific areas are needed to establish these general fish migration patterns in such areas. It should be noted that the patterns of fish activities will change according to the environmental factors at play in a given area.

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For a compromise between the sustainability of open water fishery and crop production under a flood control situation, a proposition on controlled flooding has been made above. What is important for open water fishery is flooded area, and all land greater than F_0 (30 cm) are suitable. In general it is seen that 35 % of the potential F_3 lands could be available as flooded area where fish can breed and feed; those areas would be generally adjacent to the rivers, khals and beels inside the project and thus the resident species of the closed waters can take advantage of the adjacent flooded lands.

The amount of F_3 + F_4 lands in the region show that quite large areas within Dakatia, Dhonagoda, Gumti I, Gumti II, Ashuganj and in Titas planning units are available for open water fisheries. However, recent work on the Gumti Phase II and Noakhali North feasibility projects showed that the areas of floodplain increase considerably when land greater than 30 cm (F0) are taken into account. Since this situation reflects more realistically what happens in nature, it is strongly recommended that such approach be taken in the future in all fisheries work in the SER. General mitigation measures, proposed in the Gumti Phase II and Noakhali North studies are outlined below:

In general, the main issues concerning possible mitigation measures centre around water and fisheries management. These two aspects have been described briefly below:

a) Water Management

Water resources management is, and will continue to be, possibly the most crucial factor in the development of any activities in the country, the region and the sub-region. It will thus be vital to establish priorities as to how and to where the water will be directed, and for whom. It includes the following components and possibilities for fisheries.

b) Re-excavation of Khals

Possible re-excavation of Khals, and their interconnections to Beels, with an aim of ensuring free and timely flow of water and fish (both breeding adults and fry). This could be most important during the dry season when Khals become refuge areas for some species.

c) Gate Design and Operation

Gate design, operation and location of structures is extremely important. These would ensure the timely flow of water and fish, and would be crucial for maintaining water levels in the system throughout the year, and particularly at times critical for fish.

d) Gate Structures

In general, gates will restrict the passage of fish unless they are designed, operated and managed to minimise fish losses. Some of the possible measures to alleviate this problem include:

- Installation of overshot gates, to allow the passage of floating eggs, larvae, hatchlings, surface and midwater species.

- Timely opening of gates to coincide with critical migration periods for fish and other aquatic species, such as shrimps which are commercially important.

- Careful timing of closure to coincide with the end of the monsoon when the floodplain starts to dry out.

c) **Improved Fisheries Management**

The continued improvement of fisheries management in the area should receive the highest priority, especially for those activities and/or policies that should take place despite interventions. Some of these activities include:

f) **Restocking with Fry and/or Fingerlings**

Restocking of suitable areas such as specific Beels and Khal sections with fry or fingerlings. However, this will need to take into account the ecology of the existing resident species in the area so as to prevent a major environmental unbalance due to any introduction of species. Restocking programmes should therefore only be carried out using indigenous species which occur naturally in the selected areas.

g) **Enforcement of Existing Fisheries Regulations**

The enforcement of existing regulations should particularly be carried out in relation to important areas such as Satdona and Chandal Beels, along with other known breeding, nursery and feeding areas for fish and other commercially important groups such as shrimps.

h) **Fish Passes**

Various types of structure have been known to be used to permit fish to move up and down stream, past dams and other structures. These are specially important for maintaining and managing spawning migration and preserving natural populations in rivers and flood plains. Despite of being a deltaic country with vast flood plains connected with many important rivers and though several dams and water structures have been built in Bangladesh in the past, nowhere have any provisions been made for fish passes. Thus there is no information available with regard to the design and construction of a typical fish pass in a flood control project.
Isaev and Kappova (198....) and Paulou (1989) have provided information on five major types of fish passes in USSR. These are:

- Simple fish passes; a continuous water flood enables fish to pass upstream,

- Hydraulic and mechanical fish lifts; migrating fish enter into a chamber and are periodically lifted to the reservoir upstream of the dam,

- Fish passes that work on the principle of lock,

- Floating equipment; fish are gathered in to containers, which are then transported to upstream reservoirs, and

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- Fishing complexes: fish are caught, then gathered into containers for transportation by truck to upstream reservoirs. This system is used where there is no navigation lock.

Among these five types, the simple passes that consists of fish ladders, troughs and by-pass channels are widely used in many countries of the world. The ladders or troughs would simply not work in Bangladesh, as the major carp are not known as leapers, by-pass channels are not compatible with FC/FCD/FCDI projects. The other types, floating equipment or fishing complexes, are not relevant, the only type that might offer a chance to function is the lock type fish pass. This type of fish pass has been build in the Don reservoir of USSR. They normally have two separately acting chambers; the inlet channel leading to the lock is usually 6-8 m wide and 40-50 m long, so that the entrance is away from fast flowing water beneath the dam. The water would pass through the lock chamber into the inlet channel at a rate of 0.8-1.2 m/sec which is suitable for attracting fish. This stage would last for about 30 minutes. The inlet channel is then closed and the lock chamber fills with water from below. The fish tend to congregate in the chamber and when the required height of water in the chamber reached, the chamber opens and fish readily swim upstream. When the fish have left the chamber the upper gate is closed, water is discharged and the cycle is repeated, the whole process lasts for 1.5-2.0 hours. While one chamber is filling with water, the other one is discharging.

The design of the lock chamber in respect to its length and width and duration and timings of operation would depend upon the extend of the area within the project and on the onset of the monsoon season in a particular year. It will also depend on the dynamics of the water current and the extent, depth and duration of the flooding in a given area. The use of the hydraulic model would be crucial for determining where any such structure might be placed.

i) Culture-based Capture Fishery.

In the situation where flood water is allowed into the beels, rivers and khals inside the project area, the methodology for fisheries management could have a blend of culture and capture fisheries. In such a case, the large water bodies in their varied forms can be stocked with the fingerlings of culturable species viz., the major carps. The Baor fisheries development and management project in the south-west region of Bangladesh is an example of such type of activity. The government has also taken up similar programmes in MIP and in CIP. For this type of programme to be established in a project area, infra-structure facilities with regard to fish seed production, nursery operation, extension and credits will have to be developed. The management of the water bodies has to be given to the NGO or to the fish co-operatives through the GOB under the New Fisheries Management Policy.

10.8.2 Culture Fisheries Development

Improved control over flooding is expected to improve productivity in the culture fisheries and to encourage a more rapid development of the industry. Data presented in the MPO Technical Report 17 indicate that for the Chandpur Irrigation and Flood Protection Project, the proportion of ponds cultivated increased from 16% to 51% in the first two years after project completion (1978 and 1979) and had reached the very high level of 95% by 1984. However, the same report highlights the severe losses incurred by the open water fisheries.

To what extent these increases in fish cultivation can be attributed to flood control on its own is not clear. Fish cultivation in adjacent areas outside the Chandpur scheme also increased markedly during the 1980's. Some 56% of households which owned a large pond in control areas outside the Chandpur scheme were engaging in fish cultivation by 1987, compared to around 12% of households in 1977 according to recent surveys (Paul M. Thompson, 'The Impact of Flood Control on Agricultural Development in Bangladesh', 1989). Within the Chandpur Project area, Thompson's surveys showed that the proportion of households owning a large pond who cultivated fish had increased more than in the control areas, reaching 72% in 1987. Chandpur has traditionally been an area of intensive fish cultivation, with a much higher concentration of fish ponds than in other parts of the South-East Region; the applicability of the percentage increases in fish culture realised in Chandpur to other parts of the region is therefore questionable. A part of the growth in fish cultivation between 1977 and 1987 could also be attributed to the construction of the Raipur Fish Hatchery, which should have encouraged fish culture both within the Chandpur scheme area and in adjacent areas; a further part of the growth would have been due to a general increase in farmers' appreciation of the profitability of fish culture and better knowledge of the techniques.

Data on the development of culture fisheries produced by the BBS/Department of Fisheries provide little help in determining trends in fish cultivation. The BBS data show no increase over the past few years in the numbers/area of ponds which are cultivated as opposed to 'culturable' or 'derelict': this is hardly probable in view of the growth in fish cultivation recorded both inside and outside FCD schemes in studies such as Thompson's. The BBS data show some changes in average yields from the different types of pond, but the figures are erratic.

It may be assumed that with FCD, a proportion of the ponds which would remain uncultivated in the 'without' project case will be cultivated once the flood control measures have been implemented. This would be subject to the availability of adequate credit facilities and fisheries extension services. For the purposes of making an initial estimate of the potential increases in net incremental income from pond fisheries development in a 'with' FCD project case, the following general assumptions have been made:

- yields in uncultivated (culturable and derelict) ponds in the 'without' project case will average between 250 kg/ha per year (based on comparable yields in beels and the floodplain) and 1 000 kg/ha per year (the approximate 1987/88 average recorded in the BBS statistics for the south-east region as a whole), with an average value of Tk 40 per kg in market prices, reflecting present (mid-1991) price levels in the project area for a typical mix of fish species

- in cultivated ponds, more intensive management practices will be adopted in future, both within and outside FCD projects, as the financial profitability of fish farming becomes more widely recognised and as the techniques of fish farming become better known; an average yield of 2 500 kg/ha per year for cultivated ponds has been assumed, at an average value of Tk 50 per kg (the prevailing price in the project area for major carp species).

An indicative annual cost and revenue model for a semi-intensive fish farm producing high value carp is shown in Annex VII Chapter VII.7. The net annual income (in economic prices) is estimated at Tk 36 989 per ha of ponds. Net annual returns with uncultivated ponds (ie, in the 'without' FCD project case) have been estimated at between Tk 6 150 and Tk 24 600 per ha, with yields of 250 kg and 1 000 kg respectively. Net incremental

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annual income per ha of ponds in the 'with' project case (when a presently uncultivated pond becomes cultivated) has therefore been estimated at between Tk 12 389 and Tk 30 839 per ha in economic prices. (or Tk 19 907-42 407 in financial prices).

A comparison of the prospective economic gains from increased cultivation of presently uncultivated ponds (on the basis of these estimates) with the expected losses from capture fisheries suggests that there is no practicable possibility of the incremental income from cultured fisheries offsetting the losses from the open water fisheries. Indeed, the incremental gains to fish cultivation would appear to be negligible in comparison to losses to the open water floodplains fisheries. For the proposed Noakhali project, for example, the area of floodplains (F1-F3 land) affected could be 47 612 hectares, yielding some 2 380 tons of fish per year (at 50 kg/ha), valued in economic prices at about Tk 78.1 million (@Tk 32.80 per kg). It would require between 2 532 and 6 302 ha of uncultivated ponds to be brought into cultivation to offset this loss in value terms (ie, Tk 78 083 680 divided by Tk 12 389 or Tk 30 839 net incremental income per ha of pond). The total area of uncultivated ponds within the project area is estimated at about 1 400 hectares or between 22% and 55% of the area required to offset the losses from the capture fisheries.

The available data on the proportions of ponds which are uncultivated as opposed to cultivated are highly suspect. The validity of any assumptions which might be made about differential rates of development of pond cultivation with or without flood control measures would therefore be highly questionable. It might be argued that with FCD, new ponds may be constructed in greater numbers than without FCD, given that FCD increases the relative share of higher land best suited to pond development. However, here again there is no firm evidence available from experience in existing FCD schemes on which to base any such estimates.

No incremental gains to fish cultivation have been calculated for the pre-feasibility studies in this Report. This decision has been taken on the grounds that the almost complete lack of reliable data on which to base any estimates of future pond cultivation would make any estimates highly arbitrary and unreliable. In addition, the gap between prospective capture fisheries losses from additional FCD works and the practicable incremental gains from fish cultivation would appear to preclude the possibility of enhanced returns from fish cultivation offsetting more than a part of the losses from the capture fisheries.

The analysis here does emphasise the necessity of including mitigatory measures for fisheries in the event of any new FCD schemes being implemented. These could include artificial stocking and the introduction of appropriate management regimes for open water bodies, as well as enhanced levels of extension work for culture fisheries in general.

In designing mitigation programmes it should be borne in mind that the direct beneficiaries of pond cultivation will in general be the better-off members of the rural community, with access to sufficient land to allow them to own a pond of adequate size. The direct losers from the loss of the migratory fish open water capture fisheries, on the other hand, will include both the fishermen (generally among the poorest members of the community) and the landless and other poorer groups who depend on open water fisheries for a significant part of their dietary requirements. While fish cultivation and the artificial stocking of open water bodies can help to offset the losses from capture fisheries in terms of quantities of fish, the costs of cultivated fish are inevitably greater than for fish caught in the wild, because of the costs of artificial breeding and rearing. Mitigation programmes must therefore include special provision to meet the needs of fishermen and other poorer groups (especially the landless) if the income distribution disbenefits of the loss of the open water fisheries are to be offset. These programmes should include, organisation of cooperatives of fishermen and/or landless labourers who would be assigned the leases on particular areas of open water (in khals, etc); this approach has already been tried in the South-East Region by the Mennonite Central Committee.

10.9 Navigation

The introduction of mechanical country boats is increasing the viability and effectiveness of waterborne transport. However effective flood control will always limit the areas of operation of such transport systems to natural rivers and khals and to the more deeply flooded lands which remain.

This is not particularly serious but the introduction of structures can pose a threat to the viability of water transport routes. The proposals included in the regional plan involve very few new structures on important navigation routes and where a new structure is proposed a lock would be provided in each case. However the principal structures involved (the Dakatia regulator) would not normally be closed in the monsoon season and therefore would not impede river transport in this period. In the dry season the lock would be operated and the higher levels available upstream would provide improved access further upstream.

No other existing major routes would be adversely affect by plan proposals.

The proposals for khal deepening should improve conditions for small boats in the dry season and the Noakhali North DIP proposals should result in construction of fewer cross dams which could also improve navigation.

10.10 Peoples Participation

In chapter 10 of volume 1 of this report a description of past project development problems and their relationship to peoples participation (or the lack of it) were discussed.

During the period of this study the FPCO have developed guidelines for peoples participation (GPP) which set out a framework and a basic methodology for ensuring that people are consulted, their needs assessed and addressed and that at all stages of development their involvement is actively sought and encouraged.

The consultants have attempted to follow these guidelines during the two feasibility studies which have been carried out during the last 12 months (although the final guidelines were not available until March 1993). The results of these efforts have been uneven but they have yielded valuable information which has allowed both studies to be more responsive to the perceived needs of the people.

The studies have also identified a methodology for continued involvement and cooperation with the people at the design, implementation and operational stages of the projects.

Although it is possible to lay down guidelines for a general approach and methodology it is inappropriate to impose it in the same manner for all developments. Nevertheless the consultants consider that there are some aspects which can help in almost every case.

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The Project Coordination Committee proposed under the GPP should be project location based (not implementing agency based). If it is to be effective in accommodating the views of underpriveledged groups then the representation of those groups must be as independent as possible of the implementing agencies and of local elites. This means that local organisations and or NGOs could be the representatives for these groups and the NNDIP study described in some detail how this might be done for that proposed project. It should be a continuous process throughout design, construction and operation phases of the project. If this is not done then the PCC, the NGOs and the people will lose contact, confidence in one another, and all the previous effort will be wasted.

People's participation is about people and the success or failure of many projects will depend on how individuals and groups behave and react to one another. Successful participation will require a change in attitude by many sections of society and this will not come quickly or easily.

10.11. Financial Plan

Figure 10.4 indicates the plan financing requirements in 1991 prices which has been the year used throughout this report in accordance with FPCO guidelines.

The largest single element in the plan is the Chandpur town protection project under FAP 9B which FAP 5 supports since the risks involved in not attempting to stabilise the Meghna seem immense.

The fact that there are a large number of quite small projects included in the plan could make for a bunching of expenditure in the early years.

However by delaying work in the southern polders until FAP 5B have reported and the Gumti II irrigation and drainage polder which is not recommended unless groundwater development does not take place it is possible to delay some of this. In addition the Dakatia-Little Feni transfer proposals will require detailed study and design periods before implementation and they can also be staged as shown in the schedule.

The overall levels of expenditure excluding the Chandpur town protection works would seem to be within expected levels when compared with those discussed in Chapter 2.

10.12 Institutional Aspects

Institutional arrangements for implementing and monitoring the FAP are under consideration in a number of quarters, notably FAP26. Issues to be addressed will include:

The relationship between FPCO and WARPO, formerly MPO. At the present stage of development of FAP, considerable reliance is being put on outside consultants, and FPCO is too short-staffed to be able to handle more than the administrative management of the programme. There is a need to put in place an organisation which can manage the planning of FAP on a continuing basis and provide continuity between major studies and implementation. This will inevitably need consultants and other organisation to become involved. An additional factor to be considered is that FAP is mainly concerned with planning for the flood season whereas it is widely recognised that there is a need to take an over-year view of water resources management as in FAP 5. It is

Figure 10.4

Financial Schedule (Tk.M)

YEAR										10					15					20
										2004					2009					2014
Component			Ten Year Programme									Medium and Long Term								
Major Projects																				
Chandpur Town Protection	20	1200	1200	1200																
Chandpur Irrigation Project																				
Retirement and rehabilitation	32	31																		
Meghna Dhonagoda Project																				
Retirement & Bank Strengthening	10	96	96																	
Reconstruction of Canals	1		8	8																
Ashuganj	12	75	75																	
Noakhali North DIP	35	35	110	401	442	226														
Gumti Phase II – Southeast Polder				19	90	92	92	92												
– Submersible Embkmt		1	1	8	8															
– Khal Deepening	1	23	23	23																
– I & D Polder*													13	77	78	78	77			
Ramgati – Polder 59/2 I & D				6	6	9	10	88	88	88	88									
Dakatia/Little Feni Transfer(1+2)				34	34		32	32	241	241	241	241	240							
Little Feni – Musapur Regulator(3)						20	110	110	110											
Dhonagoda – Khal Deepening (3)			1	4	4	4														
Dhonagoda – Flood Control (2)							6	6	56	56	56	56								
South Sudharam – Drainage (2)										8	8	12	13	113	113	113	113			
Sonaichari –Kilpara Extn		20	20																	
Settlement & Rural Development	32	32																		
Sub-Total (Public Funds)	143	1513	1534	1703	584	351	250	328	495	393	393	309	266	190	191	191	190	0	0	0
Minor Irrigation																				
LLP																				
Ashuganj			10	10																
Noakhali North DIP					15	15	15	15	15											
Polder 59/2 Irrigation										9	9	8	8							
Dakatia / Little Feni											13	14	13	13	13					
Dhonagoda – Khal Deepening (3)					6	5	5													
Gumti Phase II – Khal Deepening		8	8	8	8	8														
Gumti Phase II – I & D Polder*																	10	10	10	10
STW/DSSTW	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12					
FMTW	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
Sub-Total (Private Funds)	35	43	53	53	64	63	55	50	50	44	57	57	56	48	48	23	33	33	33	33
Complementary components																				
Cyclone Protection (FAP 7)	304	304																		
Environmental Protection	15	15	15	15	15	15														
Total expenditure per year	497	1875	1602	1771	663	429	305	378	545	437	450	366	322	238	239	214	223	33	33	33

* If required

recommended that consideration should be given to rearranging the planning and management functions within the Ministry to avoid duplication and to clearly define the responsibility for each stage of development.

Institutional issues relating to flood proofing are being addressed by FAP23. A programme of flood proofing should be instituted wherever needed. However, great care will be needed with the institutional arrangements for flood proofing so as to avoid the situation where central or local government has to take a major role. If this happens, the problem of lack of investment in the maintenance of the facilities is likely to occur, as it does with flood protection facilities. Villagers already have survival strategies to deal with floods, and the most important task required is to identify low-cost ways to support these strategies and make them more effective.

A particular aspect of implementation concerns construction procedures, especially with regard to earthworks. It is important to carry out earthworks using manual labour as far as possible, in order to spread the benefits of investment to the landless, but not at the expense of standards of construction. The emphasis must be on timely commencement of work, use of good material, and satisfactory compaction and construction techniques. Use of labour contracting societies has generally resulted in better quality work, and the expansion of the LCS system is recommended. However, it must be accompanied by adequate support and supervision from NGOs/BRDB and technical staff as has been recommended for NNDIP.

10.13 Operation and Maintenance

There is general agreement that poor O&M has been a major factor preventing the success of FCD projects. A great deal of interest is now being shown by Government and donors in trying to improve this situation. Within the FAP programme, two key components are FAP 13, the O&M study, and FAP20, the Compartmentalisation Pilot Project. The latter is charged with developing a Local Water Management Board with responsibility for operation and water management. Outside the FAP, both EIP and SRP are developing approaches which should lead to substantial improvements.

10.13.1 Operation

The problems of operation of completed facilities are made difficult by the nature of the topography in Bangladesh. Although land slops are in general very low, considerable differences in micro-topography exist, so that it is possible to find adjacent parcels of land with level differences of 0.5 m or more. Such differences can make the difference between farmers who want drainage because their crops are submerged, and those who wish to retain water because they fear moisture stress. Often it is not possible to accommodate this variety of needs because of the flat topography. In such circumstances it is inevitable that conflicts of interest will arise and that the process of operation will become a complicated process of political bargaining and negotiation. It has often been noted that gate committees are in fact dominated by influential landowners; this process seems likely to continue, given the structure of agrarian relations in Bangladesh. For this reason, amongst others, the consultants have proposed systems having the minimum number of structures.

10.13.2 Maintenance

Maintenance requires an inventory of the assets to be maintained, procedures and programmes for the maintenance tasks, and resources of staff and funds to carry them out. In the case of FCDI infrastructure, BWDB have recently had an inventory of assets. Whilst this is still incomplete, it is nevertheless a useful first

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step in determining the magnitude of the overall maintenance tasks. Every effort should therefore be made to continually improve this asset register, and develop from it an estimate of maintenance (and rehabilitation) requirements.

Maintenance procedures and programmes for FCDI facilities are simple, well-known and understood. The mechanical equipment involved is fairly basic and does not require sophisticated technical know-how. Earthworks maintenance, such as embankment repair and khal re-excavation is already a common activity, particularly under the Food-For-Works programme. SRP is currently developing a system of compiling needs based budgets and these are a prerequisite for efficient maintenance.

10.13.3 Funding for O&M

A significant constraint on effective O&M is shortage of funds. At present funds come through cash allocations from BWDB's revenue allocation or through FFW programmes. New legislation and the SRP programme are now making progress in the development of new changing systems to beneficiaries. This has been discussed in some detail for the NNDIP but for projects where there is no irrigation, charging for drainage raises problems which require detailed study at a national level and SRP and FAP 13 are the preferred projects to do this. It is properly outside the functions of a regional plan.

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CHAPTER 11

ENVIRONMENTAL MANAGEMENT AND MITIGATION PLANNING

11.1 Planning Framework

11.1.1 Aims, Scope and Benefits

The RWP would physically and ecologically transform aspects of the functioning and landscape of the river, coastal, estuarine and floodplain system. The environmental plan discussed here aims to ensure that any new environment could maintain the productive resource base in surety and intact for future generations of users. This involves mitigating the adverse impacts of the interventions. Yet, the RWP would be only one of many activities affecting the quality of life and environment in the region. To be effective environmental management also needs to be linked and coordinated, not only with FAP projects in other regions, but also with other sector activities.

The national environmental policy and the NEMAP lay out the general direction and issues for an integrated approach to environmental management. The potential scope of a regional environmental plan is wide. But it also needs to be specific and directly appreciate and support the daily decision-making world of individual environmental managers at the level of agricultural and fishing communities and industrial managers.

To overcome the lack of present knowledge on the expression and intensity of adverse impacts, an integrated research, monitoring and management system is required of key hydrological, chemical and biological variables. This system will allow some forewarning of issues which might otherwise go unnoticed, until it was too late to do anything about them. New types of specialists, management concepts, and an active commitment to new strategies, will be required. This will take time to organise, but can build on a foundation already in the making within various sectors in Bangladesh. It would be an integral part of the operating procedures of the RWP integrating engineering design, water management, sanitation, chemical and biological strategies within an ecological and economic systems approach.

Many mainline ministries will be involved. Support would also be required from other national and international institutions, research institutions and environmental agencies. The coordination required goes beyond the BWDB responsibilities and much of the work beyond their professional capacities. This limitation reflects the historical criteria which established such institutions and did not sufficiently appreciate the indivisible linkages between the supply of water, the rural economy and the environmental resource base, and the difficulties of achieving effective coordination between different institutions. The problems emphasise the need for additional professional training for BWDB staff and stress the need for the closer involvement of other institutions, the public and the media in the planning, implementation and monitoring of water resource projects.

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Other agencies, apart from BWDB, likely to be involved include:

International Border Issues	:	Joint River Commission (JRC)
Irrigation Development	:	Ministry of Irrigation, Water Development and Flood Control (MOIWDFC)
Agricultural Development	:	Ministry of Agriculture (MOA) /Bangladesh Agricultural Development Corporation (BADC)
Watershed Management	:	Intergovernmental Cooperation
Land Use Planning	:	Ministry of Land (MOL)
Livestock Management	:	Ministry of Fisheries and Livestock (MOFL)
Fisheries Management	:	Ministry of Fisheries and Livestock (MOFL)
Local Management	:	Ministry of Local Government, Rural Development and Cooperatives (MOLGRDC)
Flood/Disaster Management	:	Ministry of Relief and Rehabilitation (MORR)
Public Health	:	Ministry of Health and Family Planning (MOHFP)
Water Quality Monitoring	:	Ministry of Environment and Forestry (MOEF)
Industrial Investment	:	Ministry of Industry (MOI)
Pollution Monitoring and Controls	:	MOEF/Private Sector
Urban Planning and Controls	:	No single body, UDD
International Support	:	e.g IUCN, IRRI, ICLARM

Much of the research and planning required involves subject areas that remain poorly developed in Bangladesh. Until local educational curriculum have been installed and sufficient local trained staff are available, international resources will have to be relied on to assist in the process and a patient attitude adopted to the speed with which progress can be made. The upgrading of training and education will require a considerable medium-term investment. Existing MOEF proposals already are looking to strengthen their capabilities. Further support from other sources will be required if a more rapid transition is to be made.

The main programmes required for the SER are to:

- Incorporate planning and management criteria and methods to sustain development potential by conserving resources through proper zoning and integrated use of resources.

- Improve policies to deal with the problems of construction.

- Improve policies to deal with the problems of land acquisition, compensation and resettlement.

- Integrate into planning the research and if necessary protection of cultural and heritage sites.

- Establish a coordinated pollution monitoring system to plan for trends in industrial, agricultural and sanitation pollution problems.

- Integrate public health programmes and monitoring into water resource projects to deal with changing disease and disease vector profiles associated with FCDI interventions.

- Develop multi-purpose water management criteria for the design and operation of FCDI projects to maximise the biological and economic diversity of the productive resource base in agriculture, to reduce pest and disease risks and to minimise the build up of nutrients, aquatic weeds and pollutants within engineered schemes.

- Maintain a monitoring programme on the Gumti and other confined rivers where rising bed levels would lead to high future flood damage risks.

11.1.2 Sustaining Development Potential

Technical solutions for increasing food supplies and protecting farmland and assets from damaging floods will interact with an existing social and ecological context. Yet, these environments are where water and floods remain an elemental influence and also a major benefit for much of the basis of existing survival strategies and production systems. The importance of this must not be lost in the search for solutions to reduce the risks associated with floods. To be unaware of this existing status could lead planners to be uninformed of the hidden, often unquantifiable, price which may have to be paid in social, physical and ecological terms by intervening in the natural system. The impact of new and fundamental changes to the hydrological and aquatic eco-system will require wide-ranging appreciation in policy formation, if the long-term interests of the people are to be well served. This is all the more so since, at this stage, the data and methods to adequately quantify many of the affects are not available to include into the economic analysis. The project analysis by numbers, therefore, only gives one insight into the real scale of potential and problems.

Bangladesh continues to move through a crucial development period. Although people are increasingly concentrating in urban areas, close ties are being maintained with their rural lands. The population increase, together with rapidly changing values and life styles, has already created major impacts on the terrestrial landscape and aquatic eco-system which have altered dramatically, even within living memory. The remaining renewable and non-renewable productive resources are limited, and potentially fragile. This sensitivity can exceed key thresholds when put under extremes of use by humans for production and consumption, and when waste products are so poorly managed and create pollution. Whatever the scale of population demands may be now, to exceed certain thresholds may produce even greater human suffering in the future.

The approach to environmental and population management needs long-term vision, if future options and flexibility are to be maintained. Trade-offs are inevitable and will demand sacrifices, particularly in political and financial terms. However, talk of conserving resources and of sustainable development should not be seen as convenient development jargon. The vision is about survival. The essence of the strategies is to repair and reverse the mistakes of previous generations which can now be clearly recognised. The inherited system and scale of exploitation, of the only resources available to this and future generations, can no longer be seen to be sustainable, except to some who have the most to loose. Unfortunately, this includes the poorest and the rich, both internationally and nationally; the poor because it is today's literal survival that is threatened and they have no choice; and the rich because they are threatened by pressure to change the system that accumulated the wealth and the power it brings. Change is required from both groups if new and sustainable health and wealth is to be generated.

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This, and many other studies, have highlighted various growing environmental problems. The primary long-term constraint concerns the pollution hazards resulting from any continued ad hoc and uncoordinated approach to domestic, agricultural and industrial water sources and the role that FCDI interventions play in exacerbating these problems now, or in the future. Nutritional and equity problems have been placed high on the agenda, again mirroring concerns raised in other studies. Only through concerted commitment to new FCDI strategies and complementary programmes in other sectors, will meaningful solutions be found. The over-exploitation of fisheries, particularly by the continued widespread use of the "current net", is also of major concern to sustaining the fish resource base.

The catchment's settlement pattern, survival strategies and economy depend on the floodplain, estuarine and coastal resource system. To intervene in this system and change its fundamental nature should only be considered viable and sustainable if vulnerable groups do not end up worse off as a result. Given the reviews of existing studies, it is not clear that this will be the case. Thus, serious attention must be given to selecting strategies that can avoid these repercussions which, if not addressed will, in the longer term, only add to the problems of poverty alleviation and inadequate nutrition. Even if food production overall is increased this is of little value unless the mass of poor and landless people can afford to gain access to the food resources potentially available.

The interventions imply some basic changes to the energy and chemical flow systems. The local vegetation and fauna will adapt to this, but the extent to which all species could be successful and maintain their regenerative capacity is not well understood, given the lack of basic data on the ecological systems and their dynamics. This, and other studies, have highlighted the need for more research. If embarked upon seriously, this research will initially raise many more questions than answers, until a number of years of monitoring and analysis have been conducted. Policy makers will have to decide whether they wish to proceed with more interventions before some of these basic questions can be satisfactorily answered or, whether to delay and reduce the risks of a poorly designed approach to resource management. Given the complexities and dynamics of the systems involved, there is no guarantee that research would be able to find simple answers or new solutions, either to maintain the present situation, or to mitigate better the adverse consequences of the current FCDI strategies. Even if FCDI projects do continue, it is still vital to monitor the situation. Financing and organisational resources to achieve this need to be guaranteed for monitoring before any further implementation proceeds.

11.1.3 Resource Conservation, Management and Zoning

The sites of special interest which have been given consideration in the planning are listed below and shown in **Figure 11.1**:

Natural Beauty or Recreational Value

Coastal Zones and Lalmai Hills

Special Scientific Value

Offshore island and mudflats

Worthy of Protection and Conservation

Remaining habitat sites for migratory birds
Sites of high value for open water fish ecology
Remaining site of Sal forest
Sites of cultural and historic value

Worthy of Special Environmental Management & Monitoring

Sources of industrial pollution
Sources of agro-chemical pollution
Sources of concentrated urban sewage and wastes

Specific areas for resource conservation include the zoning of the region's main archaeological sites, forest areas, recreational sites and areas of last remaining important wetland habitats that are important for migratory birds and open water fisheries. Loss of these sites will not only affect the local ecology, but may have long-term economic and international ramifications which cannot be ignored. These, few sites should be examined closely from the viewpoint of the national importance. Their inherent value might warrant their consideration for national conservation and protection under the RWP, and if not coordinated through another programme to be specified by policy makers as a result of the SERS. Areas of agricultural lands where more intensive input use is already occurring, and other areas where it is likely to occur, should also be zoned for monitoring and pollution planning purposes. Particular emphasis needs to be given to such areas as the Muhuri irrigation and reservoir, and low-lying and drainage sites in the existing FCDI projects. The proposed environmental zoning plan, assuming a complete future development of FCDI, is shown in Figure 11.1. In addition, regular water quality monitoring at the sites shown in Figure 12.1 should be supported to enable a better understanding of the implications of pollution control measures associated with FCDI projects and the costs of raising pollution control standards in spite of these.

The IEE analysis has highlighted some aspects of development strategy which go beyond the scope of the immediate feasibility work and later management of any FCDI programme. The need for international coordination is an example. The Joint River Commission and the National Water Council are the two bodies concerned with the cross border issues and cooperation in planning and water management. Although the size of cross border flows in the south-east are not large by national standards, their flashy nature makes coordination important. The failure of cross-border regulatory structures, any increase in sediment erosion and increase in pollution from the cross-border catchments will all directly affect the downstream areas in Bangladesh to a greater or a lesser degree. It is unlikely that Bangladesh can have any direct influence on planning in the upper catchment, but should be in a position to know the potential ramifications of changing patterns of development, population, land use and industry in these areas.

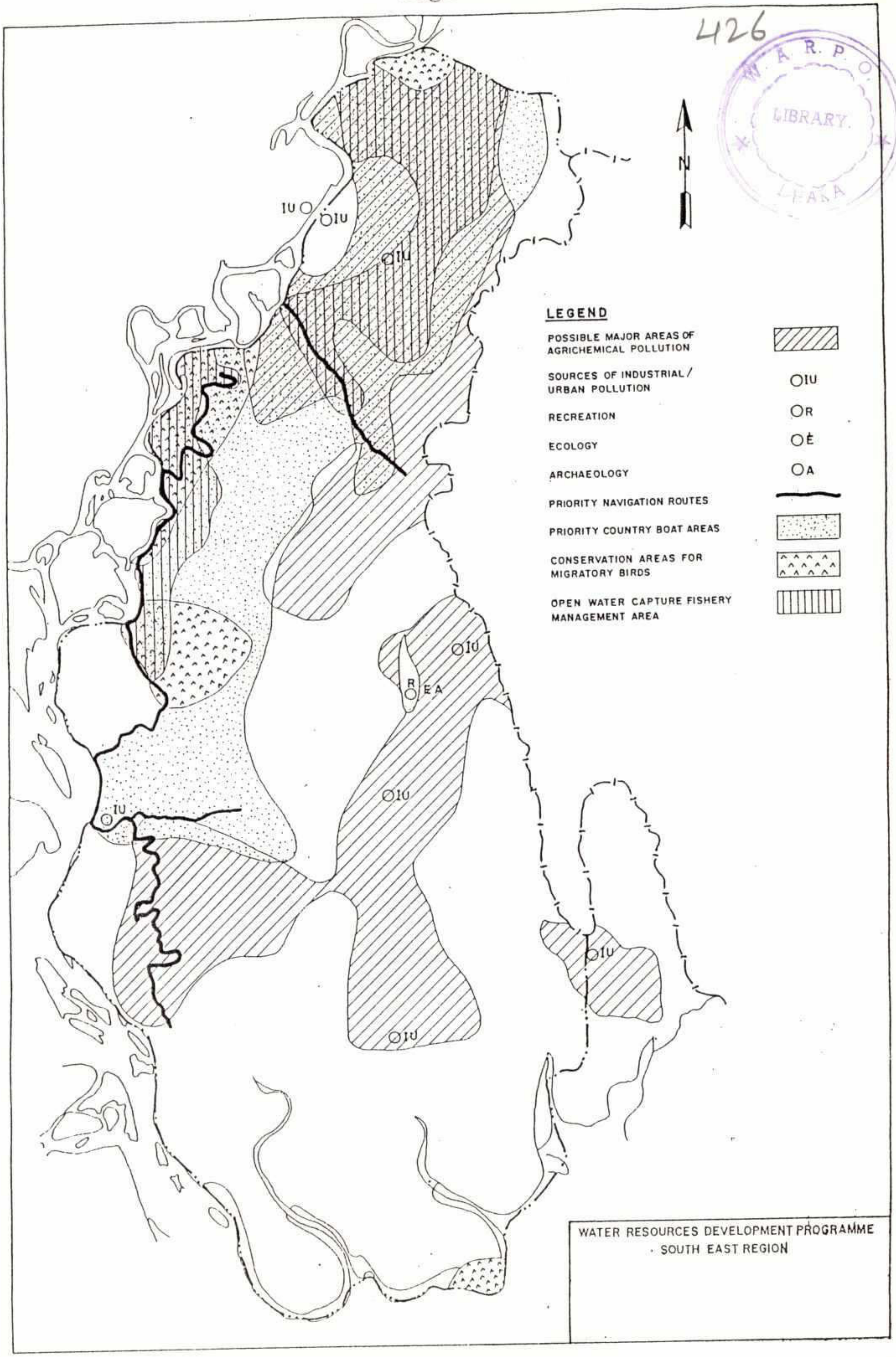
11.2 Construction Management

11.2.1 Policy

Construction policy is a subject which will be taken up in further detail at the feasibility study. At that stage a range of topics would be appraised including service facilities, labour policy, public health and safety, contractor's site installations, services and pollution control, operations and disturbance, rehabilitation and reclamation provisions, social problems and consultation with local authorities.

Figure 11.1

Regional Environmental Management Zones



11.2.2 Resettlement, Land Acquisition and Compensation

The pre-project process of land acquisition and considering the needs for compensation for private and communal assets and resettlement will be a major impact of any embankments, canals and roads. It will also be the major feature which will delay construction. These aspects are the topics of special study under FAP 15 and their conclusions and guidelines will be taken into account during the feasibility study planning. Detailed surveys and planning for resettlement and compensation will be required in the feasibility stage covering a wide range of topics, such as cadastral issues, private and communal asset losses and values, socio-economic impacts and secondary impacts areas and public attitudes.

There is often an increased strain on government services during construction phase which can raise the costs of local government services. To avoid and mitigate these, careful preparation of construction contracts, contractors responsibilities and construction planning and coordination with other government services, is required. Ensuring that labour intensive and a local labour recruitment approach is adopted may require negotiating with donors and contractors, if contracts go to ICB. These provisions can help reduce social problems and tensions.

Resettlement Planning

Early and coordinated preparations are essential to ensure that any resettlement programme can be successful and planned, evaluated and implemented in an orderly and sympathetic way. If this does not occur it could induce an unnecessary increase in economic hardship, psychological problems, crime or other social disturbances. Carefully designed cadastral surveys, supported by full socio-economic surveys, are required to fully understand the negative impacts which the land acquisition and compensation programme can impose on the local community. Furthermore, a comprehensive inventory has to be made of the full range of private and community assets to be lost to the construction programme. A clear policy of compensation also has to be discussed and agreed upon with the communities to be affected. Credit programmes may have to be considered to establish families in new enterprises generated by projects. The provision of free community legal aid services also assist in this difficult period for local people.

A survey of any areas selected to resettle affected families must also be carried out in a timely fashion to establish the suitability of the resources available, and the environmental, cultural and political conditions which the settlers will have to adapt to. It should identify any additional special assistance or training needs in the receiving areas and the likely period of time required for assistance to ensure the shortest adaptation period to their new environment. Estimates are also needed of the time, resources and budgets required to provide these.

The options for resettlement in such a densely populated region are extremely limited. Local resettlement would increase the pressure on resources in an area which is already over-populated. Although specific surveys cannot take place until the feasibility or, more appropriately, the detailed design phase, families are likely to prefer resettlement in areas close to their existing villages for three main reasons: (a) so as to not disturb their existing social and family kinships bonds (b) to allow them to maintain other plots of land they own or work on outside the affected area and (c) their possible strong cultural ties with their traditional land and environment.

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Land re-allocation would be a complicated process, but the options available would be for allocation of government land (khas) through the Guchha Gram project or a planned programme of settlement into newly reclaimed char lands. This latter option will have to face many social and political difficulties involved in the organised hierarchies of private landlords who use strong arm tactics to appropriate such land, as has been documented through the Land Reclamation Project.

There are a number of social issues important in resettlement planning. Farmers look to a wide variety of activities to supplement their income; often moving to local towns on a temporary basis. A similar drift of young people to the towns on a more permanent basis has also started. The role of women is also under-estimated as they provide a major labour input in homestead farming, livestock rearing and crop processing, in addition to the daily responsibilities in the home and with children. In areas affected by embankments many will be concerned about the loss of livelihoods as fishermen, and having to face a future transformed into one of unfamiliar alternative occupations. This would include both professional commercial fishermen or traditional fishing communities based on their caste history. The social implications will affect the two groups differently.

Although Muslims are the majority population, minority ethnic and religious groups exist that will require special attention. Respect for influential figures in the community, particularly traditional and religious leaders, is an important part of community organisation and decision-making. Local leaders are key local representatives to consider if any compensation, land acquisition and resettlement programmes are to proceed smoothly and with minimum conflict. Most conflicts derive from disputes over the use of land and irrigation water and the location of irrigation facilities and conflict of interests arising out of differences in inter- and intra-religious values and traditional customs.

The principle of mutual assistance in village and community life is a powerful factor, confirming a strong adherence to religious and social commitments. Community members will often compete to participate in these activities setting aside any consideration for material gain. The generally poor education level, "closed" attitude, dominance of the patron-client relationships in social and production systems, high dependence on religious and social figures, and the close bonds of kinship relations are significant social features. These will influence the success of both the resettlement programme and the reactions of the local communities to the sudden onslaught of a major construction project. They will also affect their treatment of construction workers who might be recruited from other areas and who will have to live locally for the duration of their contracts.

Compensation

Experience of cash compensation payments worldwide shows it is often not invested wisely or very often used for replacement of lost assets. Often it will be spent on consumer goods or other services with little potential of preserving the present level of economic livelihood. This can particularly occur when compensation is paid as one ad hoc lump sum and is not linked or phased to the agricultural calendar or assigned for specific items, such as land or buildings or draft animals. Direct replacement is far more likely to preserve economic livelihoods. The transactions have to occur in a timely fashion to avoid discontent, or even destitution for specific households with no other forms of livelihood.

The loss of buildings or other assets should be given compensation equal to their replacement value. Judicious planning of the engineering works could allow settlement to continue on the higher ground provided. This would reduce the likelihood of social and economic displacement, the squandering of cash compensation payment on unproductive expenditures and provide housing with greater flood protection. In high flood risk and densely populated areas, spontaneous settlement on embankments is likely to occur anyway. It would be better to design for it, rather than to assume that it would not happen or could be controlled.

Surveys have been carried out to establish land or assets values based on current market sale values. Allowances of Tk 400 000 has been applied to cover all costs at this stage. If land acquisition and compensation are to be implemented in successive phases, land valuations would have to keep pace with the recognised inflation increase. This may lead to some conflict amongst the local population, unless the valuation basis is clearly understood and agreed with them. Elsewhere, payments for notional losses, such as the disruption and dislocation, are commonly paid, often as a percentage of the total claim based on the quantifiable assets.

Displacement often leads to a chain of secondary impacts and disruption to a number of hidden groups who will be economically or socially vulnerable. These vulnerable groups include sharecroppers and labourers not resident in the affected area who will lose their access to farms or work places, either as a result of the project works, or due to the displacement of families to whom they have been linked by contract or patron-client relationships. The loss of access to economic assets as the means of a family's survival is often of far more significance than the loss of residence site. However, the considerable work and investment in land-raising for settlements means that both factors must be given due attention. If well-planned, compensation and mitigatory provisions can be made for these additional secondary impact problems, and for compensation claims to be lodged for a specified period after the initial displacement.

Avoiding corruption and abuse in all these displacement, compensation and resettlement procedures is a major problem to be overcome. It is in the interest of all parties that procedures are seen to be fair so that the political system retains credibility. Continuity of approach and participation of the affected population are crucial to this process. An early moratorium on land transactions is needed before land acquisition. The monitoring and review of land tenure and ownership conditions and legislation would be important to continue through the remaining planning phases.

A major problem with compensation is that, when self-sustaining assets which provided a livelihood are lost, it is very difficult to replace them. Even in cases where this is possible, there is a time lag during which some affected households become particularly vulnerable. The payment of cash compensation by itself is normally unlikely to provide a sustainable livelihood. It is not until detailed enumeration and socio-economic studies are carried out that policies and strategies can be formulated. Priorities for each household can be very different.

Communal assets are those which have no recognised individual rights attached to them. Most of these are in practice owned and controlled by government, but open access systems still traditional apply. Overall, the range of items might include access to natural grazing and browse, livestock watering points, thatching and craft materials, medicinal herbs and forest products, open access to surface water and river bed resources (physical and biological), communication routes, community structures (religious facilities, tubewells, veterinary and government infrastructure and development projects), future development potential, health and social impacts, and disruption factors. The direct losses to any project might only include a few of these assets.

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Compensation for communal items are likely to be restricted to loss of infrastructure. Any project should unconditionally undertake to provide land, capital and the facilities to relocate lost community assets, whether they be government property or not. Further provision for compensating communities could be in the form of cash payments or selected development assistance. This provision may not necessarily reach the sections of a community who were most affected. The sensitivity of the local political system has to be relied upon to ensure that an overall notion of fairness is satisfied.

Valuation of communal assets is difficult in either commercial or economic terms since these methods cannot reflect the long-term value to society of processes and contributions which local facilities, grazing lands and river ecology make and for which there is no market. The loss of communal assets will intensify the pressure on resources elsewhere in the economy.

11.2.3 Protection of Cultural and Heritage Resources

Palaeolithic sites and other archaeological items might be uncovered or affected by the construction activities. A detailed survey and planning programme for these sites might be recommended after reconnaissance surveys in the feasibility study. Archaeological surveys have not yet been allowed for and should be carried out by professional staff supplied from or approved by the National Department of Archaeology. Preliminary surveys need to identify the possible impacts and to detail the remaining needs for the pre-construction period. In some cases, the source of construction materials may be the same as sites used by other FAP projects in other regions. Whether this work needs to be carried out as part of the SERS, or coordinated under FAP supporting work overall, needs to be clarified.

The RWP would probably not significantly affect cultural resources, as most known sites are already on high ground. However, until detailed project location and design details are known this problem cannot be adequately ranked. The main cultural resources which might be affected would be religious sites, infrastructure and graveyards. To reclaim or preserve the cultural and heritage resources affected before construction work begins could require considerable attention and time. Early consultations will be required with the relevant authorities and local communities to establish if any such sites are sufficiently valuable to warrant a relocation programme. If any graveyards were to be affected, detailed discussions would have to be held with the concerned communities to establish fully their desires. A sensitive and highly personal approach would also be vital to make it clear that the authorities fully recognise the importance of the adverse consequence of the construction works. Wherever possible schemes should be designed to avoid having to disturb such sites.

The changes in lifestyles associated with FCDI projects can lead to a loss in various socio-cultural features of potential importance. These can be mitigated by the promotion and conservation of cultural traditions through encouraging multi-purpose production strategy in the engineering and planning design and by the specific allocation of support resources under the regional plan. This could involve the Ministry of Culture, as well as arts, crafts, educational and media organisations to help establish cultural conservation and educational strategies.

11.3 Regional Employment Strategy

The creation of employment and a diversification of the economy is a major development need. The contribution of the RWP overall is likely to be of some, but not major significance. As such, the focus must be shifted to other sectors of the economy which may have more to offer in achieving government's strategic objectives.

While agriculture will continue to provide the main means of employment for the future the remaining natural resources and their current systems of use offer little scope for major employment generation. The livestock and arable sectors are unlikely to become commercialized systems in the near future, as they are still mainly family enterprises. In order to promote employment in the RWP labour intensive methods would need to be specified for all construction work. This would imply some careful consideration in the case of ICB contracting. Alternative industrial developments are being considered and developed within the framework of the other aid projects and existing commercial interests.

Some possibilities exist for the development of tourism and amenity but would need to maintain the integrity of the important archaeological and cultural heritage sites. Wetland and wildlife sites are unlikely to be more than of specialist and scientific interest, rather than of commercial value for tourism.

11.4 Urban, Industrial and Other Development

It has not been possible to review plans for new urban or major industrial developments in the region. Studies and coordination ought to be carried out at the feasibility stage to ensure that conflicting interests do not arise in the need for future gas or mineral exploration/development, other industrial needs or for the defence needs of cantonment and communication infrastructure. The existing exploited minor deposits of high quality glass and ceramics sand which exist near to Comilla are not believed to be of impact importance. The industries shown in **Figure IV.3.10 of Annex IV**, the existing urban layout and the high density of rural settlements throughout the region do raise serious questions for future water quality and water management.

11.5 Public Health

11.5.1 Nutrition

In spite of the major benefits from FCDI, in terms of the overall increase of food production, there are major concerns for the nutritional impact of FCDI projects. This focuses on the loss in open water fisheries and the potential ramifications of inadequate mechanisms for the equitable distribution of benefits and adverse impacts. The worries are that the poorer and more vulnerable groups have and will be affected dis-proportionately. The access to free sources of the minor species of floodplain fish is believed to have an important role in providing some vulnerable groups with protein, vitamins, minerals, oils and calories. Some of these would be difficult to mitigate without requiring the affected groups to move into raising extra income. The losses have important ramifications for various health problems including general anaemia and lowered resistance, eye problems and difficulties for pregnant and nursing mothers.

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Mitigation could be by three approaches. The first would need a carefully planned and targeted health and nutrition monitoring and action programme integrated with each project. However, as malnutrition is a major national issue, irrespective of FCDI developments, these programmes ought to be part of the general regional development strategy. The second would leave the planning bodies and donors to coordinate and ensure that the general health sector plans were addressing the specific problems which FCDI might exacerbate. The third approach would be for replacement culture fisheries to be placed under the direct control and targeted towards these specific social issues and groups, and not developed or leased as commercially orientated businesses. The practical problems of targeting programmes are probably insurmountable and unrealistic to consider, unless there were a strong political commitment, particularly at the local level.

Specific advice on which mitigation strategy options which should be studied and planned for in feasibility studies will be required. Different strategies would require the inclusion of specialists such as nutrition and public health inputs at the feasibility stage. The relationship of these studies to the research studies being undertaken by FAP 16 will also be important to rationalise and to avoid unnecessary duplication. It is still unclear as to which research studies will actually be carried out.

11.5.2 Disease and Disease Vectors

Current disease conditions are seasonally controlled by the annual cycle of flood events, drainage patterns and the seasonal changes in temperature and humidity. These provide physical limitation on the ability for habitats and breeding cycles to be maintained throughout the year. Certain diseases are favoured by this condition and others are restricted by it. Local micro-climatic changes brought about by dry season irrigation, and by the drying out of the environment through flood control, will alter the balance of habitats and their suitability for, either the existing, or new disease and vector regimes.

The major risks associated with FCDI interventions throughout Bangladesh will be the spread of habitats suitable for the mosquito vectors responsible for malaria, lymphatic filariasis, Japanese encephalitis and dengue virus fever and the sandfly vector of leishmaniasis. Increased populations of biting insects can also lead to skin irritation and infections. Presently filariasis and leishmaniasis are confined to areas in the north west region and malaria mainly to the hill tracts and higher ground of the country. However, a number of confirmed blood slides and deaths are confirmed every year of people in the SER. The risk of a spread of the disease cannot be ignored in feasibility study planning.

Similarly, FCDI projects will change the conditions of waterborne diseases such as diarrhoea and cholera. The prediction of the impact of these health factors is more difficult, as it will depend upon the ability of the designs to avoid poor drainage and stagnant and permanent pools of water. The prevalence of disease is also primarily determined by the quality of sanitation and waste disposal techniques and the access of the population to clean sources of potable water. Thus, with no mitigatory or complementary programmes, the impacts could be either positive or negative. There is a high international and national priority being given to provide people with access to clean water. It would seem appropriate that the RWP should have this as a specific objective of the plan.

Some health problems can be caused by the excessive growth of phytoplankton and aquatic macrophytes. This is usually a symptom of eutrophication and build up of nutrients from decaying organic matter and flows of human and animal excreta, which themselves contain pathogens affecting health. These blooms often occur on a highly seasonal basis soon after there is little or no inflow, turbidity is declining and when water temperature increases. This occurs mainly from late July to early September. The main risk species are the Cyanobacteria, Microcystis spp. and Anabaena flos-aquae. They impart bad odour and taste to the water. Both species can be toxic, even lethal at high concentrations, to people and animals drinking untreated or poorly treated water. In most cases, the effects are sublethal and cause intestinal and dermatological disorders.

There is insufficient knowledge at present to predict, for any particular mix of local conditions and FCDI interventions, when, and if, these changing disease or vector profiles might become a problem. More research is required on the disease and vector species, habitat requirements, seasonal limiting factors and their geographical distribution within the region. There is a scaling problem involved in the thresholds which have to be crossed in terms of species and disease transmission from region to region and area to area. The transformation of habitats would also depend on the scale and proximity of FCDI interventions. The risks and potential future costs are, however, potentially too great to ignore. Proposals under FAP 16 seek to have considerably more research work done on these issues.

11.6 Water Management Planning

FCDI interventions bring many consequences. Some have been anticipated and others will be unforeseen and have unforeseen consequences. Embankments will cut off the supply of water-borne organic materials and organisms brought in with the annual flood from the upper catchment areas. This will leave a new local aquatic ecology reliant mainly on local supplies of organic matter and resident organisms. Meanwhile the lost organic matter will be passed downstream into the estuarine and marine system. Tidal regulators will cut of the ebb and flow of water with as yet unknown affects. Irrigation will spread water over larger areas in the dry season. New health and pest hazards will occur as habitats change. Aquatic weed populations and species composition will change as nutrients build-up in drainage channels and pools from run-off from a densely populated landscape of urban and rural people and their associated industries, farms and livestock. The nutrients, chemicals and pathogens these sources provide also pose a potential pollution problem for the water supplies of downstream consumers. These risks need to be traced and properly managed if problems are to be avoided. Since these phenomena involve macro-scale and localised systems and movements, they cannot be seen simply from a project perspective and require a regional, national and ultimately international planning perspective.

The detailed study of the biological properties and ecological processes of man-made water systems which is proposed is still a relatively new science. However, certain criteria and guiding principles are available to plan with. But, biological controls and ecological management alone cannot be regarded as being sufficient or wholly effective. Only coordinated action involving a number of authorities and strategies will suffice. Any analysis must concern the dynamic ecological, social and economic framework into which the water development programme is to be set. Planned management must ensure that the nature of these processes are properly understood and that the planned interventions contribute to the protection of water quality, public health and development in an integrated way. To achieve these long-term objectives will require considerably more research and testing of plans. It will require the recruitment and training of staff with new backgrounds and education. It will also require an integrated management system to coordinate, supervise and monitor the programme which collaborates with public health officials and social workers.

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The objective will be to reduce risks to public health or poor water quality and to make better economic use of the new productive resources FCDI will provide. To enhance water quality is contingent on how nutrients and pollutants can be managed and extracted from the system. The focus should shift to a closer examination of the chemical, nutrient and energy cycle as a whole. It should examine how this system can be more effectively managed to enhance water quality and economic productivity. Many of the existing nutrients are an organic source of a "free imported or local good" which can reduce the need for expensive manufactured inorganic fertilisers. Pollutants need to be avoided altogether, controlled at source or extracted and disposed of safely in the drainage network.

11.6.1 Channel Morphology, Navigation and Breaches

Continued access for major and minor navigation is crucial to the viability of both community services, commercial and marketing activities and fishing needs. There should be no scheme which does not place navigation criteria on an equal footing to the needs for agriculture. The access for boats applies as much along the coast, as it does from river to floodplain. The needs are for the fishing communities and fish landing, and for general communications and travel. This will require careful survey of routes and landing points use to enable both locks and the careful siting of bridges to maintain the logic of route directions. Wherever structures are located sedimentation problems downstream will need to be dealt with by careful design and operation of the system or by a costed dredging programme and strategies to flush or remove aquatic weeds.

If roads and embankments were well-designed as a continuous system with multi-purpose objectives in mind, they could form a linked system for the movement and management of fish stocks, as well as maintaining lines of access for navigation and evacuation of water hyacinth to open water. Such an approach would involve some redesign to avoid road/bank erosion, but might prove viable when the multiple benefits are taken into account.

Sedimentation problem will also be associated with the confinement of the flood paths of most rivers draining from the Tripura Hills. The construction of any embankments that will contain the natural flood spreading pattern will lead to changing sedimentation, scouring and bank erosion characteristics. The option of containing the flashy rivers from the Tripura rivers has been rejected. This was because of the future problems of scouring and rising river bed levels increasing the flood risk considerably on surrounding land which would have ended up lower than the river. The Gumti river has already been embanked for most of its course. Special care over monitoring this scheme will be needed. Continued dredging may be one option, but disposal of this material will create problems in the long-term. Decisions on how to re-route the river, once rising bed levels create unacceptable high risks need to be planned and taken well in advance of any breaches which would re-route the river in an uncontrolled fashion causing major damage in settled areas.

Embankment breaches and extreme events will likely occur in the lifetime of the project. Coordinated and designed means of removing water quickly from behind coastal and other embankments will have to be considered at feasibility stage as well as the integration of non-structural measures into the plan.

Increased downstream flooding from FC and the costing of adverse impacts has not been specifically analysed in the hydrological or economic analysis. The reason for this is that the analysis only makes sense once a known series and implementation sequence of projects is specified. This will have to be considered in more detail at feasibility stage. As the SER lies downstream of the all the other FAP regions it will be susceptible to their downstream flood effects. Careful phasing of FAP projects would be needed and flood warning system or non-structural measures. It is also clear that interregional planning and mitigation for downstream effects is required to allow proper analysis of these effects.

Induced drainage problems could occur inside embankments. Detailed topographic surveys and drainage planning for small scale drainage structures is required. Continued monitoring of problems in practice (inside and outside schemes) and installation of small structures if necessary after main works are completed would be a recommended mitigation.

11.6.2 Soil Quality and Management

There are a range of minor impacts identified which are likely to occur in very specific local sites. As soil surveys and planning continues these sites might be identified and a selective monitoring programme established. In the longer term improved local soil testing facilities can be set up supported by local extension services. The general loss of fertility associated with intensive agriculture involve the decline or low levels of organic matter. The major quantities of domestic sewage and aquatic weeds available suggest that concerted efforts to develop composting programmes should involve recycling and use of these resources. Protecting the ecological processes that maintain soil fertility are also vital and would involve encouraging crop rotations, minimal use of harmful chemicals and the use of green or livestock manures.

The moisture loss on high ground and homesteads associated with FCDI projects will require the monitoring of water table and impacts. Small-scale irrigation technologies and agro-forestry programmes for homestead farms might be associated with the water supply programme recommended. Where water tables fall, conversion to deeper tubewells would, in any case, be required. This would have the added advantage of avoiding the present health risks known to be associated with polluted shallow groundwater.

11.6.3 Water Quality and Pollution

The water quality problems which may be encountered and should be planned for include algal blooms, pollution from faecal bacteria and pathogens, increase in pest and disease vector breeding sites, agro-chemical pollution of surface and groundwater water sources, industrial pollution, loss of biological diversity and controls reducing water quality problems, and the proliferation of aquatic weeds. The intensity of problems can be expected to increase in drought years and the concentration of nutrients by evaporation is greatest. The intensity of problems may also increase under the influence of FCD because an open draining system has been converted to a closed controlled drainage system. This means that water levels are continuously lower due to the absence or reduction of inflow. Also, micro-topography presents problems of designing a fully effective drainage operation. Reduced flow also means a decline in turbidity which allows a greater depth of penetration of sunlight and a possible stimulation of algal production. This would be further aggravated if fish and aquatic and amphibious organisms feeding on micro-organisms were not managed and protected as part of the strategy.

HYV cropping, induced by FCDI and current extension methods, demands good control of pests and diseases to ensure economic feasibility and debt repayment capacity. Modern agro-chemicals provide the only answer as farming systems support lacks the research and institutional means to extend alternative integrated pest control management systems. Government is already aware of this. Limited research is testing alternative ways to

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protect the environment as agricultural techniques become more intensive. The shift to non-chemical means of pest control are already being adopted in a number of other countries where historic irrigation and mechanised farming schemes have created a range of physical, biological, economic, health and structural problems caused by the excessive and uncontrolled use of agro-inputs.

Bangladesh already uses between 4-5 000 tonnes of pesticide annually. If all farms in the region were to apply agro-chemicals, the long-term risks to local ecology, water quality, the food chain and human health would be considerable and strategically very important. By definition, most agro-chemicals are poisons, often derived from naturally occurring chemicals originally discovered in plant materials. Some are highly selective in their action, others indiscriminate. Some are bio-degradable, others gradually dissipate or are fixed in the soil or water medium. Some can enter and accumulate in the food chain, and many are hazardous to the health of workers, unless strict precautions are taken.

A number of international organisations and pressure groups monitor and release information on dangerous and banned chemicals which have a tendency to be dumped in Third World countries. These include amongst other the Pesticide Action Network, the United Nation's Consolidated List and the FAO's International Code of Conduct. Amongst the most hazardous agro-chemicals banned or severely restricted for use are DDT, EDB, Aldrin/Endrin, Chlordane/Heptachlor, Parathion, 2,4,5-T, Paraquat, DBCP, Lindane/HCH, Toxaphene and PCP. New research is also coming to light that suggests that, even those agro-chemicals passed by the strict standards in the developed countries, may have unacceptable levels of adverse human and ecological toxicity in the environment due to their inter-actions and synergist effects which are features which cannot be measured in the standard trials and testing procedures. There are also considerable problems in Bangladesh with the illegal smuggling of banned and undefined mixtures of agro-chemicals.

It is already known that considerable care is needed in the selection and management of chemicals because of the location of the irrigable areas and the nature and use of the waters entering the drainage system. Harmful effects can feed back through the groundwater system or through the aquatic based food chain. The floodplain aquatic faunal system, particularly fish, crustaceans and molluscs, as well as soil micro-organisms, are sensitive to toxicity. Specialized ecological zone exist in the estuarine and coastal areas which are also sensitive. These sensitivities means that careful monitoring will be an essential part of the routine activities of the MOEF working in close conjunction with the Fishery Department.

It is unlikely that the short-term maintenance of high yields using intensive chemical approaches in agriculture would cover the costs of the long-term loss in the degradation of these other productive resource systems, the potential public health risks, the later need to repair any damage and the resistance to chemicals which is already a well-established phenomena worldwide and in Bangladesh. This would be a typical area where some sacrifice of yields may be advisable while replacing these loss through other productive ventures in paddy culture, such as fish and bullfrog culture which themselves aid pest control measures.

The effects of long-term use on soil and water chemistry, micro-biology and local flora and fauna ecology are poorly researched, but the potential risks should not be ignored. The evidence worldwide indicates that proper planning and guidance to farmers should be carefully prepared based on long-term needs rather than short-term expediency. To do otherwise may disturb important local ecological features and without prior knowledge of the implications. The need for a closer examination of the alternative measures of pest control and maintaining sustainable yield levels should be a high priority for implementation as a rational policy.

Other sources of pollution are the discharges of industry and sewage and waste from domestic sources. These impose both chemical and biological problems with potentially serious health and ecological risks if not planned for and managed properly. Oil-based pollution is spreading with the conversion of the transport, agricultural processing and farming systems to engines. This involves more spillages and exhaust gases. The industrial complexes involving newsprint, tanneries, jute mills, sugar mills are discharging mercury, lead, chromium arsenic and iron into the water network which FCD projects under FAP will be intervene in. Concentrated discharges of sewage greatly increase the biological oxygen demand. All these sources of pollutants seriously affect water quality for the proper functioning of the aquatic, terrestrial and human ecology.

11.6.4 Pollution Management

The management approach should seek to integrate different methods to minimise the conditions which can lead to poor water quality. This would concentrate on physical and biological management techniques to counteract or remove the causes of poor water quality in situ. This would include the protection and stocking of fish and other fauna to encourage the uptake of nutrients, potentially toxic micro-organisms and disease vectors in the food chain. This policy should be encouraged in the main drainage systems, in the fields and in the standing water bodies. Encouragement would be given to systems of harvesting of these fauna and useful vegetation to remove biomass and pollutants from the system. The only sensible measures for the management of industry is for the treatment and payment at source. The setting up of these capacities, both in terms of staff and finances, is a considerable task beyond the terms of reference of this study. The MOEF would be the main body to liaise with donors on these issues.

All agro-chemicals are part of an industrial trade network which actively promotes the expansion of markets and sale. Commercial interests should not be allowed to interfere with good farming practices and preservation of a healthy environment for future resource users. Public education through agricultural research and extension, as well as the role of the media and NGOs, all have a role to play in combating these problems. As part of the FAP project donors could specifically fund and support such programmes.

No FCD schemes should be allowed to proceed to implementation unless their capacity to drain and, if need be, flush areas of potential risk had been carefully studied. Similarly, no schemes should proceed until they have shown adequate analysis of the implications of their agricultural chemical use on the enrichment and degradation of the ecological and economic systems that they may affect, either within schemes, or as a result of passing on problems to downstream areas. The direct effects of schemes on the drainage mechanisms for sewage and industrial pollutants should also be clearly analysed and planned.

Further research into the dynamic interactions with climate, seasons, flora and fauna could establish other biological control and management mechanisms. This research work of ecologists and other specialists should be coordinated under the MOEF. It could call upon the a range of other institutions to assist, such as BRRI, the Fisheries Research Institutes, and the Engineering Research Institutes. International assistance could involve specialists supplied through such organisations as UNEP, IUCN, AWB and ICLARM.

Deterioration of environmental sanitation conditions and the protection of water quality for downstream users are not just responsibilities associated with BWDB projects. Improved public health, sanitation and proper waste disposal provisions in the villages and towns are vital if a deterioration in the quality of life is to be avoided.

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Where embankments intervene in the flood and drainage regime and divert external sources of nutrients and pollutants directly downstream and out into the sea, the impacts on the estuarine and marine resources and economy must be assessed.

Major improvements to sewage disposal, industrial pollution and agro-chemical pollution would be advisable with or without the RWP and must be seen as a complementary programme. Nevertheless, pollution planning data is virtually non-existent and feasibility study provisions to collect relevant data should be considered, as well as the urgent needs for direct support to a proper regional and national monitoring and training programme.

11.6.5 Wetlands and Aquatic Flora and Fauna

The remaining wetlands sites have a number of potentially important roles apart from their productive use in water supplies and crop production. They maintain an important habitat for a diversity of aquatic flora and fauna and provide sites for resident and migratory birds.

Detailed research is required into the role of aquatic flora and fauna. This should include research into the life histories and habitats of those major and minor species which are valuable as a source of economic products, poor people's protein, vitamins and oils, and which provide important biological controls on pests and diseases.

Fisheries already play an important role in providing employment, generating exports, enhancing water quality, sustaining public health and aiding nutrition for the poorer groups. Various indigenous species readily consume vegetable detritus, eat the algae responsible for undesirable blooms, control the growth of water weed, and eat pest and disease vectors which affect humans and livestock. Apart from the locally consumed range of minor species and the commercially marketed major species of fish, there are other important economic aquatic fauna which sustain livelihoods. Crustacean shell materials are already used in lime making and major new industrial uses for crustacean shells are being developed based on chitin and its products. There are many potential uses in the chemical, medical, pharmaceutical and food industries whose economic values could be a significant loss if habitats and bio-diversity were threatened by short-sighted FCDI planning. Some of the most notable uses being developed are their roles as food preservatives and their applications in the treatment of sewage, paper mill effluent, food factory waste and purification of water. In the medical field it has been found to have uses in accelerating wound healing and for skin grafting. The cosmetic industry has found uses for chitosan as have the hi-fi and acoustic industry.

To sustain the varied forms of survival strategies, commercial opportunities and feeding systems which minimise disease and pest problems is vital, and should not be threatened by FCDI development. While the data base is limited, the important areas which could be identified have been have been included in the zoning plan. Integrated management for economically and socially important aquatic fauna is mainly based on the preservation of suitable habitats and the avoidance of pollution or over-exploitation. The approach taken has encouraged the maximum research into the engineering and regional planning options for maintaining these. The main possibilities are shown below.

- Engineer the means to maintain the capacity of migratory species to move from floodplain to river. The viability of this appears uncertain. Effective management planning would require a better understanding of the ecological and engineering requirements of the major and minor species.

- Engineer the means to maintain the capacity of resident floodplain species to move from beel and khal to floodplain through flood management criteria that allow for this and to integrate these systems with paddy culture and integrated pest management systems. The viability of this is more likely.

- Specifically allocate minimum wetland and floodplain sites within schemes to be fisheries development areas in the main flood season, but still allowing rabi and boro cropping on suitable lands. The viability of this appears certain, but would need careful design, a political commitment and would imply a trade-off with crop production in limited seasonal areas. As development has not already occurred, this trade-off is only notional and would not be any loss to current farming. It would imply a loss if the policy were introduced into the existing FCDI schemes. This aspect would require more detailed study.

- Specifically reserve areas within the region that would never be brought under flood control so as to maintain reserves for open water fish systems, bird habitats and to sustain the aquatic bio-diversity. These areas would mostly be the deeper flooded zones closer to the main rivers and would still have the capacity to continue with their current cropping systems. They could also be the more expensive areas to develop for full FCD and could be used for flood storage under any national FAP strategy.

Whether to maintain selected deep flooded zones as protected areas is a fundamental question which policy makers must answer for the feasibility study stage. The present evaluation indicates that it is unlikely that embankment works and structures could effectively offer solutions which could sustain the present open water fisheries and wetland ecology system and its inherent species diversity. Thus, this may be the last occasion when this type of alternative could be seriously looked at. The allocation of conservation areas to maintain integrity of original habitat and floodplain systems should be registered under the Protected Areas Network under the NEMAP. Improved conservation and management programme are required integrated under national management approach with defined priorities for each set of regional sites. Loss of species will needs to have an extended field survey capacity and gene bank programmes. Further works would also be advisable through national and community environmental education programmes.

11.6.6 Aquatic Weeds

Most of the common aquatic flora have been recorded in the watercourses around the region. The most important problem is water hyacinth and the blockage to navigation channels it creates. In heavy concentrations it can lead to de-oxygenation of the water body, threaten the viability of aquatic flora and flora (particularly fish) and create human health problems. These sites are often associated with nutrient enriched water, areas of poor drainage and where obstructions impede flushing. Otherwise, various species are present in water bodies throughout the region, but are flushed out with the annual floodwater and die and decay rapidly in the saline water of the estuaries.

In spite of its voracious growth characteristics and classification as a problem weed which is virtually impossible to eradicate, it also has many existing productive and future potential uses. It is used for livestock fodder, organic fertiliser, floating seedbed nursery and fuel. Its high cellulose content makes it useful as a raw material for industry. Its ability to rapidly absorb nutrients and chemicals (including heavy metals) in the water system give it a potentially important role in controlling the over-enrichment of water bodies. It could also be used for the extraction of some industrial pollutants at source and allow for their safer disposal.

In productive and navigation areas, and in water routes controlled by structures, it is important to control its presence. The current system is based on hand removal and the natural flushing of drainage channels in the floods. Any system which blocks these routes will inevitably face the problems of removing the backup of floating weed vegetation. Either the drainage systems have to be designed to let this flow of material through directly or through a bypass channel, or else specific development projects should be sited at these blockage locations to make use of the material which will accumulate there. These could be small-scale industries either making fertiliser or creating the raw material for composting, craft materials or industrial cellulose purposes. Research, education and a support programme for economic utilisation of prolific water weeds could be designed at the feasibility stage.

11.7 Research and Management Coordination

The considerable scope of future work in the field of environmental management and monitoring will require a properly established and coordinated units of trained staff within the MOEF and the BWDB. At the present time there is a considerable reliance on consultants to carry out one-off studies. While it may be possible to rely on the inputs of international and national consultants for some initial planning surveys and studies, this approach should only be a short-term strategy. The long-term work requires daily coordination and development by personnel properly trained in the fields of environmental monitoring, planning and management. The major thrust of overall coordination should rest with the MOEF, but the BWDB should have the responsibility to bring its planning and design criteria up to the standards which reflect this more comprehensive and inter-linked approach to water resource development. The BWDB already has responsibility for monitoring various water variables important to the overall planning.

Recommendations have already come from the MOEF for environmental cells to be set up within the main government institutions. The minimum requirement would be for one senior management post within each region to allow the coordination and supervision. This post would need to be supported by field staff to carry out sampling and monitoring work. The questions of the full institutional staffing, facilities and management systems are not within the scope of the terms of reference of this study. The content of the next chapter will have some relevance to the final approach which might be adopted in each organisation.

11.8 Consultation and Public Participation

It is important that the future planning procedure incorporates a major element of public participation and liaison at all levels. The present study has done this to a limited degree. Once some policy reaction has been indicated as a result of this study report, then the major affected parties can be drawn into the continued planning and future implementation. This would include administrative, political, media, NGO and community representatives. The basic structural and non-structural provisions and problems of land acquisition and compensation will initially need careful consideration. Later, in the feasibility stage, close liaison and coordination with other departments who would be involved in the execution would be necessary.

CHAPTER 12

ENVIRONMENTAL MONITORING, TRAINING & FUTURE STUDIES

12.1 Aims and Objectives

This study has found insufficient basic research analysis and data to allow an appreciation of the likely magnitude of changes in key parts of the ecological and socio-economic systems. Current levels of basic monitoring and the availability of trained staff to carry out environmental monitoring are also in short supply. Further research and analysis will be needed to confidently assess how FCDI should be operated and effectively managed to mitigate adverse consequences and protect the environment.

The primary aim now is twofold. First, to ensure that adequate baseline studies are carried out during this feasibility phase, and before any final decisions on implementation of a final programme. This work will be mainly carried out probably by consultants and will draw together in greater detail the available data base. Second, to feed this programme into a longer term institutional monitoring programme. Both approaches should establish sufficient baseline data to catalogue and model the "before project" situation. It would then develop a capacity to detect and monitor change and assess the implications of this change. As a result, it ought to be able to advise, on an on-going basis, the actions necessary to offset any foreseen and, as yet, unforeseen adverse consequences arising from projects. The monitoring programme should also serve to refine the mitigation strategies as they are currently identified, given present knowledge.

Without trained staff and proper facilities being immediately available, this programme will take some time to establish. The major expenditures will be for training programmes since international resources will have to be relied upon in the initial stages to create a core of local staff who can take over this training function. Some limited investments in field and laboratory facilities will also be required.

The objective of the programme will be:

- to provide the operational facilities, personnel, technical and analytical skills, and the necessary finance to identify any adverse changes in the structure and quality of the environment which might threaten the self-sustaining nature of the resource base or the quality of the resources in current use.

- to provide the means to increase the database on, and understanding of, natural seasonal and annual fluctuations in key environmental parameters and inter-relationships.

- to provide the means of reporting to the relevant government authorities and the public the changes in environmental conditions brought about by the increasing interventions with the biological, chemical, physical and hydrological systems.

- to provide one mechanism whereby the management of a variety of currently isolated project activities within the floodplains and catchment may be brought together and an integrated resource management capacity installed to protect the interests of future generations of resource users.

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12.2 Benefits Expected

The benefits of providing the necessary finance and resources for monitoring will include the means to assess water quality and management of supplies for potable uses and for irrigation and fishing in a project area. It will provide the means to monitor conditions outside project areas where other downstream river, estuarine and marine users and ecology may be affected. It will also identify the management needs for important wetland and river bed resource users and ecology. Competing demands do, and will, exist between some of these categories. The monitoring programme will help identify the nature of the minimum needs required by these various groups to maintain future development potential and conservation of resources. The monitoring programme will also help identify the main sources of pollutants and ensure that a programme of pollution control at source can be instituted. This will help ensure that the real costs are borne by the polluters and do not become a hidden cost paid by other sections of society. It will also ensure that industrial producers, in time, price their goods at the true market values which would include the pollution protection costs.

12.3. Institutions Available

Under the current system the institutions which are responsible and available for monitoring are as follows:

SUBJECT AREA	INSTITUTIONS INVOLVED
WATER	
Water Tables	BWDB
River Flow	BWDB
Sedimentation and Morphology	BWDB & SPARRSO
Climate and Rainfall	BWDB & Department of Meteorology, MOD
Navigation	BIWTA
POLLUTION	
Potable Water Quality	Dept Public Health Engineering, MOLGRDC
Water Quality (biological & chemical for major towns and rivers	DOE, MOEF
Pollution Sources (industrial)	DOE, MOEF
Pesticide Research	Plant Protection Division, MOA
Pesticide Residues (limited capability)	DOE, MOEF
Atmospheric (occasional)	DOE, MOEF
Soil Quality	Soil Research and Development Institute (SRDI)
HERITAGE	
Archaeological Sites	Dept of Archaeology, MOCS & National Museum

BIOLOGICAL

Wetlands	Revenue Department, MOLGRDC & Natural History Dept, National Museum
Forests & Forest Products	Dept of Forests, MOEF
Flora	University Depts of Botany, National Herbarium
Fauna and Birds	University Depts of Zoology, Life Science Institute (JU), National Zoological Garden
Fish	Dept of Fisheries, MOFL
Endangered Species	MOEF, BRRI, FRI, WWF & IUCN
Wildlife	Wildlife Advisory Board, MOA

There are also a number of private agencies, NGOs and societies with particular or general interests in the field of general conservation and environment:

Bangladesh Centre for Advanced Studies (BCAS)
Bangladesh Wildlife and Nature Conservation Society (BWNCS)
Bangladesh Bird Preservation Society (BBPS)
Bangladesh Academy for Rural Development (BARD)
Bangladesh Institute of Herbal Medicine
Barind Protection Society (BPS)
Centre for Development Research (CDR)
Coastal Area Resource and Management Association (CARDMA)
Fisheries Society of Bangladesh (FSB)
Forum of Environmental Journalists (FEJ)
Friends of the Earth - Bangladesh (FOEB)
Nature Conservation Society (NCS)
Society for the Protection of the Environment (SCOPE)
Society for Conservation of Nature and Environment (SCONE)
Wildlife Society of Bangladesh (WSB)
Zoological Society of Bangladesh (ZSB)

12.4 Socio-economic Surveys for Resettlement and Compensation

Numerous FCDI impacts have already been felt in the region. The RWP will extend and intensify these and affect many central linkages in the operations and structure of the social and economic systems. Some of these will have important political and social ramifications which government should be aware of. Socio-economic studies can assess the key areas where the planning and implementation of the programme might cause hardship and a re-structuring of the social and economic framework.

Socio-economic research (as opposed to monitoring) is currently carried out by a number of research institutes and project consultancies on an ad hoc basis. These give a good general data base for a number of areas and issues in the region. The needs of the next planning phase will become specific to particular project areas and type of interventions. The feasibility studies will need to carry out some semi-detailed socio-economic survey and inventory of private and communal assets of areas where land acquisition, resettlement and compensation

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may occur. This will provide important data on costs and planning options to help optimise amongst project alternatives at the feasibility stage. These surveys would also form one benchmark for future monitoring, if projects went on into detailed design and implementation. It would be preferable that these surveys be supported by new air photography to correlate sample household data with land tenure arrangements and cadastral data.

12.5 Culture, Heritage and Archaeology

National research capacity to follow up on the historical and archaeological heritage is limited by the pressure on their scarce skilled resources. It would be preferable to integrate the research under an on-going programme which incorporates it into the scope and understanding of the history and significance of the whole region.

12.6 Water Resources

Detailed discussion on groundwater and surface water modelling are discussed in Annexes V and VI. In general, the groundwater model and monitoring is adequate to assess likely physical impacts at the macro, but not local level although this should improve with time and with more detailed study. The available monitoring is less coherent for assessing the full range of water quality issues which might affect potable water supplies and the use of groundwater for irrigation and its impact on fisheries and lowland ecology. A considerable amount of analysis has been undertaken by the IDA Deep Tubewell Projects that is relevant to part of the project area.

The understanding of surface water impacts suffers from a lack of monitoring sites and modelling reliability on the floodplain and in the wetlands to assess ecological implications. A few isolated studies and some ad hoc sampling by the DOE have looked into water quality issues in selected locations. Regular monitoring of surface water supplies is desirable and Figure 12.1 proposes some typical sites where this would cover the issues of monitoring pollution from industry, sewage and agro-chemicals. This programme should be coordinated under the DOE once its institutional strength has been improved.

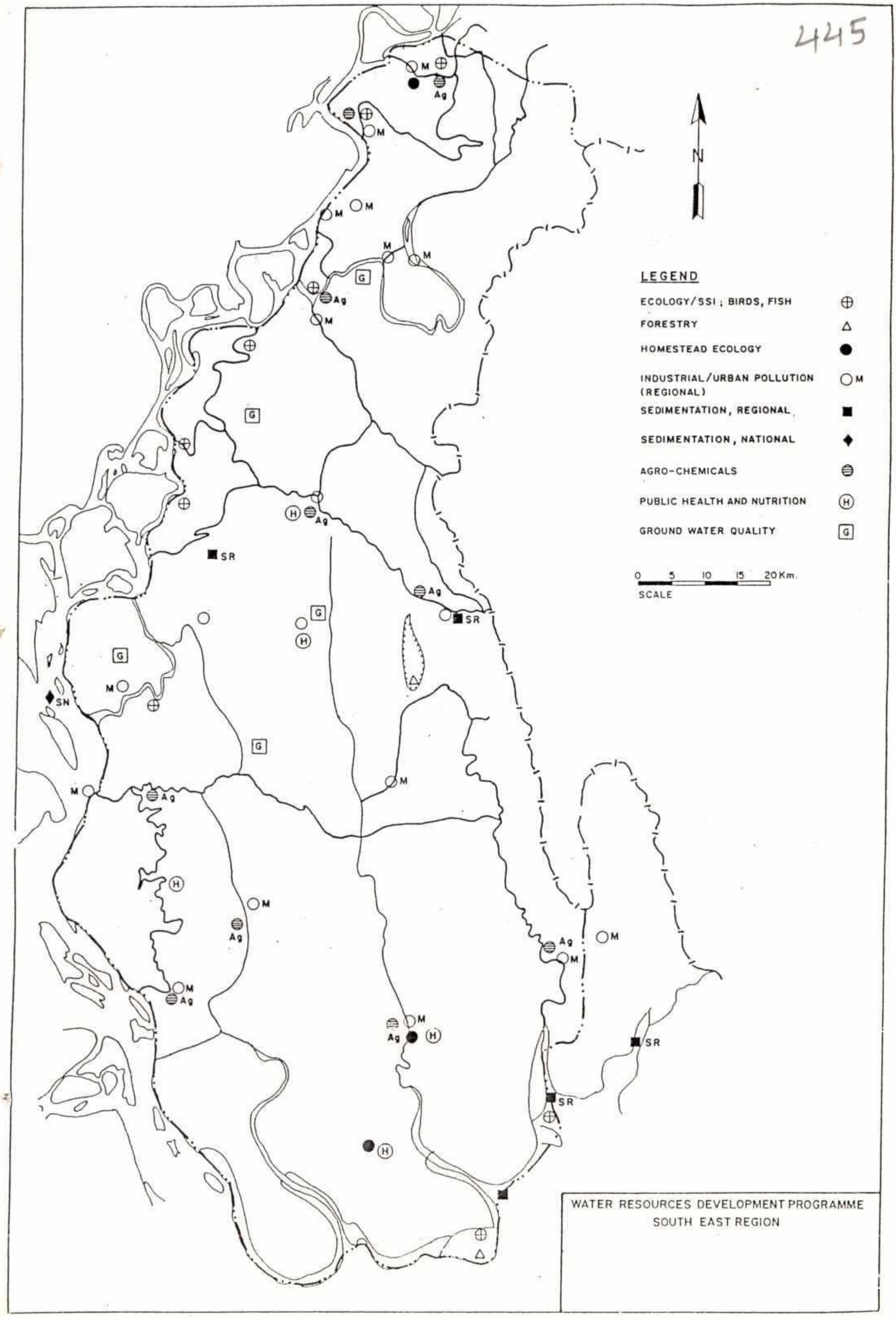
The key characteristics of morphology and sedimentation in lesser rivers should be dealt with by BWDB. The monitoring of channel sedimentation as it affects navigation is already an on-going planned responsibility of BIWTA. Marine and freshwater navigation paths will have to be carefully surveyed during the feasibility surveys and give special attention to internal routes within schemes, as well the more obvious major routes used by larger boats and ferry/commercial services. Close liaison is required with them to ensure that any RWP structures, drains and canals can maintain or even enhance access for navigation. The Gumti river has already been embanked for most of its route to the Meghna confluence. There is a need for a continued and careful monitoring programme to track the rate of scour and bed rise along the confined channel. This is the direct responsibility of BWDB.

12.7 Ecology

The surveys during this study found that the relative importance and distribution of the natural and lesser known economic terrestrial and aquatic flora and fauna of the area are poorly known. Although this study has provided a general list of known species, significant gaps remain. Basic information on the dynamics of the chemistry, micro-biology and productivity of the systems is lacking. More detailed surveys will be required if these issues are to be addressed in the feasibility planning stage. However, the minimum required will be monitoring over

Figure 12.1

Environmental Monitoring Sites



one year to cover the main seasonal variations. This would not allow the implications of annual variations to be assessed. Thus, the contribution of feasibility surveys in these areas will be extremely limited. The best that could be done would be to undertake a structural survey of habitats and species types with basic biological and chemical parameters specified for the time of survey. If this approach is to be adopted as part of the SERS, additional resources will be required to provide the botanical, zoological, micro-biological and chemical specialists and laboratory facilities to enable the study to carry out rapid identification and assessments in the field and follow this with proper analysis and interpretation. The scale of this programme would depend on the number of project sites select for feasibility study and the complexity of the habitats and potential impact areas in each.

The importance of the wetland and estuarine/coastal ecology and its major fisheries has been stressed. Little is really known of how this system operates and maintains itself and how the fluctuations in the water levels, extreme climatic events and impact of FCDI and agricultural inputs influence the system. Basic ecological research is required to allow further understanding on the dynamics and regenerative processes which control the development and survival of these ecology systems and their relationships to agricultural production and human health.

The status of research studies recommended under FAP 2, 5 and 16 are not known as yet, but these have recommended a number of representative sites where research and monitoring should be undertaken which includes sites in the SER. It has yet to be determined who would carry these out. In the longer term this ecological and habitat monitoring work should fall under the general coordinating control of the MOEF. They would require the assistance of research institutions, such as IUCN, WWF, ICLARM, BRRI, the various local NGOs and the proposed environmental cell of BWDB. These could provide monitoring and data in their own specific areas of interest. One example would be the monitoring of population trends in the remaining wetland and coastal sites for migratory birds and the impact of development and noise pollution from irrigation pumps. Some of this work can also be encouraged through research grants to university students as the environmental training systems evolve. The basis of this work is, by nature, inter-disciplinary and process orientated. This implies the need for a strong institutional and academic support service.

More information is also needed on the functional relationships between the wetland and floodplain ecology/habitats and the groundwater aquifers. How much water moves laterally and how far? How dependant is the lowland ecology on water levels in the river channels or draining from higher groundwater? What sorts of feedbacks exist between the wetland ecology and the field and human ecology system? How much organic matter from the floodplain ecology enters the river system and visa versa, and what is its contribution to soil fertility and crop productivity? How important is agro-chemical and industrial pollution in affecting the quality of the river and groundwater water or bottom sediments?

Little or no information is available, even though the problems have been long identified. Research aimed at answering some of these questions should be encouraged and should form a major national research objective. These are all beyond the capacity of feasibility studies to address and can only come from longer term and detailed research and monitoring. The priority areas to monitor are the critical wetland and fish habitats, the remaining forest area, the sites of freshwater mollusc extraction, the impacted areas at the major FCDI schemes, the Meghna and Feni estuarine zones and the coastal mudflats.

12.8 Water Quality

Water destined for domestic, fisheries, irrigation and estuarine use must be of sufficiently good quality to maintain productivity and a basic quality of life. This involves standards that require minimum physical, chemical, biological criteria to be met. There is much concern over the imposition of too high a set of standards in poor countries like Bangladesh which may incur high costs to achieve. There is therefore some demands from politicians and planners to seek to reduce standards set in the developed countries which are more appropriate to the local financial constraints. However, this may be false economy as the costs of the degradation to productivity and the quality of life may end up costing the country and health system far more in the long-term. The crucial issue is to aim to understand what the minimum requirements actually should be. On this issue there is no simple answer and the debate is still strong worldwide. Draft water quality standards were issued by the MOEF in July 1991.

The most cost-effective approach, which can immediately be followed, is to ensure that there is a coordinated and integrated approach to water management between various sectors and built into the design criteria of projects and that the primary quality indicators are monitored. This means that the processes which lower water quality and introduce human, floral and faunal health-related problems need to be identified, understood and the systems managed to avoid or minimise these problems.

The current management approach is not sufficiently integrated and is reactive, rather than pre-emptive (i.e. actions taken to maintain or enhance water quality are generally implemented in response to declines in water quality to unacceptable levels even if these were known). Moreover, the actions which might be taken appear to treat the problems as physical and chemical ones, rather than as ecological or overall resource use management issues.

Effective management requires first, that the kinds, amounts and timing of the inputs are known (the object of monitoring) and secondly, that there is a realistic plan for the management of the catchment, which is able to affect the inputs. Regular monitoring is needed to establish the direction, rates and magnitude of any changes in the levels of nutrients and other biologically active substances in the system. Monitoring of selected biological variables is also necessary in order to provide some index of response to any physical-chemical changes. Since most water quality problems arise from high inputs of sediments, nutrients, sewage, agro-chemicals and industrial wastes, monitoring of these inputs is essential to detect any changes and thereby provide advance warning of potential problems. Potential sources of these substances need, on an on-going basis, to be identified, evaluated and, where possible, controlled through legislation on controls at source and by sanitation and public health and educational programmes. In view of the sensitivities of the aquatic fauna to pesticide levels and use the ability to measure residues through a monitoring programme is vital. This facility is very restricted in Bangladesh at present.

It is recognised that the full range of sources are diffuse and difficult to manage and that the programme will take many years to implement. But the longer that the problems are not seriously addressed, the greater the impacts will be as population, agricultural and industrial development proceeds.

12.9 Health

The major risks to public health discussed in the evaluation are not subjects directly for BWDB to monitor. But unless the conditions before and after interventions are monitored under careful supervision, and in close liaison with the other research elements, it will be difficult to tie the individual research results together. Baseline surveys by the Ministry of Health using its research institutes are advisable as part of the planning process.

The baseline surveys must determine the current status of the vectors and disease and trace the likely paths of impact of FCDI to help the final project design to fully mitigate and avoid future problems. Basic monitoring should then continue to test the various models and examine, in practice, what happens in each location. It should trace the thresholds which are reached as more and more geographical locations come under the influence of the various FCDI interventions. The surveys should also test for the possible transmission of the disease that could be brought into the area during the construction activities and identify the occupational health units which will be required during the construction operations.

The most important factor in promoting a healthy environment during and after construction is the on-going programme of health education to make people aware of any new risks that they may face as a result of the interventions. This must be directed towards two distinct target groups - health professionals and the general public. Health professionals require specific in-service up-dating in the new potential health hazards, their epidemiology, prevention and treatment. The general public requires a less technical and less formal programme of health education. This should be designed to explain in the most appropriate ways the possible health hazards, the means of recognizing them, the ways of avoiding them when they do occur, and the availability and (when appropriate) the urgency of treatment. This programme should be designed during feasibility study phase so that the health sector has the opportunity to respond in a coordinated way with the various activities of the BWDB.

These are studies that should be carried out to support all future projects. The availability of data and planning needs in time for feasibility studies could be a major limitation unless feasibility studies are given adequate resources to carry out the necessary studies at the project level.

12.10 Training Requirements

BWDB has recently started to change its approach to water resource development away from an engineer-dominated attitude with little co-operation undertaken with other agencies although all its staff are engineers it employs no specialists in the natural or social sciences. It has cooperated with the Department of Forestry to test out tree planting on embankments, with the Department of Fisheries, in BWDB controlled water bodies, and with landless co-operatives and women in earthwork construction and maintenance.

The question of training should first address the employment strategy which BWDB intends to follow in the future. If it did not recruit non-engineering staff then environmental training needs would be considerably different from those required of BWDB if it did. Many of the fields of environmental management require direct access to teams of inter-disciplinary specialists and multi-disciplinary analysts. If these people were not available in BWDB then much closer direct links would have to be set up with the MOEF which does intend to recruit such staff in the future.

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The first level of training would need all engineering staff entering BWDB to be made aware of the linkages which BWDB work has with other sectors and the social and ecological responsibilities which water resource interventions imply. This can be dealt with by induction courses. For those staff already in service, annual orientation and regular refresher courses can be held. The preparation and delivery of these courses are best prepared through a multi-disciplinary approach involving a range of competent and knowledgeable social, economic and natural scientists, together with people with planning and engineering backgrounds. Once a basic portfolio of material is ready its presentation has to be made appropriate to the age, educational backgrounds and level of responsibility of the participants who will be involved. These course materials then only need some reviewing on an annual basis to improve and update their content on the basis of the experience in use and changing circumstances in the country.

The second level of training would use actual projects in various stages of planning, design, construction and operation as research case studies to identify key issues of concern and where major strategic or tactical re-thinking is required on historic BWDB approaches to water resource planning. These issues would have to be professionally researched and prepared for use in seminars and workshops. This would involve a research programme calling in various research institutes to collect data and make case study material available in a suitable format for educative discussions, usually over a two to three day period. This type of training is most fruitful when the researchers and training facilitator coordinate the topic material with field trips that expose the participants to the actual field sites/habitats and communities where the problems are arising. The critical debates have to be carefully summed up and conclude with the identification of potential solutions and new ways of approaching the design and operation of the particular facet of concern.

First this general approach to training it would be necessary to consider either the re-training of engineers in other subject fields, or training new specialists to enter BWDB employment. There are three main areas where this could be necessary:

- the creation of professionals to staff an environmental cell who, in the future, would be able to become legally registered as competent to carry out EIA on behalf of the BWDB for presentation of projects for environmental clearance through the MOEF. The alternative to this is for BWDB to continue recruiting consultants to prepare these EIAs for them.

- the creation of a body of environmental scientists (physical, natural, social and economic sciences) capable of carrying out field research to enable environmental considerations to be fed directly into the planning and design of BWDB projects and to establish a coherent ecological and socio-economic database and models. This work could be carried out both in BWDB and the MOEF in a coordinated fashion or the work could be left solely with the MOEF. The less coherent approach would be to continue to have ad hoc surveys and research through consultants and university research.

- the creation of field officers trained in the skills of monitoring key environmental indicators to ensure that each region had a consistent monitoring capability. Again this could be carried out alongside and complement the work being proposed in the MOEF or can be left to them alone. This work is not most appropriately done by consultants as it requires permanent facilities and staff presence on a long-term basis.

The training requirements for these subject fields are quite different. There is currently no institutional training capacity in Bangladesh for EIA. However, private local organisations, such as BCAS, could offer this facility in conjunction with their international networks and linkages. This facility could also be offered through training budgets which brought international trainers into the country or else took students out to overseas training courses. Typical institutional locations for such training are available, for example, through the IUCN in Switzerland, at Wye College at the University of London and the University of Aberdeen in Scotland. There are also a number of private international companies who offer services in EIA training.

The second area requires an extension of basic specialist university science training to encompass the new fields of research coming to the fore in modern environmental studies. The most obvious gap is that there are no courses or training available in ecology and environmental pollution. Dhaka University does offer degree courses in environmental management. Funding to address these issues would take some years to organise and produce a sufficient cadre of staff. Thus, in the meantime, it will be necessary to set up scholarships to have more people trained overseas until the local facilities can be created. The former strategy should receive the priority in this approach with the overseas component only seen as a short-term stop-gap measure.

The third area of monitoring skills is less difficult to deal with as, within the scope of existing institutions, this type of training should be possible to organise, if the funds and commitment were made available.

12.11 Financing

The estimation of training and other environmental management costs has not been possible at this stage as there are so many policy and strategic issues on which decisions are required by the BWDB, MOEF and the donors. These issues will have to be taken up in more detail in the feasibility planning stage.

There are many issues raised which concern the future studies required to enable a coordinated approach to feasibility surveys if future projects are to be taken straight on into the detailed design and tendering stages. These include:

Compensation and Resettlement Studies
Ecology Studies
Water Quality
Pollution Monitoring
Archaeology Studies
Sedimentation Studies
Public Health Studies

The costs of these will depend on the projects selected for study, the area they cover and their complexity. These aspects should be given greater emphasis and resources at the outset of the studies than was the case with FAP 5.

GLOSSARY OF TERMS AND ABBREVIATIONS

ACE	Associated Consulting Engineers Ltd.
ADB	Asian Development Bank
ADP	Annual Development Plan
AEZ	Agroecological Zones
Aman	Summer monsoon rice crop
AMD	Agriculture Marketing Department
ASR	Agriculture Sector Review
AST	Agricultural Sector Team
ATAP	Annual Technical Assistance Plan
Aus	Later winter/early summer rice crop
AWB	Asian Wetland Bureau
Baor	Ox-bow lake
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARD	Bangladesh Academy for Rural Development
BARI	Bangladesh Agricultural Research Institute
BB	Bangladesh Bank
BBPS	Bangladesh Bird Preservation Society
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Centre for Advanced Studies
BCR	Benefit Cost Ratio
BDW	Broadcast Deep Water
Beel	Permanent water body
BFDC	Bangladesh Fisheries Development Corporation
BFRI	Bangladesh Forest Research Institute
BIHM	Bangladesh Institute for Herbal Medicine
BIP	Barisal Irrigation Project/Bhola Irrigation Project
BIWTA	Bangladesh Inland Water Transport Authority
BJC	Bangladesh Jute Corporation
BJMC	Bangladesh Jute Mills Corporation
BJRI	Bangladesh Jute Research Institute
BKB	Bangladesh Krishi Bank
BM	Baor Manager
Boro	Winter rice crop
BPDB	Bangladesh Power Development Board
BPH	Brown Plant Hopper
BPS	Barind Protection Society
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRE	Bramaputra Right Embankment
BRFE	Brahmaputra Right Flood Embankment

GLOSSARY OF TERMS AND ABBREVIATIONS (CONTD.)

BRRI	Bangladesh Rice Research Institute
BS	Block Supervisor
BSCIC	Bangladesh Small and Cottage Industries Corporation
BSIC	Bangladesh Standard Industrial Classification
BTS	Bangladesh Transport Survey
BTMC	Bangladesh Textile Mills Corporation
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
BWNCS	Bangladesh Wildlife and Nature Conservation Society
CA	Catchment Area
CAD	Command Area Development
CARDMA	Coastal Area Resource and Development and Management Association
CARE	Cooperation for American Relief Everywhere
CBR	Crude Birth Rate/California Bearing Ratio
CCB	Cenchuri Beel
CDR	Centre for Development Research
CDSP	Char Development and Settlement Project
CE	Chief Engineer
CEA	Canadian Executing Agency
CEP	Chief Engineer, Planning
CEP	Coastal Embankment Project
CIDA	Canadian International Development Agency
CIP	Chandpur Irrigation Project
CIRDAP	Centre on Integrated Development for Asia and the Pacific
CSD	Central Storage Depot
CVDP	Comprehensive Village Development Programme
CWASA	Chittagong Water and Sewerage Authority (see WASA)
DAE	Department of Agricultural Extension
DANIDA	Danish Development Agency
DD	Deputy Director
DDP	Delta Development Project
DFC-I	Drainage and Flood Control Project (Phase I)
DFC-II	Drainage and Flood Control Project (Phase II)
DFR	Draft Final Report
DGF	Directorate General of Food
DHI	Danish Hydraulic Institute
DOC	Department of Cooperatives
DOF	Department (or Directorate) of Fisheries
Doincha	Sesbania sp. a crop used for green manure, fodder and firewood
DPEC	Department of Project Evaluation Committee
DPHE	Department of Public Health Engineering

GLOSSARY OF TERMS AND ABBREVIATIONS (CONTD.)

DPS	Directorate of Planning Schemes
DsHTW	Deepset Hand Tubewell
DSPEC	Departmental Special Project Evaluation Committee
DSSTW	Deepset Shallow Tubewell
DTW	Deep Tubewell
DW	Deep Water
DWASA	Dhaka Water and Sewerage Authority (see WASA)
EC	European Community
EC	Executive Committee
EC	Electrolytic Conductivity
ECI	Engineering Consultants International
ECNEC	Executive Committee for the National Economic Council
EIA	Environmental Impact Assessment
EIP	Early Implementation Project
EIRR	Economic Internal Rate of Return (IRR)
EMP	Environmental Management Plan
EPCB	Environmental Pollution Control Board
EPI	Extended Programme of Immunisation
EPWAPDA	East Pakistan Water and Power Development Authority
ERD	External Resources Division/Economic Relation Division
Eto	Evapotranspiration
EV	Extreme Value
FAO	Food and Agriculture Organization
FAP	Flood Action Plan
FC	Foreign currency
FCD	Flood Control and Drainage
FCDI	Flood Control, Drainage and Irrigation
FEC	Foreign Exchange Component
FEJ	Forum of Environmental Journalists
FFW	Food for Work
FFYP	Fourth Five-Year Plan
FiFYP	Fith Five Year Plan
FIR	Farmgate Irrigation Requirement
FMT	Force Mode Turbine
FMTW	Force Mode Tubewell
FOEB	Friends of the Earth - Bangladesh
FP	Floating Pump/Family Planning
FPCO	Flood Plan Coordination Organization
FRI	Fisheries Research Institute
FS	Feasibility Study
FSB	Fisheries Society of Bangladesh
FWA	Family Welfare Assistants

GLOSSARY OF TERMS AND ABBREVIATIONS (CONTD.)

FY	Fiscal Year
FYP	Five Year Plan
GCA	Gross Cropped Area
GDP	Gross Domestic Product
GEPA	(West German Organisation)
G-K	Ganges Kobadak Project
GMFR	General Marital Fertility Rate
GOB	Government of Bangladesh
GPA	Guidelines on Project Assessment
GRP	Gross Regional Product
GSB	Geological Survey of Bangladesh
ha	Hectare
Haor	Deep lake (structured depression)/low-lying river backswamp
HTW	Hand Tube Well
HYV	High Yielding Variety
IAM	Investment Analysis Model
IAPP	Intensive Aus Production Programme
IBRD	International Bank for Reconstruction and Development (World Bank)
ICB	International Competitive Bidding/Investment of Corporation of Bangladesh
ICPP	Intensive Crop Production Programme
ICDDRB	International Centre for Diarrhoeal Disease Research of Bangladesh
ICLARM	Internationl Centre for Living Aquatic Resources management
IDA	International Development Agency
IDP	Infrastructure Development Project
IECO	International Engineering Company
IEE	Initial Environmental Evaluation
IFAD	International Fund for Agricultural Development
IBRD	International Bank for Reconstruction and Development (World Bank)
IMED	Inter-Ministerial Evaluation Division
IMP	Irrigation Management Programme
IMR	Infant Mortality Rate
IRCP	Intensive Rabi Crop Programme
IRDP	Integrated Rural Development Programme
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ITAP	Intensive Transplanted Aman Programme
ITCZ	Inter Tropical Convergence Zone
IUCN	International Union for the Conservation of Nature and Natural Resources - The World Conservation Union
IUD	Intern-uterine Device
IWDFC	Irrigation, Water Development and Flood Control
IWWRB	International Waterfowl and Wetlands Research Bureau

GLOSSARY OF TERMS AND ABBREVIATIONS (CONTD.)

JICA	Japan International Cooperation Agency
JRC	Joint River Commission
JU	Jahangir Negar University
KBK	Kolabashukhali
Khal	Channel
Kharif	Summer and fall (kharif I - early summer, March through June; kharif II -late summer and fall, July through October)
Khesari	Grasspea, Lathyrus Satirus
KIP	Karnafuli Irrigation Project
KSS	Krishi Samabaya Samity (Village Cooperative)
KTCCA	Kotwali Thana Central Cooperative Association
LAD	Least Available Depth
LC	Land Category
LCB	Local Competitive Bidding
LFS	Labour Force Surveys
LGD	Local Government Division
LGEB	Local Government Engineering Bureau
LLP	Low Lift Pump
LPS	Litre Per Second
LRP	Land Reclamation Project
LV	Local Variety
Mashkalai	Blackgrain
MAWTS	Mirpur Agricultural Workshop and Training School
MCC	Mennonite Central Committee
MCH	Maternal and Child Health
MDIP	Meghna Dhonagoda Irrigation Project
MES	Meghna Estuary Study
Mha	Million Hectares
MIP	Muhuri Irrigation Project
Mm^3	Million Meter Cube
Mmt	Million MetricTon
MOA	Ministry of Agriculture
MOD	Ministry of Defence
MOEF	Ministry of Environment and Forestry
MOFL	Ministry of Fisheries and Livestock
MOHFP	Ministry of Health and Family Planning
MOI	Ministry of Industry
MOIWDFC	Ministry of Irrigation, Water Development and Flood Control
MOL	Ministry of Land
MOLGRDC	Ministry of Local Government, Rural Development and Cooperatives
MORR	Ministry of Relief and Rehabilitation
MOSC	Ministry of Sports and Culture

GLOSSARY OF TERMS AND ABBREVIATIONS (CONTD.)

MOSTI	Manually Operated Shallow Tubewell for Irrigation
MP	Muriate of Potash
MPO	Master Plan Organisation
MS	Mild Steel
MSL	Mean Sea Level
MUV	Manufacture Unit Value
MTFPP	Medium-Term Foodgrain Production Plan
NACOM	Nature Conservation Movement, Mymensingh
NCA	Net Cultivable Area
NCS	National Conservation Strategy
NCSB	Nature Conservation Society of Bangladesh
NEC	National Economic Council
NEMAP	National Environmental Management Action Plan
NER	North East Region
NERWMP	Northeast Regional Water Management Project
NFC	National Flood Council
NGO	Non Government Organization
NHC	Northwest Hydraulic Consultants
N/K	Net Benefit/Investment Cost Ratio
NIRDP	Noakhali Integrated Rural Development Programme
NMIDP	National Minor Irrigation Development Project
NPK	Nitrogen, Phosphorus, Potassium
NPV	Net Present Value
NRDP	Noakhali Rural Development Programme
NWC	National Water Council
NWP	National Water Plan
NWPP	National Water Plan Project
O&M	Operation and Maintenance
ODA	Official Development Assistance (UK)
OER	Official Exchange Rage
OM	Organic Matter
PC	Planning Commission
PC-II	Application form for a feasibility study
PCR	Project Completion Report
PDB	Power Development Board
PDP	Primary Distribution Point
PEC	Project Evaluation Committee
PEP	Production and Employment Project
PFDS	Public Foodgrain Distribution System
pH	Acidity/Alkalinity unit
PHC	Primary Health Centre
PIT	Project Implementation Team

GLOSSARY OF TERMS AND ABBREVIATIONS (CONTD.)

PIU	Project Implementation Unit
PMC	Project Management Committees
PMU	Project Management Unit
PP	Project Proforma
PPP	Preliminary Project Proforma
PSO	Principal Scientific Officer
PTL	Project Team Leader
Purdah	The practice of secluding women
PVC	Poly Vinyl Chloride
PWD	Public Works Department
Rabi	Winter dry season (November through February) crop
RCB	Reinforced Concrete Block
RDI	Rural Development Infrastructure
RDO	Rural Development Officer
RDRS	Rangpur Dinajpur Rural Service
RESP	Rural Employment Sector Project
RPP	Revised Project Proforma
RRA	Rapid Rural Appraisal
R/S	River Side
RSC	Residual Sodium Carbonate
RSS	Reconnaissance Soil Survey
RWP	Regional Water Plan
SAR	Staff Appraisal Report
SCARP	Salinity Control and Reclamation Project
SCF	Standard Conversion Factor
SCONE	Society for Conservation of Nature and Environment
SCOPE	Society for the Protection of the Environment
SE	Superintending Engineer
SEG	Sell Environmental Group
SERM	South East Regional Model
SFYP	Second Five-Year Plan
SIA	Social Impact Analysis
SIDA	Swedish International Development Authority
SLI	Shawinigan Lavalin International
SMAM	Singulate Mean Age at Marriage
SOB	Survey of Bangladesh
SODAPS	Soil Data Processing System
SODAT	Soil Data (MPO version)
SPARRSO	Space Research and Remote Sensing Organisation
SPEC	Special Project Evaluation Committee
SRDI	Soil Resources Development Institute

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GLOSSARY OF TERMS AND ABBREVIATIONS (CONTD.)

SRP	Systems Rehabilitation Project
SSD	Social Services Department
STW	Shallow Tubewell
SWMC	Surface Water Modelling Centre
SWSMP	Surface Water Simulation Modelling Plan
TA	Technical Assistance
TAPP	Technical Assistance Project Proforma
T&V	Training & Visit
TCA	Total Cultivable Area
TDP	Transport Distribution Point
TDS	Total Dissolved Solids
TDW	Transplanted Deep Water
TFYP	Third Five-Year Plan
TMFR	Total Marital Fertility Rate
TOR	Terms of Reference
TRDP	Tangail Rural Development Project
TSP	Triple Super Phosphate
UAO	Upazila Agricultural Officer
UC	Union Council
UCCA	Upazila Central Cooperative Association
UDD	Urban Development Directorate
UE	Upazila Engineer
UFO	Upazila Fisheries Officer
UHC	Upazila Health Complex
UHFWC	Union Health and Family Welfare Centre
UNDP	United Nations Development Programme
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UNICEF	United Nations International Children's Emergency Fund
Upazila	Subdistrict
USAID	United States Agency for International Development
VT	Vertical Turbine
WAPDA	Water and Power Development Authority
WASA	Water and Sewerage Authority (Chittagong and Dhaka)
WBS	Work Breakdown Structure
WHO	World Health Organisation
WID	Women in Development
WRC	Water Resource Cell
WSB	Wildlife Society of Bangladesh
WWF	World Wildlife Fund
XEN	Executive Engineer
ZSB	Zoological Society of Bangladesh

REFERENCES

1. Draft Report on the Meghna Muhuri Water Transfer, International Engineering Co./Rahman & Associates, September, 1972.

2. Muhuri River Project, Feasibility Studies, Pakistan Techno-Consult, January 1967.

3. Muhuri Irrigation Project - Project Completion Report (FAO, March 1987, amended and updated April 1989.

4. Evaluation of Muhuri Irrigation Project Bangladesh, Canadian International Development Agency (CIDA)/Keith Project Management Inc, June 1990.

5. Master Plan, International Engineering Co., December 1964.

6. Feasibility Report on Comilla and Noakhali Project - Phase I (Dakatia Unit), BWDB/Netherlands Engineering Consultants, February, 1980.

7. Feasibility Study, Comilla-Noakhali Project, Muhuri Unit, International Engineering Co./Rahman & Associates, December 1973.

8. Noakhali Irrigation Project Preliminary Report, Bangladesh Water Development Board, September 1982.

9. Inception Report on Noakhali Irrigation Project, Bangladesh Water Development Board, January 1983.

10. Rural Credit Market in Noakhali District, Sajjad Zohir, 1989.

11. Water Under the Bridge, The Final Report (1986-1989) of the Irrigation and Drainage Component of the Noakhali Rural Development Project - Phase II, NRDP-II/DANIDA, August 1989.

12. Water Under The Bridge, The Final Report (1986-1989) of the Irrigation and Drainage Component of the Noakhali Rural Development Project - Phase II, NRDP-II/DANIDA, 1989.

13. Little Feni and Noakhali Regulators, International Engineering Company Inc, October 1961.

14. Feasibility Report - Structures for Little Feni River Sub-Project (Second Small Scale Flood Control, Drainage and Irrigation Project), North-west Hydraulic Consultants Ltd., 1988.

15. Draft Feasibility Report - Rehabilitation of Old Dakatia and Little Feni River (Sub Project Nr 19, Rehabilitation of Water Development Project, EPC/Harza/MacDonald April 1988.

16. IDA Second Small Scale Flood Control, Drainage and Irrigation Project, Feasibility Reports for Appurtenant Structures Schemes (2 Nr) at Ichakhali and Bamansundar, Northwest Hydraulic Consultants Ltd, December 1987.

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REFERENCES (contd)

17. IDA Second Small Scale Flood Control, Drainage and Irrigation Project, Feasibility Report, Structures for Kahua River Sub-Project, Sub-Project Nr 35 (Appurtenant Structures), Northwest Hydraulic Consultants Ltd, 1988.

18. Second Flood Damage Rehabilitation Project, Feni Regulator: Downstream Scour. Report on Hydraulic Model Study and Design, Sir William Halcrow and Partners, March 1991.

19. Evaluation of Historical Water Resource Development and Implications for the National Water Plan, Harza Engineering, Sir M. MacDonald & Partners et al, June 1991.

20. Productivity and Employment Implications of Small Scale Family, CIRDAP Study Series Nr 98, Akhanda, A M and Karim, M R.

21. Bangladesh Population Census 1981, District Series, Bangladesh Bureau of Statistics, 1981

22. District Statistical Series, Bangladesh Bureau of Statistics, 1983.

23. Yearbook of Agricultural Statistics, Bangladesh Bureau of Statistics, 1987/88.

24. Statistical Pocket Book of Bangladesh, Bangladesh Bureau of Statistics, 1990.

25. Statistical Yearbook of Bangladesh, Bangladesh Bureau of Statistics, 1990.

26. Bangladesh Census of Non-Farm Economic Activities 1986, Zila Series, Bangladesh Bureau of Statistics, 1990.

27. Preliminary Report, Population Census, Bangladesh Bureau of Statistics, July 1991.

28. Report on the Upazila Development Monitoring Project, Volume 1, Bangladesh Bureau of Statistics, November 1991.

29. Inland Fisheries Development Project, Fifth Annual Report, Department of Fisheries, 1982

30. Population of Bangladesh. Country Monograph Series 8, ESCAP.

31. Draft Rapid Rural Appraisal of Meghna Dhonagoda Irrigation Project, FAP 12 - FCDI Agriculture Study, June 1991.

32. Draft Project Impact Evaluation, Meghna Dhonagoda Irrigation Project, FAP 12 - FCDI Agriculture Study, 1991.

33. Draft Final Report, Volume 1, FAP 12 - FCDI Agriculture Study, December 1991.

REFERENCES (contd)

34. Guidelines on Economic Analysis, Flood Plan Coordination Organisation, May 1991.

35. Guidelines for Project Assessment, Flood Plan Coordination Organisation, July 1991.

36. Pattern of Agricultural Unemployment, Bureau of Economic Research, University of Dhaka, Habibullah, M - 1962.

37. Population Development and Evaluation Unit, Hossain and Ahmed, International Engineering Co Inc., 1964.

38. Labour, Employment and Wages in Bangladesh Agriculture, BIDS, Hye, S A, 1989.

39. Technical Report Nr 17 (Fisheries losses), Master Plan Organisation, 1985.

40. Technical Report Nr 1, Crop Production Limitations in Bangladesh, Master Plan Organisation, 1987.

41. Technical Report Nr 13, Procedure for Preparing Cost Estimates, Master Plan Organisation, 1987

42. Unemployment and Over-employment in Agriculture, a Case Study of Bangladesh. BR Publishing Corporation, Masum, M, 1982.

43. The Impact of Flood Control on Agricultural Development in Bangladesh. Flood Hazard Research Centre, Thompson, Paul M, 1989.

44. Land Resources Appraisal of Bangladesh for Agricultural Development, Report 2, Agro-Ecological Regions of Bangladesh, Food and Agricultural Organisation, 1988.

45. Study on Foodgrain Marketing, Ministry of Food, 1988.

46. MPO, SWSMP Phase I, Main Report, December, 1988.

47. MPO, NWP Project Phase II, Main Report, Volume I, June, 1991.

48. MPO, NWP Project Phase II, Bangladesh Water Balance Model, Users Manual, December, 1990.