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Noakhali North Drainage and Irrigation Project
Feasibility Study
Volume 1 - Main Report

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Resources Development Consultants Limited
House of Consultants Limited
Desh Upodesh Limited

NOAKHALI NORTH DRAINAGE AND IRRIGATION PROJECT
FEASIBILITY STUDY

MAIN REPORT

FAP- 5

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ANNEX

ANNEX A Terms of Reference

CHAPTER 1

INTRODUCTION

1.1 Background

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.

1.2 Terms of Reference

The original TOR called for a feasibility study of a project to be identified during the preparation of the regional plan and therefore the consultants to a certain extent were required to guess what inputs would be required at the feasibility stage. Once the project had been identified it was possible to more accurately define the requirements.

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 original Terms of Reference (TOR) envisaged the preparation of a feasibility study covering an estimated area of approximately 100 000 ha but the area covered by the recommended project covers approximately 160 000 ha. This required some increase in the extent of all field studies including agro-socio-economic bench-mark surveys and engineering surveys.

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.

a) Assessment of Flood and Drainage Hydraulics

The Noakhali North Project is simple in concept but requires extensive study to prove its viability at the feasibility level; topographic level surveys including the linkage to the hydrological datums system (water level gauges) being particularly critical.

All flood protection and drainage projects under the FAP regional studies are dependent on the results of the MIKE 11 Surface Water Simulation Model, and the corresponding regional models. In the case of the South East Region the model has been developed to a good level of confidence in modelling terms, but it must still be borne in mind that the margins for error are considerable when taken in the context of flood phasing. The project benefits are highly dependent on improvements in flood profiles or regimes and therefore good flood level calibration and verification is required especially in the spatial context.

The previously used measure of inundation is based upon peak mean daily flood depths and was considered too crude a basis for this level of study. The durations, depths, timings and frequencies of flooding need to be considered when trying to assess the effects of different interventions and to estimate how farmers will react to changes in the water regime. This requires extensive further model testing and post processing analysis of output to identify areas flooded to particular depths at critical periods of the year for the principal crops.

A further complexity for the modelling in this particular area is that the Meghna river is tidal as are the southern boundary conditions. No tidal effects were built into the SERM or the FAP 25 general model. It was therefore, necessary to develop tidal boundary conditions and to calibrate these since the principal benefits are to be derived from tidal fluctuations of water level.

b) Verification of Topographic Mapping and Survey of Sample Areas

The new 1:10 000 scale mapping of the coastal region to be prepared under FAP 18 is based upon a 300m x 100m level grid but was available in time for the study (not expected before 1994). However, the area is largely covered by the old 1:15 840 scale mapping based on a level grid approximating to 200m x 100m which is slightly closer than that proposed for the new mapping which is being prepared for BIWTA by FINNMAP. Some uncertainly existed on the level of accuracy of these 1:15 840 maps (Irrigation Planning Maps (SOB/BWDB) 4" to 1 mile) which were produced decades ago. However, provided that the old maps were checked by verification of bench-marks and sample survey areas the consultants considered that the old mapping should be acceptable for feasibility study purposes.

The sample topographic survey areas were carefully chosen as their importance was not only to verify the accuracy of the existing mapping but also to check that a grid of 200m x 100m adequately describes the microtopography for drainage purposes in terms of calculating flood duration/depth/area relationships. Comparison of actual inundation in 1992 against that predicted by the regional model results was intended to provide valuable information as to the reliability and applicability of the model output. These sample areas were also to be included in the areas sampled for the socio-economic field surveys to provide a consistent database on representative areas.

c) Increased Scope of Environmental Assessments and Local Participation

The other discipline where major changes in the scope of the TOR were required is in the attention to be given to the environmental implications of the project. FAP and donor concerns indicated that the standards required for feasibility studies were not commensurate with the TOR or levels of input provided in the original contract (the original TOR did not require any environmental studies for the feasibility study).

This aspect was the largest single cause of the increase in funding required. Both expatriate and local consultant inputs were included to cover the physical and social environment issues which are now required by donors. The additional inputs include an EIA coordinator, ecologist, and sociologist (expatriates) and their local counterparts. Also local specialists for field work were required in fisheries, aquatic and terrestrial ecology, water chemistry, health, nutrition and community organisers for local participation.

The original terms of reference and the amended terms of reference are included in Annex A together with the original and revised man month allocations.

These allocations clearly illustrate the increased allocations to sociology, the environment and related disciplines which have been partially offset by reductions in engineering inputs.

However, it was recognised that even with the amended TOR and the additional funding that there would still be limitations in what could be achieved within the time available. Also the consultants were asked to share resources with the Gumti II Feasibility Study which was to be carried out in parallel over the same period of time.

The period of study which none of the agencies wished to extend, meant that a full years fieldwork could not be carried out for the fisheries and ecological studies to support a full EIA in accordance with the FAP or World Bank guidelines. This was fully understood by all concerned parties when the decision to proceed was taken. This situation was reported in the second interim report (December 1992) and discussed with BWDB and FPCO in review session, in February 1993.

However it was felt that the studies proposed should allow an improved assessment of the impact of the proposed intervention on the existing environment and the formulation of proposals for mitigating adverse impacts. As the duration allowed for the study (9 months from mobilisation to draft report) does not allow complete adherence to the guidelines, the consultants approached the work in a manner which clearly identifies the major issues, quantifies these as far as is possible. In addition in order to confirm the general conclusions, and to verify the accuracy of the quantification, the consultants have included recommendations for the additional surveys and investigations which it will be necessary to complete before the project design can be completed. Some of these will be required for the design in any case.

It may also be noted that since 1992 was such an unusually dry monsoon event that even a full year of data collection would not have provided a very good assessment of normal conditions.

Additionally it must be recognised that owing to the lack of basic data of a statistically valid nature at regional or sub-regional level in several key areas even a full years fieldwork in a normal year will not allow an accurate measure of trends on a regional or project area basis.

1.3 The Project Area

1.3.1 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 1.1 in its sub-regional setting. The gross area within the above project boundary is 160 814 ha. The elevation varies between about 3.5 m and 5.0 m above Public Works Datum (PWD).

It is important to state at the outset of this report that the study of this area for drainage purposes must be approached on a sub-regional basis and for this reason the consultants have 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.

1.3.2 Population

The Noakhali North Project area comprises parts of four districts of the south east region, Chandpur, Lakshmipur, Noakhali and Comilla. The populations of each district within the project area are given for the decade ending 1991 in Table 1.1 which also provides a comparison with national and divisional statistics.

TABLE 1.1

Noakhali North Project Area Populations

District/Region	1981		1991	
	Total District Population	Population in project Area	Total District Population	* Population in Project Area
Noakhali	1 736 000	1 005 000	2 216 000	1 283 000
Lakshmipur	1 120 000	506 000	1 309 000	591 000
Chandpur	1 796 000	148 000	2 022 000	167 000
Comilla	3 356 000	121 000	4 023 000	175 000
Total	8 008 000	1 780 000	9 520 000	2 186 000
Bangladesh	87 174 184	-	104 766 143	-
Chittagong Division	22 324 627	-	27 096 904	-

* Estimated - Assumes pro-rata growth rate to that in each district except in Noakhali where 1991 data is already available.

(Source: Bangladesh Bureau of Statistics [BBs] 1991)

Table 1.2 gives more precise demographic details for the two districts which contribute 85% of the project area and the national and divisional figures. The most striking feature of this table is that both project districts have far higher population densities than either the country as a whole or the division. It is also noticeable that these figures are also much higher than for the whole of these two districts. This is because the project area includes all of the principal urban areas in these districts but excludes the more lightly populated areas in the polders to the south of the project area.

TABLE 1.2

Demographic Features of Noakhali North Project Districts
(areas within project)

District/ Region	1981				1991			
	H/H Size	PopDen	List	Sex Ratio	H/H Size	PopDen	List	Sex Ratio
Bangladesh	5.72	651	18.21	106.1	3.34	781	24.82	106.0
Chittagong Div.	5.67	528	18.02	103.8	5.69	640	25.83	105.0
Noakhali	5.6	1253	25.2	97.8	5.6	1599*	28.00	98.3
Lakshmipur	5.5	979	21.8	100.3	5.4	1144*	25.50	101.1

(Source: BBS 1991) * Prorata from growth rate for whole district.

1.3.3 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 shape of the depressions and their surroundings is illustrated by the indicative contours in Figure 1.2. 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 Comprehensive Drainage Scheme, implemented in the early 1970s, set out to cure the drainage problems in the south-west of the project area by the construction of Rahmatkhali Regulator outfalling to the Lower Meghna River, and the excavation/enlargement of WAPDA and Rahmatkhali Khals. However, this scheme appears to have been based upon the assumption that Noakhali Khal would remain fully operational.

Due to the construction of the cross-dams nos 1 and 2 in the late 1950s, and early 1960's, which successfully accreted large areas of land to the south, this drainage route has been greatly extended and has silted up over a long distance. This trend was becoming apparent even as the Comprehensive Drainage Scheme was being designed and implemented. The water level and tidal range records for the Noakhali Khal near the old coastal embankment show clear trends of increasing maximum water levels and decreasing tidal variation in the period 1967 (start of record) to 1974.

Thus by the time the scheme was completed the Noakhali Khal was already virtually non-functional as an effective drain and the Rahmatkhali regulator was being heavily overloaded.

It was thought possible that some of the early season flooding within the Begumganj depression is due to the present inability to open Kazirhat Regulator, at the outfall of the Little Feni River, sufficiently early to evacuate flash floods from the Tripura Hills and also because of its limited capacity.

Therefore a fuller solution must be based upon modelling analysis of the whole sub-region, including the Dakatia and Little Feni basins.

1.3.4 Hydrogeology

Information on the hydrogeology of the project area is more limited than in areas further north, since salinity has prevented extensive ground water development.

The geology of the project area is dominated by a least several thousand feet of sandy, silty and clayey formations of alluvial and marine origin. The layers are interceded in an apparently irregular pattern, where substantial lateral variations in lithology may occur within even short distances. The formations are basically sandy, with fine and fine-medium sand dominating. A tendency to find coarser materials with increasing depth may be observed.

A shallow aquifer is found near the surface. This aquifer is recharged locally every year during the monsoon. The water however remains too saline for domestic or irrigation use in many areas, although it is likely that in the northern part with careful setting of tubewell strainers a limited layer of fresh water overlaying the saline water may be exploited. The aquifer thickness varies, but is generally of the order of 12 to 18 metres which, salinity permitting, may be adequate for hand pumps particularly of the inclined 'rower' type, but certainly not for significant irrigation or piped water supply schemes. Below the shallow aquifer are found alternating sand and clay layers, containing saline water probably of marine residual origin.

Below 130 to 150 metres fresh water is encountered in some areas. The thickness of the fresh water zone is not known, but it is at least 90 metres. The aquifer is recharged further inland, from whence the fresh water flows towards the coast in gently declining layers. Pressure differences and/or clay layers prevent mixing of the saline and fresh water, and in the coastal belt distinct but relatively thin clay zones are normally found at the top of the fresh water zone. Some development of this aquifer has occurred in the last few years.

1.3.5 Soils and Agriculture

The Land Resources Appraisal of Bangladesh for Agricultural Development (FAO 1988) has described some 30 agro-ecological regions throughout the country. Those of importance in the project areas are the Old Meghna Estuarine Floodplain which covers most of the area; the Lower Meghna River Floodplain towards the south and west, and beyond that the Saline Young Meghna Floodplain. Apart from some soil salinity occurring in the Saline Young Meghna Floodplain, the principal determinants of agricultural development are the flooding regime and availability of irrigation, rather than any intrinsic soil properties. The broad land capability classes are indicated in Annex E with most of the area within the project area falling into land capability class II. The area of class III in the south-west suffers from a salinity limitation, and the small area of class IV from a slight tidal surge risk.

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 aeas. These areas amount to 32.4% of the gross project area and inlcude 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.

1.3.6 Fisheries

The construction of Rahmatkhali Regulator in the 1970s isolated much of the khal system within the southern part of the project area from the Lower Meghna River, and therefore capture fisheries rely primarily on resident rather than migratory species, although the gates are opened at certain times in the dry season to admit both fish and irrigation water. In the north of the project area migratory species have direct access through the Dakatia River. Pond culture fisheries are relatively well developed, due to the influence of the Raipur Fish Hatchery, which was established to offset the negative effects upon fisheries within the adjacent Chandpur Irrigation Project and which has proved to be a catalyst for the development of a number of private hatcheries and nurseries which are now well established.

Figure 1.1
Project Location Map

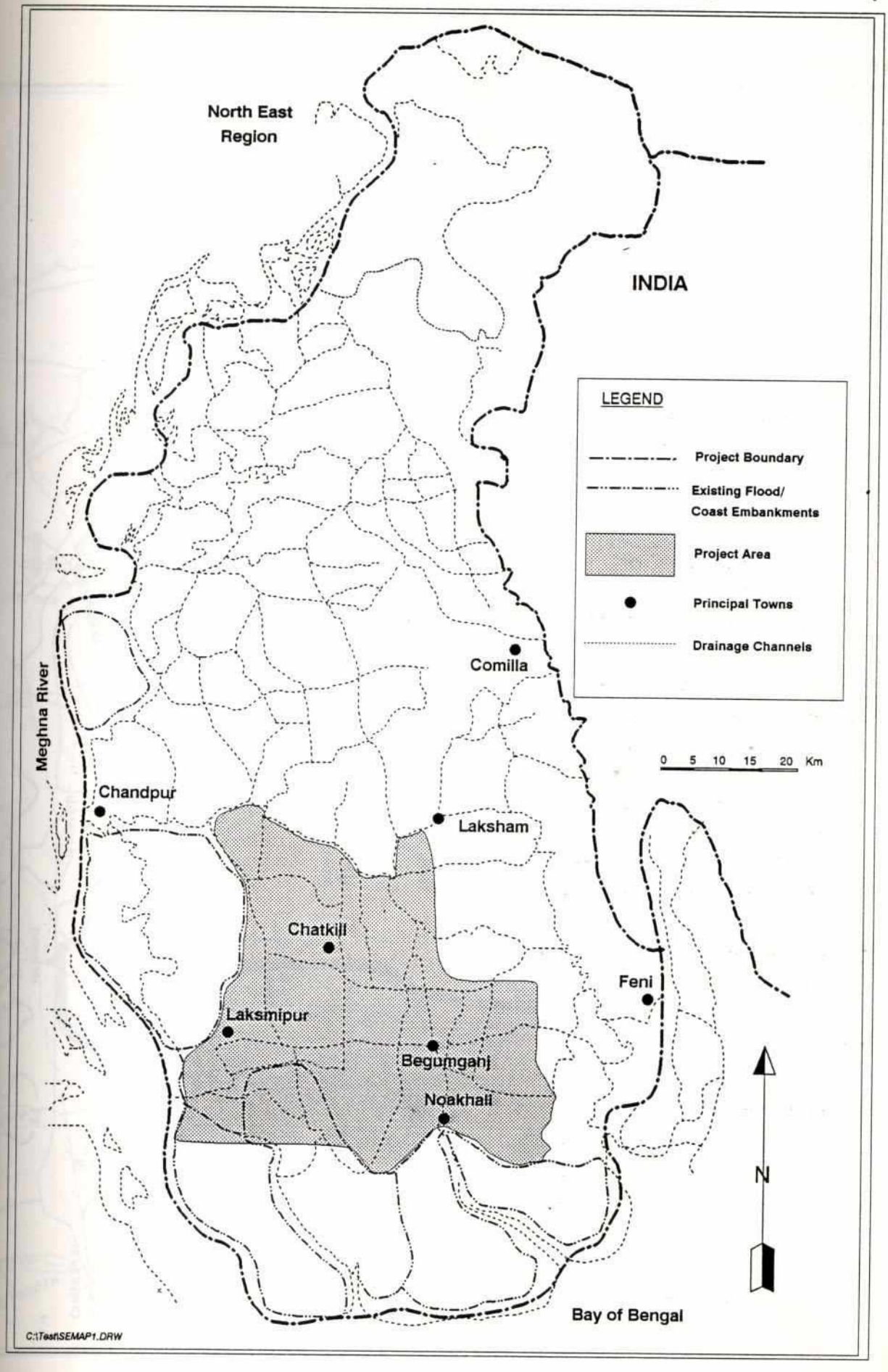


Figure 1.2

Topography

Figure 1.3
Transport Networks

Figure 1.4

Distribution of Minor Irrigation in 1991

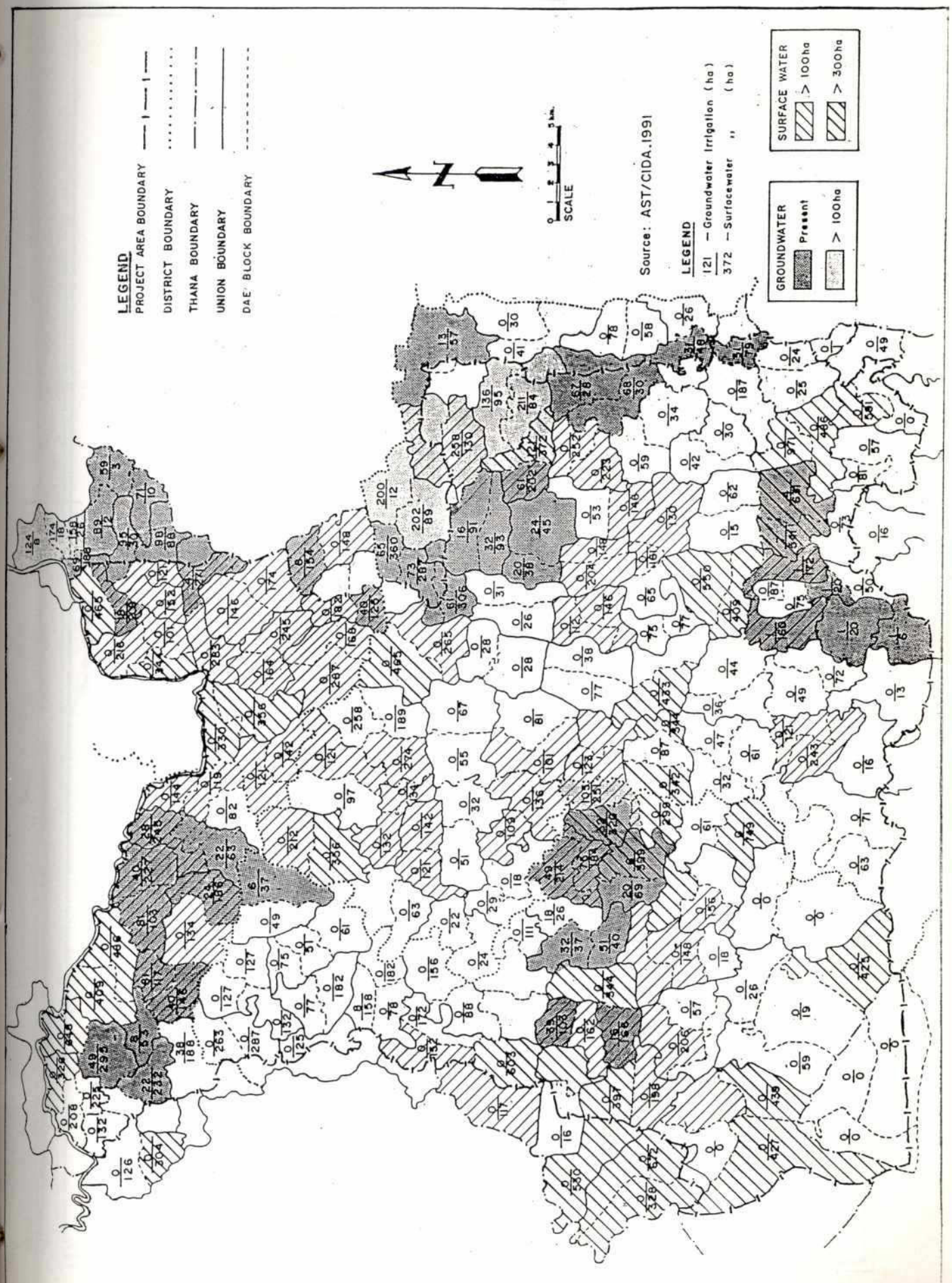


Figure 2.1
Sub-Regional Drainage System

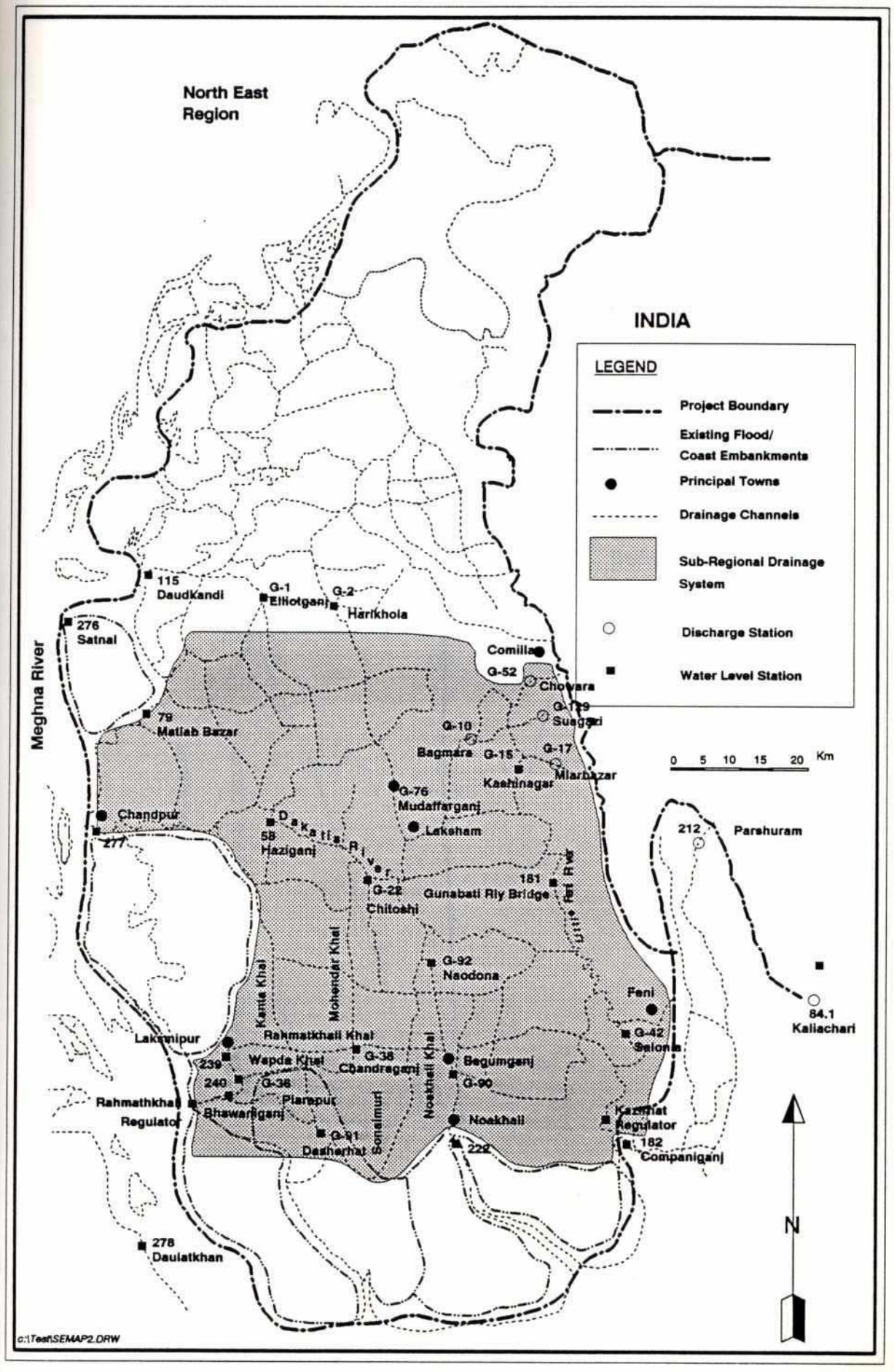


Figure 2.3
Meghna Water Surface Profiles

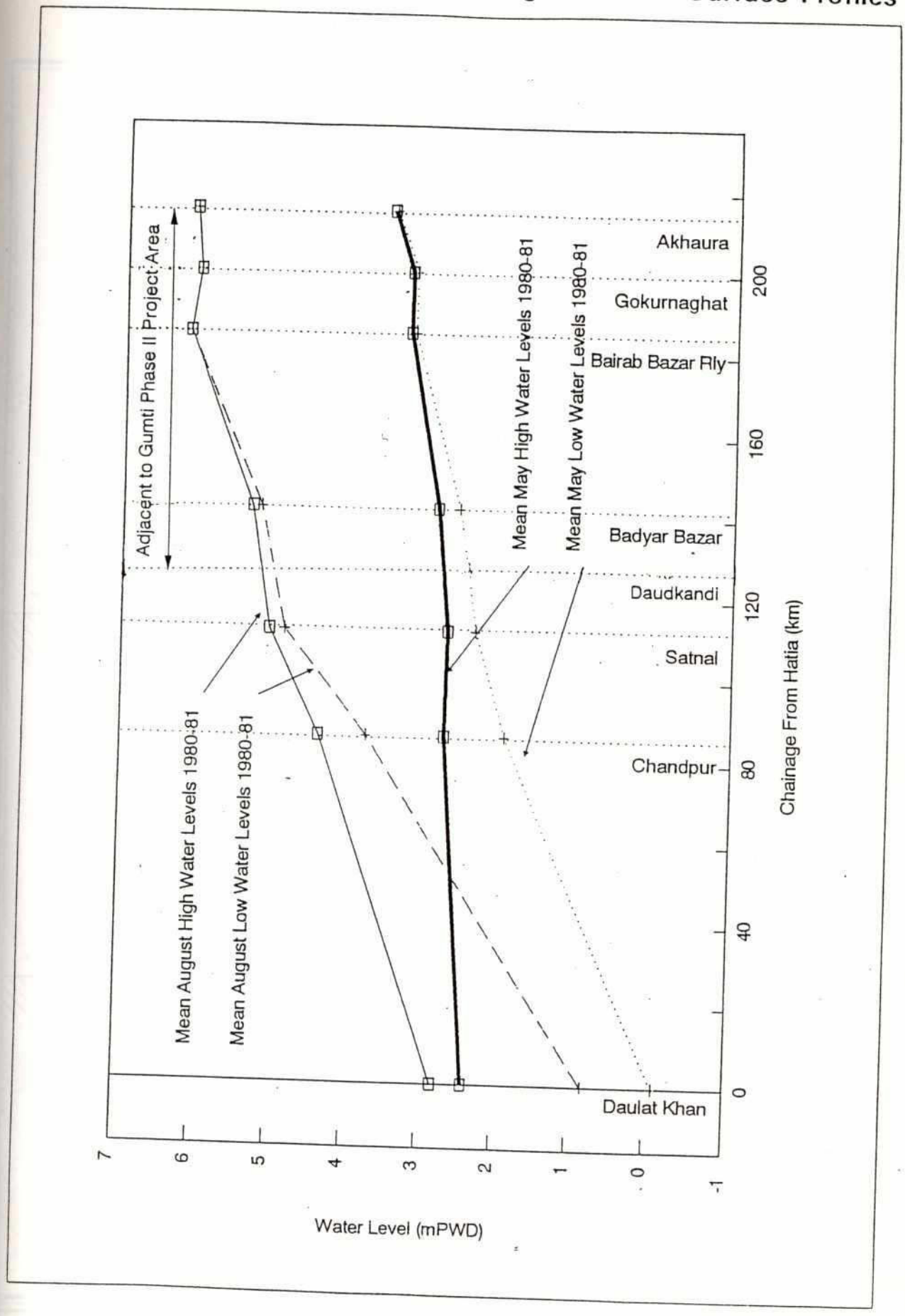


Figure 2.4
Typical Irrigation Channels

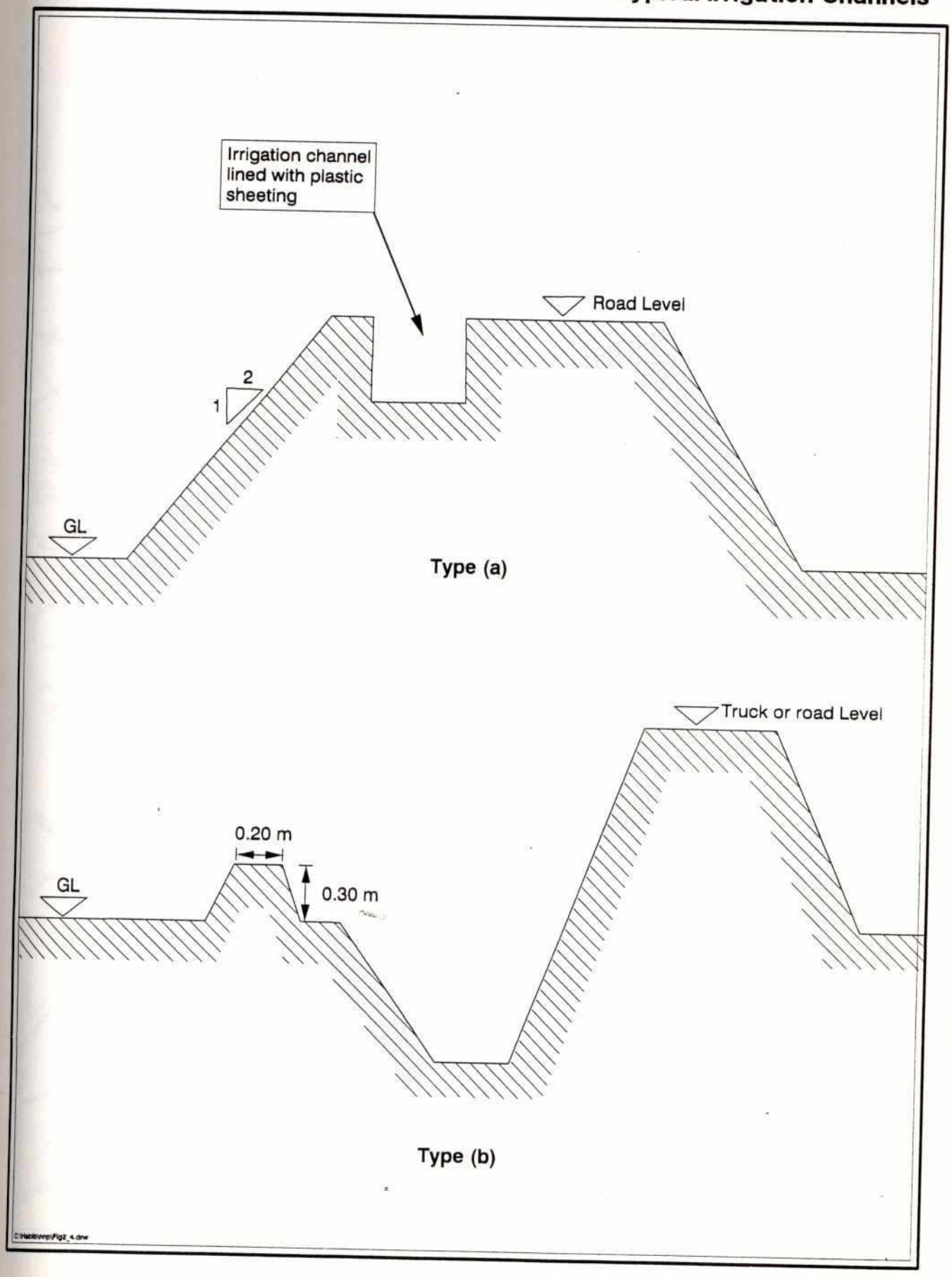


Figure 3.1
Planning Zones

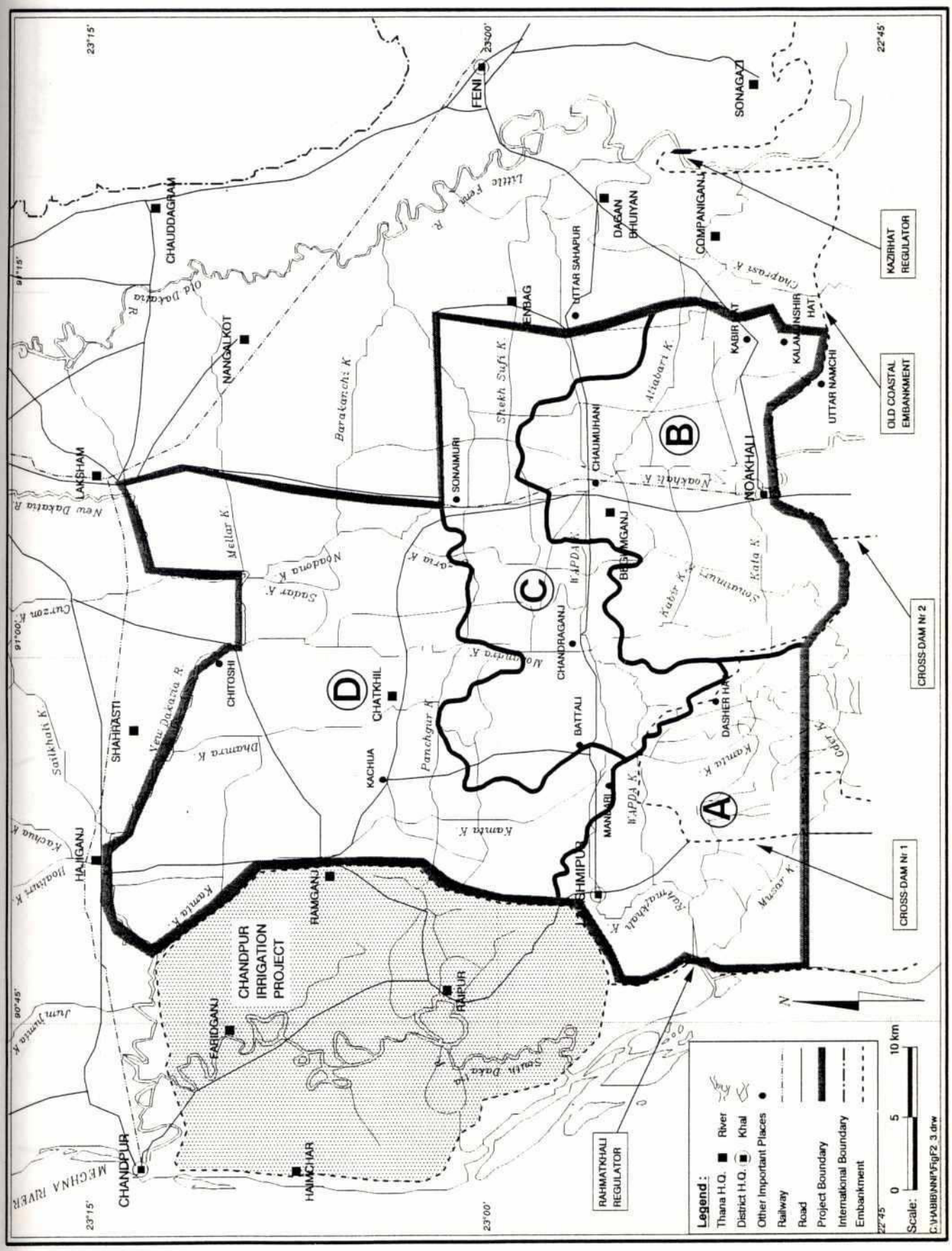


Figure 3.2

Agroecological Zones

1.3.7 Infrastructure

Railways and important road links are shown in Figure 1.3. All-weather access to most parts of the project area is relatively good, apart from in the south-west corner. The absence of a bridge over the lower reaches of the New Dakatia River does however mean that road traffic to the north and west (particularly to Dhaka) has to pass through Comilla in the east.

The existing Rahmatkhali Regulator cuts off navigation access from the Lower Meghna River, and waterborne traffic is not of major importance inside the khal system. Craft do however enter the Dakatia River at Chandpur and the northern reaches of Kamta Khal. There is frequent traffic from Chandpur to Laksham in the monsoon season but in the dry season this tends to diminish.

All thana headquarters except Senbagh are connected to the national grid power supply by 11 kV or 33 kV lines, and the 132 kV lines from Chittagong to Comilla and from Comilla to Chandpur pass adjacent to the project area. Additional capacity is planned for both these lines, and a new 132 kV line is under construction from Feni to Begumganj.

Gas is supplied from Feni by 10 inch diameter pipeline to Senbagh, Chowmuhani and Begumganj.

1.3.8 Flood Control and Drainage Works

Part of the southern boundary of the project area lies along the former Coastal Embankment, and much of the area lies within the polders thus formed (59/1A in the east and 59/1B in the west). With the construction of Cross Dam Nrs 1 and 2 during the late 1950s and early 1960s land accreted to the south of the Coastal Embankment at a dramatic rate. This left the embankments more or less redundant but the drainage of polders 59/1A and 59/1B restricted. This drainage problem was tackled in part by the Comprehensive Drainage Scheme as discussed in Section 1.3.2.

The project area is largely shielded from Lower Meghna floods by the flood control embankment of the Chandpur Irrigation Project (CIP), completed in 1976. The CIP embankment is linked to Rahmatkhali Regulator and thence to the Meghna left bank embankment which protects polder 59/2A.

Kazirhat Regulator was constructed at the mouth of the Little Feni River in 1967/68. Although it successfully excludes sea water, sedimentation downstream of the flap gates impedes the evacuation of early monsoon floods. The gates have to be dug free each year, and a pilot channel excavated downstream. It takes about two months for the pilot channel to erode sufficiently for the upstream water level to fall to normal. The drainage problems of the Little Feni/Old Dakatia basin are compounded by flashy rivers from the Tripura Hills, such as Kakri and Pagli, which not only give rise to the early floods but also obstruct the channels with huge quantities of sand. Over the years, the upper reaches of the Old Dakatia have been repeatedly excavated, mainly under the Food For Work (FFW) Programme. There is still a tendency, however, for the direction of flow in the upper Old Dakatia to be reversed, with drainage through the New Dakatia River instead. This drainage impedance particularly affects the Sonaichari Irrigation Project, in the north-east corner of the sub-regional drainage basin.

To the north of the project area both the Chandpur, Laksham road and the Chandpur-Comilla railway restrict natural floodplain drainage which is confined to a few khals.

Two other major schemes in the vicinity are the Meghna Dhonagoda Irrigation Project (MDIP), which includes a major flood control and pumped drainage component, and the Muhuri Irrigation Project (MIP) to the east of Feni, protected from seawater flooding by Feni Regulator. Neither has significant hydrological linkage with the project area, although there are minor channels linking MIP with the Little Feni River.

1.3.9 Irrigation Development

Existing irrigation is indicated in Figure 1.4. Because of ground water salinity, the dominant mode, at least in the southern part of the project area, is low lift pumps (LLP). The Meghna River water at Rahmatkhali Regulator is fresh, and there is an informal arrangement for opening the gates during the dry season to admit tidal water for irrigation. However the benefit of this water is presently limited to the south-western part of the area. Since most of the khals are not deep enough to gain benefit and the quantities admitted are small.

An updated estimate based upon the 1991 Agriculture Sector Team census suggested a total area of irrigation within the project area, made up of:

-	Low lift Pumps	-	27,660 ha
-	Shallow Tubewells	-	1,020 ha
-	Deep Tubewells	-	2,000 ha
-	Traditional/Hand Tubewells	-	8,420 ha
	Total	-	39,100 ha

As stated in section 1.3.5 the area of boro grown is substantially greater than this which indicates that much of it is irrigated under relatively poor conditions.

1.4 Previous Studies

A number of previous studies of relevance to the project area are reviewed 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 siltation, 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, followed 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 triangular 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.

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(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 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).

(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 (1993) 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.

1.5 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.

1.6 Objectives and Targets of the Project

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 1.5 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.

The irrigation objective is to be achieved by modification of the regulator gate design and by the deepening of the secondary khals to create a reservoir to store the tidal water entering the system. Additional measures tested for their effectiveness in improving the system include:

i) Additional regulators on the Little Feni (downstream of Kazirhat) and on the Dakatia (upstream of Chabagadi)
ii) Khal deepening in the north of the area adjacent to the Dakatia river.
iii) An embankment along the south side of the Dakatia river.

The tests for effectiveness include:

a) Examination of existing records and the model runs for the existing situation.
b) Information gained from local participation meetings.
c) Testing the effects of physical improvement on the hydrodynamic model.

1.7 Approach

1.7.1 Relationship with Gumti Phase II Study

As already explained in section 1.2 the TOR for the study were substantially amended in 1992. The constraints of time and budget were further compounded by the request to combine the staffing and logistics for the two feasibility studies (Gumti II and Noakhali North) and to complete both studies within one year. The combination of resources for the two studies had the advantages of consistent, shared methodologies and produced some cost savings but it reduces flexibility in programming fieldwork and analysis with both projects needing key personnel at critical times.

The following paragraphs describe various aspects where important decisions have had to be made to achieve a result in the time available.

1.7.2 FPCO Guidelines

The Flood Plan Coordination Organisation (FPCO) has produced the Guidelines for Project Assessment which was last issued in May 1992. 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. Since May 1992 a further amendment to the agricultural annex to the a guidelines has been issued (March 1993). Also the Guidelines for Environmental Impact Assessment were issued in October 1992. The project has followed these guidelines wherever possible. As already explained due to the constraints concerning study duration and resources available to the study it was not always possible to follow the guidelines comprehensively. In addition, the very low water levels of the 1992 wet season prohibited achievement of some databases required by the Guidelines. This is explained in the relevant sections and annexes of the report.

1.7.3 Surveys and Investigations

The 1992 draft Regional Plan Report contains a great deal of valuable data which has been used during the course of this study. In addition to this, a substantial amount of additional secondary data was collected from agencies such as the Bangladesh Bureau of Statistics (BBS), Agricultural Sector Team (AST), Department Agricultural Extension (DAE) and individual thanas. A considerable effort was made to collect and use this data.

In order to check and update this data as well as to obtain information that was not otherwise available, a large proportion of our resources have been spent in the field, obtaining primary data. This survey work is described in detail in the respective annexes but is summarised below, with cross references to the appropriate Annexes.

Farmer Surveys (for details see Annex E, Appendix E.I)

The farmer surveys consisted of a large-scale questionnaire survey of 384 farmers which focused on:

Land use and cropping pattern related to flood water levels
Farm size and tenancy
Irrigation
Input use and crop yields
Fishing as a secondary activity
Losses of crops and household assets to flooding
Non-farm sources of income.

A sub-sample of typical farms were selected for a more detailed case study questionnaire. This gathered additional data on the above topics and investigated on-going changes to land holdings, cropping patterns, yields, and livestock.

The sample survey of 384 farmers was chosen as a statistically valid sample of the project area as a whole. The project area has been divided into 4 agro-hydrological Zones (A,B,C and D), shown in Figure 1.2. A sample of 12 mouzas/villages were selected at random in each zone. A list of all farmers in the selected mouzas was drawn up a random selection made of 8 farmers in each mouza for interview.

Plot Surveys (see Annex I, Appendix I.III and Annex E, Appendix E.I)

A survey of 60 fields, with some questions about the farms in which they are located, were collected in each of the five sample 2 km squares selected for topographic and hydrological surveys. The topographic survey provided the opportunity to relate water levels to cropping patterns and so facilitate the impact of the project on agriculture assessed.

Detailed topographic and hydrological investigations in the 2 Km squares generated detailed physical data which was related to agronomic data. The survey in these squares had a different approach to that in the 48 mouzas. Initial investigations took the form of informal interviews with farmers which aimed to classify land types relative to flood depth, and understand farmer decision making in response to floods and given varying levels of resources. Informal interviews were followed up by a formal questionnaire survey that concentrated on individual fields where water levels and land heights could be measured.

Women, Landless People and Fishermen (see Annex E, Appendices E.I to E.IV and also Annex G)

In each of the 48 sample mouzas, two fish pond owners and two landless people were interviewed. These were selected at random from the same sample frame drawn up for the farmer survey. The total number of interviews given were 100 women, 80 professional fishermen, 96 fishpond operators and 96 landless people.

The survey of professional fishermen was carried out in villages where fishing is more important. Therefore there were more interviews in Zones A and D.

Irrigation Pumps (see Annex I, Appendix I.X)

A questionnaire survey of 96 irrigation pump operators was carried out. The survey aimed to sample different irrigation modes (LLP, STW etc.) in a range of hydrological conditions (main and minor khal, saline ground water etc.). Stratification of the sample was based on hydrological and secondary data. The sample frame was based on a DAE block with a list of all pumps in the block being drawn up with assistance of the Block Supervisor.

Water Quality (see Annex H, Appendix H.V)

A sampling programme for surface water quality was carried out in the wet season and the dry season. This included samples from the main rivers and khals at their in-flow and out-flow from the study area and at confluences along with those of the internal river system. It also included sample sites from the internal rivers and floodplain. Samples were also taken from ponds and tanks, viewed in the context of possibilities for aquaculture and waterborne disease and particularly how this is likely to change under intervention conditions. Samples were also taken from possible industrial pollution sources.

Aquatic Ecology (see Annex D, Chapters D.4 and D.5)

The primary aim of this data collection exercise was to provide an understanding of the present system for input into the fisheries studies and the flora and fauna impact assessment. This included baseline data collection of the aquatic ecology of the area, dividing it into separate but inter-dependant aquatic environments. This interfaced with the household level interviews of full-time fishermen, pond fishermen and occasional fishermen (for both land occupying farmers and landless people) to allow a model of the fishing system to be built up.

Flora and Fauna (see Annex D, Chapter D.3)

An inventory of flora and fauna found in the study area was compiled from existing sources including published lists, government gazetteers and the work of the MOEF/IUCN. This was then verified in the field by interviews with key informants and observations. They were classified by habitat type and an assessment made as to how this is likely to change as a result of intervention and the consequential change in species types, distribution and numbers.

39

Fish Catch Survey (see Annex F, Chapter F.4 and Appendix F.II)

During the initial stages of the project, a requirement for fish catch and fish market surveys was determined. Sample areas were selected within the project boundary from where questionnaires concerning fish catches in floodplain, khals and rivers, as well as their market prices, were completed.

Health and Nutrition (see Annex H, Appendix H.IV)

A review was made of the existing health data for the area, specifically the District Surgeons returns for last year. These identified major issues, however the figures were verified to see the degree to which they under count disease incidence due to differences in access to health facilities and any other factors. Efforts were concentrated on those diseases the incidence of which were likely to change as a result of intervention in the land and water management system. Mental illness levels in the area was also reviewed, specifically suicide rates, to assess if these are related to mental stress and trauma linked to insecure livelihoods possibly as a result of flooding.

The nutritional studies reviewed existing data held by the Bangladesh Institute of Nutrition. The Helen Kieler Institute and BBS. This indicated the recent past and present levels of nutrition amongst the population in the area.

Topographical and Engineering Surveys (see Annex I, Appendix I.IV)

A sub-contract was awarded in October 1992 for performance of the following aspects of survey work.

- additional channel cross sections and long sections
- checking the zeros of all water level gauge stations
- detailed topographic survey of 5 nr 2 km square sample areas
- Site survey of the Rahmatkhali regulator
- Verification of all existing bench-marks in the project area and correlation with the hydrological gauge datums.

Also staff gauges were set up to monitor monsoon flood levels within the sample areas with local people being employed to take readings. Unfortunately, due to the very low 1992 monsoon water levels, few gauges registered any measurable water levels.

In addition to the contracted survey work the consultants staff undertook a number of additional surveys as follows:

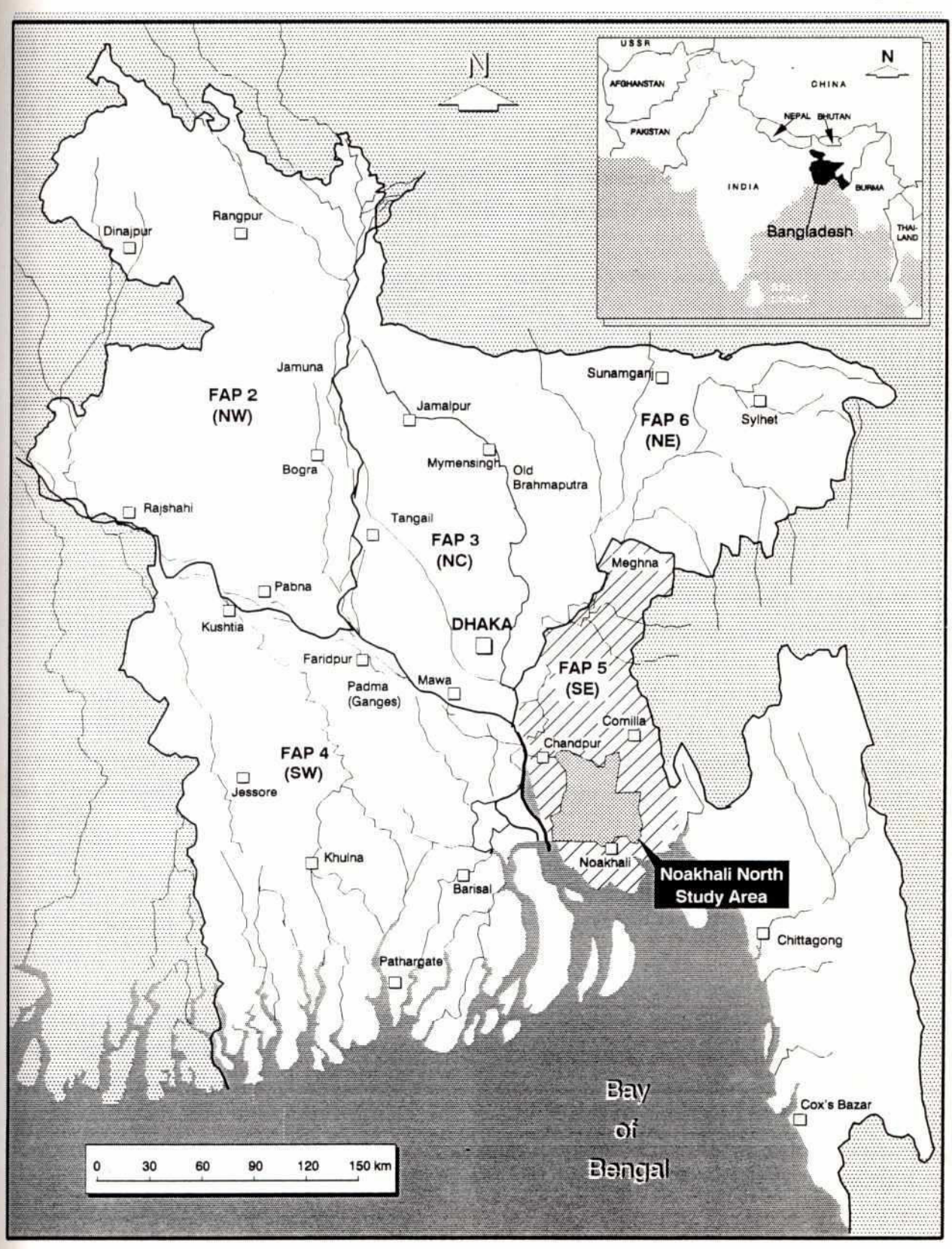
i) Cross sections of the lower reaches of the Noakhali Khal (south of the project area).
ii) Cross sections of the Little Feni river at the proposed site of the new (Musapur) regulator.
iii) Auger hole borings along the lines of the principal khals to ascertain soil types and EC values of the shallow aquifers.
iv) More extensive ground water salinity surveys to identify areas favourable for ground water development.

Infrastructural Surveys (see Annex I, Appendix I.VIII)

All the bridges over khals scheduled for improvement were inventoried during the topographical survey contract. These were later assessed in terms of the need for alterations or replacement as a result of the proposed works.

In addition a broader inventory was undertaken of railways, roads, gas and electricity distribution and the infrastructure. The Noakhali North area is already largely flood proofed and the entire area will benefit from lowered water levels in the with project situation. Provision of increased flood proofing is, therefore, not required.

Frontispiece



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CHAPTER 2

WATER RESOURCES

2.1 Hydrology

2.1.1 Climate

The monsoonal climate which affects the Project Area, and indeed the whole of Bangladesh, is part of a system which affects the whole of the Indian sub-continent. The three main seasons are as follows:

i) The South-West monsoon: Lasting approximately from May to October, and producing the main rainy season; almost 90% of the annual rainfall total in the study area occurs during this period, when both temperatures and relative humidity are high;

ii) The North-East monsoon: Extending from November through to March, establishes the cool dry season of winter; only occasional rainfall occurs, associated with weak cyclonic disturbances;

iii) A short hot season: This precedes the South-West monsoon and can extend from the March through till May; the highest maximum daily temperatures can occur at this time, and the season is associated with variable convective storm activity which can occasionally develop into severe cyclonic storms; during this season, flash flooding from the rivers draining the Tripura hills to the east of the region can be a problem in the Little Feni catchment directly to the east of the project area.

The study area can also be affected by severe tropical cyclones which develop in the Bay of Bengal. Cyclones most commonly occur in the periods before and after the main monsoon season in the months of May and October. In recent times, severe cyclones have affected the region in 1970, 1985 and 1991. Tropical cyclones are generally accompanied by very strong winds, high rainfall, and storm surge, which in coincidence with high tides can have disastrous consequences in coastal regions.

Wind speeds are lowest in the North-East monsoon periods, but then pick up during the pre-monsoon hot season when nor'westers and localised storm activity can occur. Wind speeds tend to level off during the South-West monsoon.

Mean daily temperatures are fairly constant between the months of April and September, and show little variation across the region, being of the order of 28°C. From October, temperatures begin to decline, and mean daily temperatures reach a minimum of about 19-19.5°C in January. In April maximum daily temperatures in the region can often exceed 35°C, while in January, minimum daily values can be below 10°C. Increased cloud cover during the South-West monsoon period prevents extremes of temperature when the sun is at its maximum declination. This is reflected clearly from the plots of sunshine hours. There is a dramatic fall in the hours of bright sunshine during the main monsoon period.

Relative humidity is high throughout the year. Maximum values occur in July, when the mean is of the order of 87.5% throughout the region. March produces the lowest value of 70.7% at Chandpur, and January 71.2% at Noakhali.

In an average year, potential evapotranspiration exceeds rainfall between the months of October and March throughout the region. Rainfall in the early and late monsoon periods is highly variable, however, and the average conditions do not give a representative indication of requirements for irrigation. There is a requirement for irrigation between the months of October and April, even under average rainfall conditions.

2.1.2 Rainfall

The annual rainfall over the project area varies from about 1990 mm in the North-West (Chandpur) to about 3180 mm in the South-East (Noakhali). At 80% exceedance probability, annual rainfall drops to about 1765 mm at Chandpur and to about 2855 mm at Noakhali.

The peak rainfall months are June, July and August. During these three months, about 58-60% of the annual rainfall total can be expected. However at Noakhali even the September rainfall exceeds the peak monthly rainfall at Chandpur.

There is no effective rainfall for agriculture in the project area between mid October and the end of March. Even going into May supplemental irrigation may sometimes be required.

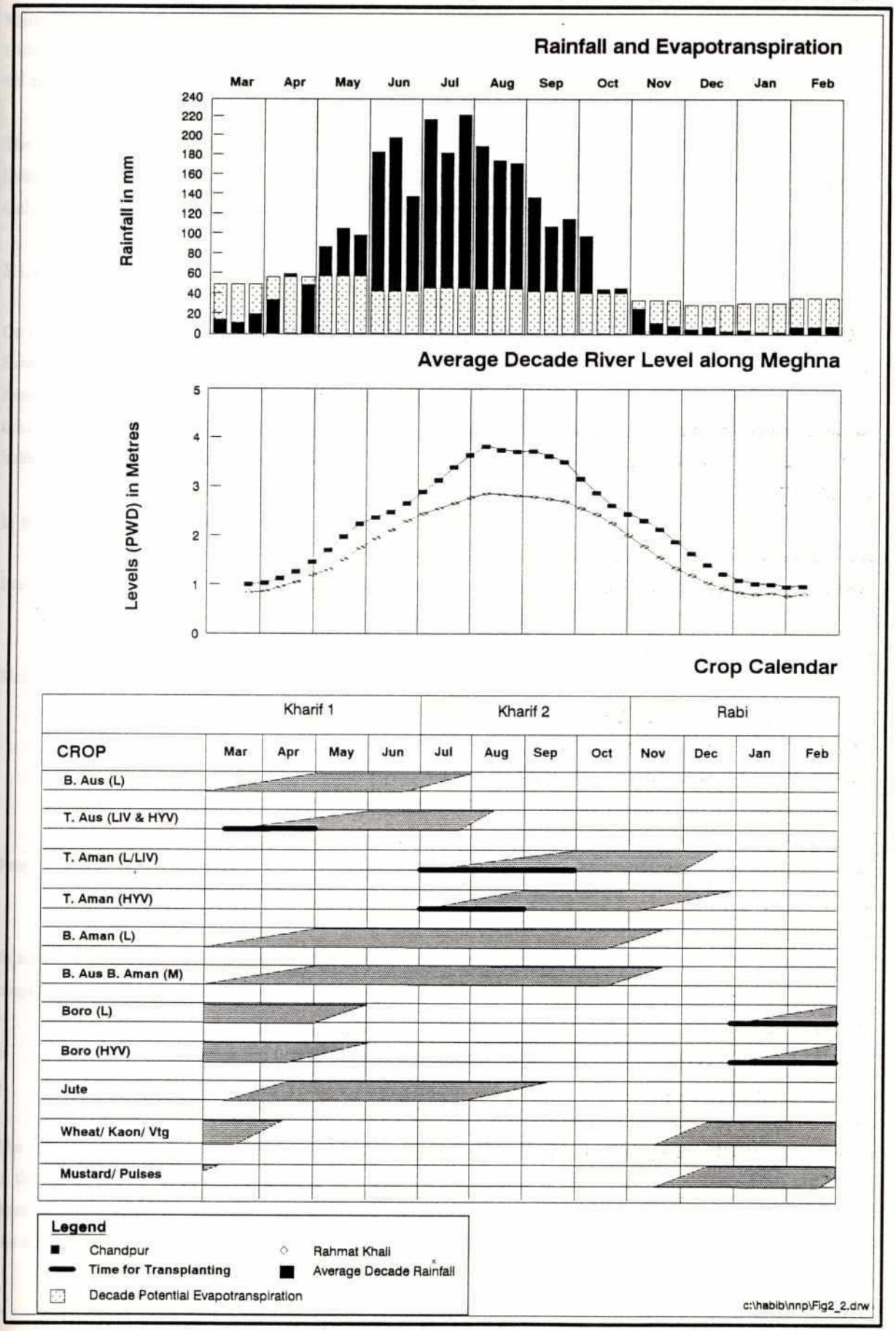
2.1.3 Drainage Conditions

A general map of the drainage system in the project area is presented in Figure 2.1. The sub region is bounded to the west by the River Lower Meghna, and it is this that dominates drainage of the greater part of the region. The mean annual flow at Chandpur is of the order 35,280 m^3/s, but seasonally the discharge varies between a mean monthly minimum 6,875 m^3/s in February and a mean monthly maximum of 88,690 m^3/s in August. 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 2.2 shows hydrographs of mean decad discharges 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. Seasonal water surface profiles between Bhairab Bazar and Daulat Khan are shown in Figure 2.3. The profiles shown are for 1981, but the year chosen is of no significance since a similar pattern occurs every year. 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.

Figure 2.2

Relationship Between Rainfall Evapotranspiration, Floods and Crops



The only important main rivers are the Dakatia and Little Feni rivers and there is a complex network of interconnecting Khals throughout the area. The most important are the Noakhali, Rahmatkhali and WAPDA Khals. The area does receive inflows from a number of flashy rivers draining the western slopes of the Tripura Hills, but all of these debouch into the Little Feni river and no flash flooding or sediment is carried over into the main project area.

The Dakatia River forms the northern boundary of the project area. During times of flood, water levels in the Dakatia are higher than the surrounding land. But this is mostly due to the collection of local rainfall run-off. Only in exceptional years does the Meghna make any direct contribution to flooding.

2.1.4 Flooding Characteristics

On the basis of the old flood phase classification system, only 7% of the area is flood free as reported by MPO. However both the hydrodynamic model and local enquiry suggest as much as 24% is flood free, using the same classification (most of this is in Zone A). The timing, rate of rise, and duration of flooding are, in addition to the flood peak attained, very important factors influencing agricultural damage, cropping patterns, fisheries, and indeed the general disruption caused. Seasonality of flooding is therefore a key variable.

In terms of seasonality, flood problems include:-

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, particularly late aman rice.

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 Lower Meghna (small areas of the Lower Dakatia).
- 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 Dakatia in the north, the old coastal embankment in the south, the Meghna in the west and the Little Feni catchment boundary in the East. During the main monsoon season, the Meghna controls flood extent in the area, and in the northern part of the area, there is very little east to west gradient.

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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. These are discussed in Chapter 10. Solutions cannot be analysed using traditional hydrological methods because of the interdependence of the various catchments and very flat sub-regional topography which makes catchment definition extremely hazardous.

2.1.5 Water Level and Flow Data

The locations of water level and discharge measurement stations in or close to the project area are given in Figure 2.1. It is generally the case that digital records of daily water levels exist only for the post 1983 data. Data availability for these and for the main river stations are summarized in Tables 2.1 and 2.2. A considerable volume of additional hydrometric field data was collected for the project as part of the SWSMP. Some additional hydrometric field data were collected as part of this investigation in order to verify the tidal boundary at Rahmatkhali and the status of the Noakhali Khal.

A number of additional water level recording stations were set up by the SWMC in 1986 to permit hydrodynamic model calibration. The records at these stations are taken over too short a period to permit their use in frequency analysis.

There are no long term relevant discharge measurement stations in the region. The stations at Chandpur and Daulat Khan on the Lower Meghna are strategic stations in the national hygrometric network, but other than assisting in defining boundary conditions in the Lower Meghna, give little insight to conditions within the project area itself. The station at Ganabati Railway Bridge is affected by has a poor rating.

2.1.6 Sediment Data

Sediment deposition from rivers rising in the Tripura Hills is a problem in several areas of the Little Feni and the upper reaches of the Dakatia. There are, however, very few sediment data available for the project area. There is no routine sediment or water quality sampling at any location. The Land Reclamation project recorded sediment concentrations downstream of Rahmatkhali Regulator in 1987 which suggest that there is very little sediment carried in the WAPDA/Rahmatkhali Khal system. The Surface Water Modelling Centre (SWMC) recorded sediment concentrations on a few occasions during 1990 and 1991 at Chandraganj, and these showed even lower values. Both sets of data are presented in Annex I.

This is as expected since the water is mainly run-off from direct rainfall on the project area and its immediate surrounding areas. Almost all the sediment arriving from the Tripura hills is deposited in the Little Feni catchment and the upper reaches of the Dakatia.

Also no sediments from Meghna overspill are deposited in the project area. The model clearly shows that in most years all the flood water is derived from stored rainfall and there is no net inflow from the Meghna. Even in the peak of the monsoon season in high flood years the quantities of inflow are for short durations only and there is net outflow every day.

Also virtually all the tidal effect is attenuated in the reach below Hajiganj and inflows above Hajiganj are virtually non-existent.

TABLE 2.1

Mean Daily Discharge Availability for Noakhali Sub–project

No.	Station Name		Type
84.1	Kaliachari		
181	Gunabati Railway Bridge	T	
212	Parshuram		
G–10	Dakatia at Bagmara		Df/S/W
G–17	Kakri at Miarbazar		S/W
G–22	Dakatia at Chitoshi		S/W
G–38	WAPDA Kl at Chandraganj		Df/S/W
G–52	Sonaichari at Chowara		Df/S/W
G–129	Pagli at Suagazi		S/W

59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91

Average Daily Water Level Availability for Noakhali Sub–project

No.	Station Name		Type
58	Haziganj	T	
79	Matlab Bazar	T	
115	Daudkandi	T	
181	Gunabati Railway Bridge (d/s)	T	
182	Companiganj	T	
222	Noakhali	T	
239	Lakshmipur	T	
240	Bhawaniganj	T	
G–1	Elliotganj Khal at Elliotganj		
G–2	Harikhola Khal at harikhola		
G–15	Little Feni at Kashinagar		
G–22	Chitoshi		
G–36	WAPDA Khal at Piarapur	T	
G–38	Chandraganj	T	
G–40	Noakhali Khal at Begumganj		
G–42	Little Feni at Selonia	T	
G–76	Curzon Khal at Mudaffarganj		
G–91	Mohendra Khal in Dasherhat		
G–92	Noakhali Khal at Naodona		
	Rahmatkhal at Rahmatkhali Regulator (u/s & d/s)	T	
	Kazirhat Regulator (u/s & d/s)	T	

59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91

TABLE 2.2

Tidal Daily Water Level Available on the Main River

No.	Station Name		Type
276	Satnal	T	
277	Chandpur	T	
278	Daulatkhan	T	

59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91

Sources:
(i) Surface Water Hydrology, BWDB, e.g. 212
(ii) Surface Water Modelling Centre, e.g. G–10

Legend:
Dw : discharge (weekly)
Df : discharge (fortnightly)
S : discharge with suspended sediment

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Water Level:
W Non–tidal
T Tidal

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 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.

2.1.7 Salinity data

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 have been plotted as series of monthly maxima for February, March and April from 1966 to 1992, and the results are shown in Annex I. This shows 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.

In the long term the possible construction of a Jamuna barrage with large scale diversions of water elsewhere could affect the situation but in this case not only might Rahmatkhali be affected but Bhola island and other schemes in the south west would be affected even more. In the absence of detailed knowledge of how such a barrage might be operated if it were ever to be constructed the consultants have assumed that the operating rules would continue to allow flows similar to those provided for in the NWP II. As stated above under these conditions the trend in salinity levels should continue to decline and salinity poses no problems for the proposed project.

2.1.8 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 (See Appendix I.V to Annex I. 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.

2.2 Flood Control and Drainage

2.2.1 River Morphology

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.

There are severe erosion problems at Chandpur and along the north western portion of the Chandpur Irrigation Project (CIP) embankment. Both the town and the CIP have suffered damage in the past and remain under threat of erosion from the Lower Meghna as this huge river turns through almost a right angle bend at the junction of the Padma and Upper Meghna. This problem is discussed in the South East Regional Plan report and a proposal had been made by FAP 9B for a hard point at Chandpur which the Regional Plan supports. However, for the purposes of this report and the Noakhali North Project, the erosion at these locations poses no threat, since the CIP eastern embankment remains as a second line of defence.

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 a char opposite the Rahmatkhali Khal mouth disappeared and there was some erosion, the gross erosion rates reported were not of the main left bank. 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 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. After the construction of the cross-dams nos 1 and 2, in 1959 and 1964 respectively huge areas of land were accreted to the south of the old coastal embankment.

Water level records began to be collected for the Noakhali Khal at a station near Noakhali in the mid 1960's. These records are shown in detail in Annex B. 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. The 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.

The LRP report of 1988 also identified the siltation problems of Noakhali Khal and further suggested that the mouth of the khal would continue to move east by up to 20 kms, particularly if additional cross-dams are built to accrete further land. Also this study has included a resurvey of the Noakhali Khal which shows a 20 km length of the Noakhali Khal has a bed level above +3.00m PWD. This confirms the LRP analysis. The LRP report suggested that during the early monsoon period (April-June) spring tides bring flows into the Begumganj depression. This situation in fact occurs throughout the dry season and since these flows are partly saline the

local population tends to construct cross dams in the khal to keep these flows out. The reverse flows are not large in quantity and therefore do not contribute greatly to flooding but the proposed drainage improvements could draw more water into the system. For these reasons a regulator on the khal has been included in the plan for the proposed project.

2.2.2 The Existing Scheme

As outlined in chapter 1 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 in section 2.2.1 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. This report recommends additional work to the bed and some remodelling of the structure to improve the hydraulics. The 1993 survey at the structure site revealed a very deep (11m) scour hole downstream (river side) of the structure and a smaller hole 5 m deep upstream. This latter hole seems to have been caused by opening of only one or two gates for irrigation which can generate quite high heads across the structure. Despite these holes the structure has shown no distress whatever and the downstream stilling basin is still unaffected.

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.

iv) A criticism which might be made of the old scheme, as designed is that the gate arrangement at Rahmatkhali regulator does not provide an easy or reliable method of admitting irrigation water in the dry season. However, it is possible, that at the time it was considered that this was of marginal importance, since low lift pumps were much less used and also the water quality was suspect (see section 2.1.7).

v) The design of the existing Rahmatkhali regulator is particularly unfriendly to migratory fish with uncounterweighted flap gates and, difficult to operate, radial gates. However, in spite of this, recent catch surveys indicate a susprisisgly high percentage of migratory species do seem to penetrate through the regulator. The proposed modifications to the regulator should substantially improve accessibility and this is described elsewhere.

2.2.3 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 laying 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.

2.3 Groundwater

2.3.1 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 sands 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.

2.3.2 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 extent 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.

2.3.3 Expected Future Groundwater Development

a) 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.

b) 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.

It 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.

2.4 Minor Irrigation

2.4.1 Irrigation Areas

A summary of existing irrigation in the project area is given in Table 2.3. This data is taken from the AST data for 1991 and has been updated to include known additional recent groundwater development (see Annex I, Appendix I.IX). As described in the agriculture and economics annexes 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 obvious but by evaluation of other supporting data it has been possible to make some adjustments to the AST data.

Firstly this study has undertaken a survey of pump operators (see Annex I, Appendix I.X. This survey indicated that a substantial proportion of LLP operators move pumps from place to place irrigating more that one area with the same unit. This dual usage of pumps is not identified in the AST data.

TABLE 2.3(a)
Inventory of Minor Irrigation in the Noakhali North Area

Thana	DTW	STW	MTW	LLP <1 cs	LLP 1 cs	LLP 2 cs	LLP 3-5 cs	DTW	STW	MTW	LLP <1 cs	LLP 1 cs	LLP 2 cs	LLP 3-5 cs	Tradit--ional	Total Irrigation	Surface Water	Groundwater (suction)	Groundwater (Total)
	nr	nr	nr	nr	nr	nr	nr	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
Noakhali	0	0	21	84	46	6	1	0	0	17	1,469	1,286	271	73	1,591	4,707	4,690	17	17
Begumganj	1	52	20	549	192	55	1	28	397	49	2,199	1,418	762	51	4,219	9,123	8,649	446	474
Chatkhil	0	0	4	428	24	2	0	0	0	1	1,915	153	14	0	157	2,240	2,239	1	1
Senbag	14	70	2	74	11	2	0	384	453	1	258	89	31	0	296	1,512	674	454	838
Laksam	0	22	1	311	99	63	0	0	63	0.2	1,522	736	1,327	0	1,019	4,667	4,604	63	63
Hajiganj	7	1	0	9	52	73	3	174	4	0	61	645	2,032	0	168	3,084	2,906	4	178
Shahrasti	9	0	0	45	55	22	1	196	0	0	211	544	384	1	117	1,453	1,257	0	196
Faridganj	0	9	0	0	15	45	0	0	61	0	0	125	656	0	22	864	803	61	61
Ramganj	0	4	4	301	131	41	0	0	14	1	924	869	536	0	250	2,594	2,579	15	15
Laksmipur	14	18	3	211	171	413	0	342	101	0.4	773	1,519	6,490	0	1,064	10,289	9,846	101	443
Ramgati	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	45	176	55	2,012	796	722	3	1,124	1,093	70	9,332	7,384	12,503	125	8,903	40,534	38,247	1,163	2,287

Source : AST/CIDA (1991), WITHOUT DTW UPDATE

TABLE 2.3(b)
Estimated Current Irrigation Coverage

Thana	DTW Command	Revised DTW Nrs	Estimated DTW Irri. ha	Estimated Groundwater ha	Estimated Irrigation ha
Noakhali		0	0	17	4,707
Begumganj	28.0	3	76	522	9,171
Chatkhil		20	506	507	2,746
Senbag	27.4	14	354	808	1,482
Laksam		0	0	63	4,667
Hajiganj	24.9	7	177	181	3,087
Shahrasti	21.8	9	228	228	1,485
Faridganj		0	0	61	864
Ramganj		3	76	91	2,670
Laksmipur	24.4	25	632	734	10,580
Ramgati		0	0	0	0
Total	25.3	81	2,049	3,212	41,459

Table assumes 1991 (AST) irrigation plus revised DTW Numbers, with 1991 average DTW command area.

Secondly the AST data was compiled in 1991 and the farmer surveys and BBS data is for 1992. It is reasonable to assume that there was some growth during 1991/1992. This growth has been assumed at 5%. Thirdly there are very substantial differences of areas per LLP unit between one thana and another as reported by AST data. It is interesting for example that the area per unit in Noakhali is much higher than in the neighbouring Begumganj thana whereas conversely the area of traditional irrigation reported in Begumganj is much higher than that in Noakhali. It is quite possible that much of the traditional irrigation reported in Begumganj is in fact supplied by LLP. This would tie in with the data from the farmer surveys where very little traditional irrigation was reported.

Table 2.4 shows the AST data with the two adjustments discussed above.

TABLE 2.4

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 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 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.

2.4.2 Irrigation By Mode

According to the AST data and, even more so, according to the farmer surveys, the dominant irrigation mode is LLP. Table 2.5 shows irrigation by mode for each zone as reported by AST adjusted as described in the previous section.

TABLE 2.5

Irrigation by Mode and Zone

Zone	DTW	STW	MTW	Traditional	LLP	Total
A	345	0	0	188	3735	4268
B	13	3	18	3984	5470	9488
C	804	874	53	2108	7427	11265
D	936	194	1	2487	20748	24366
Total	2097	1072	72	8766	37380	49387

LLPs account for over 75% of all the irrigation in the project area. As described above even this may be an under estimate since much of the land recorded as traditional irrigation takes water which was originally lifted by LLP.

2.4.3 Pump Surveys Results

It is noticeable that there are very large differences in the AST data of the areas served per LLP unit. During the topographical survey the surveyors were asked to obtain details for all the pump units they observed along the khals during their surveys. These khals were of course, the larger khals in the network. Unfortunately not all the survey parties followed these instructions but the results obtained are nevertheless valuable and they confirm random field interviews along the major khals.

The number of pumps for which details were obtained was 56 and the power of the engines varied from 3 hp to 25 hp. The largest unit was an electric powered pump near Lakshmipur commanding 40 ha where REB are now offering cheap power rates for such units. Only five units were serving less than 10 ha and the average command area was 21.3 ha.

Discussion with farmers and villagers at typical pump locations on the large khals yielded similar results to those given above and typical tertiary channel lengths quoted were from 1.0 to 1.5 km and exceptionally 2.4 km.

These results tend to confirm that where there are more reliable sources of water farmers manage to organise quite large units for distribution and will take water quite long distances. If this had not been the case it would be quite impossible for the areas reported to be growing Boro rice.

There are of course very large numbers of smaller pump units serving very small areas and it is these that tend to be moved from place to place. The pump operator survey consequently showed the overall average area per pump to be only 8.2 ha.

A number of installations were visited in the field and it is clear that farmer groups are adopting sensible and practicable methods to achieve good distribution.

However the pump operator survey showed that the most common limitation on command area was the supply of water in the khal (72%) of responses. Only in Zone A was this not the primary problem. In Zone A the major problem is stated to be transmission difficulties (54.2% in Zone A and 32.3% overall). The only other significant problem recorded was "competition from other pumps" which could also be directly connected with water availability.

2.4.4 Surface Irrigation Distribution

As stated in the preceding section 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.

Figure 2.4 shows two types of arrangement for tertiary canal alignments. Type (a) shows a channel cut into the top of an existing road embankment. The particular system seen had come from Rahmatkhali Khal with a proper discharge box, a culvert under the main Begumganj-Lakshmipur Road and then a plastic lined channel. This was stated to be 1.5 miles (2.4km) long and to be commanding 65 acres (26.3 ha).

The more common type (b) shows a channel using an existing small khal adjacent to a village road or track with a small bank on the other side using material excavated from the Khal. This small bank would be broken in the monsoon to allow drainage. In this type the pump is mounted on a temporary cross dam at the small khal's outfall to the main khal. Again in the monsoon season the pump is removed and the cross dam demolished to allow drainage. There are many such khals and embankments available in the area. These systems are simple, cheap and effective and it is anticipated that these types of systems would be typical in the future.

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.

2.4.5 Groundwater Irrigation

The potential has been discussed in section 2-3 and it is expected that groundwater will continue to be a slow growing and still minor element of the total irrigation development in the project area. Also most of the existing development has occurred outside the areas identified for development in this study and this is likely to continue to be so.

CHAPTER 3

AGRICULTURE

3.1 Data Collection and Surveys

The principal sources of data used by the study were field investigations and Government statistics. The structure of the field surveys was designed to incorporate the division of the study area into four agro-ecological zones (Figure 3.1) on the premise of different flooding regimes and access to irrigation within each zone. Consequently much of the output from the surveys is presented by zone. The majority of surveys were based on questionnaires administered to a statistical sample of 12 randomly selected mouzas within each zone. Respondents were selected at random from lists of village inhabitants provided they fulfilled the requirements of the survey. Thus for example the farmer survey interviewed eight farmers in each mouza, picked at random until the predetermined quota for each farm size was fulfilled. The following surveys were completed :

1. A large-scale questionnaire survey of about 384 farmers, with more detailed case studies of about 50 of these farmers.

2. A survey of about 300 fields in the five 2 km square topo/hydrological survey areas.

3. A questionnaire survey of 96 fish pond operators.

4. A questionnaire survey of 80 professional fishermen.

5. A questionnaire survey of 96 landless people.

6. A questionnaire survey of 96 irrigation pump operators.

7. A questionnaire survey of 96 women.

8. Environmental fieldwork.

9. Health and Nutrition fieldwork.

10. An inventory of infrastructure.

11. Topographical survey of 5 sample squares.

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In addition to the above, a series of people's participation meetings was carried out by a multi-disciplinary team to focus on key aspects of villagers' response to changes in water levels and irrigation, and their willingness to contribute to implementation, operation and maintenance. These also evaluated peoples' attitudes to project proposals and elicited their participation in the planning process.

Government statistics were collected from both District and Thana level offices, most notably from the Department of Agricultural Extension and the Bangladesh Bureau of Statistics. Other sources of information included banks, NGOs, parastatals and other consultants.

3.2 Topography and Soils

3.2.1 Topography

The Noakhali North project area is divided into 3 physiographic units extending over the floodplains of the Meghna river (See Figure 3.2). (1) Lower Meghna River Floodplain stretching along the left bank of the Meghna river comprises older tidal deposits with irregular relief of gently undulating ridges and basins. (2) Young Meghna Estuarine Floodplain, occurs in the southern part of the Noakhali project area from southern left bank of the Meghna to Little Feni rivers in the east, mainly comprises level char land and mud. (3) Old Meghna Estuarine Floodplain, which covers the northern part of the area, consists of an almost smoothed out plain of very low relief with broad ridges and extensive shallow basins.

3.2.2 Soils

Soils in the project area show slight differences by physiographic units. Soils in the Lower Meghna River Floodplain are generally non-calcarious and deep silts, but soils on ridges are lighter than those in adjoining basins and depressions. In the Young Meghna Estuarine Floodplain near the coast, soils are finely stratified, non-calcareous, silty alluvium, and less affected by salinity. Deep silty soils are predominant in the Old Meghna Estuarine Floodplain.

Apart from some soil salinity occurring on the southern edge of the area, the principal determinants of agricultural development are the flooding regime and availability of irrigation, rather than any intrinsic soil properties. According to the land capability classes of each soil association, most of the soil associations falls into land capability class II (See Figure 3.3). The area of class III in the south-west suffers from a salinity limitation, and the small area of class IV in south-eastern edge along the Oder Khal suffers from a tidal surge risk. Crop suitability classification in the reconnaissance soil survey carried out during 1965 and 1966 shows that most of the soil associations were well to moderately suitable for wet and dry land cropping.

3.3 Current Land Use

The Noakhali North Project area covers approximately 160,800 ha gross, extending over parts of 3 Thanas in Lakshmipur District (56,400 ha or 35% of the total area), 4 Thanas in Noakhali (92,500 ha or 58%) and 2 Thanas in Chandpur (11,900 ha or 7%) and one in Comilla. The gross area includes 52,200 ha (32% of the total area) of non-cultivable land of perennial water bodies, infrastructure and settlement areas. Net cultivable area (NCA) is estimated at about 108,600 ha which accounts for 68% of the gross area. Table 3.1 shows distribution of the area by four planning zones A, B, C and D.

Figure 3.3

Land Capability

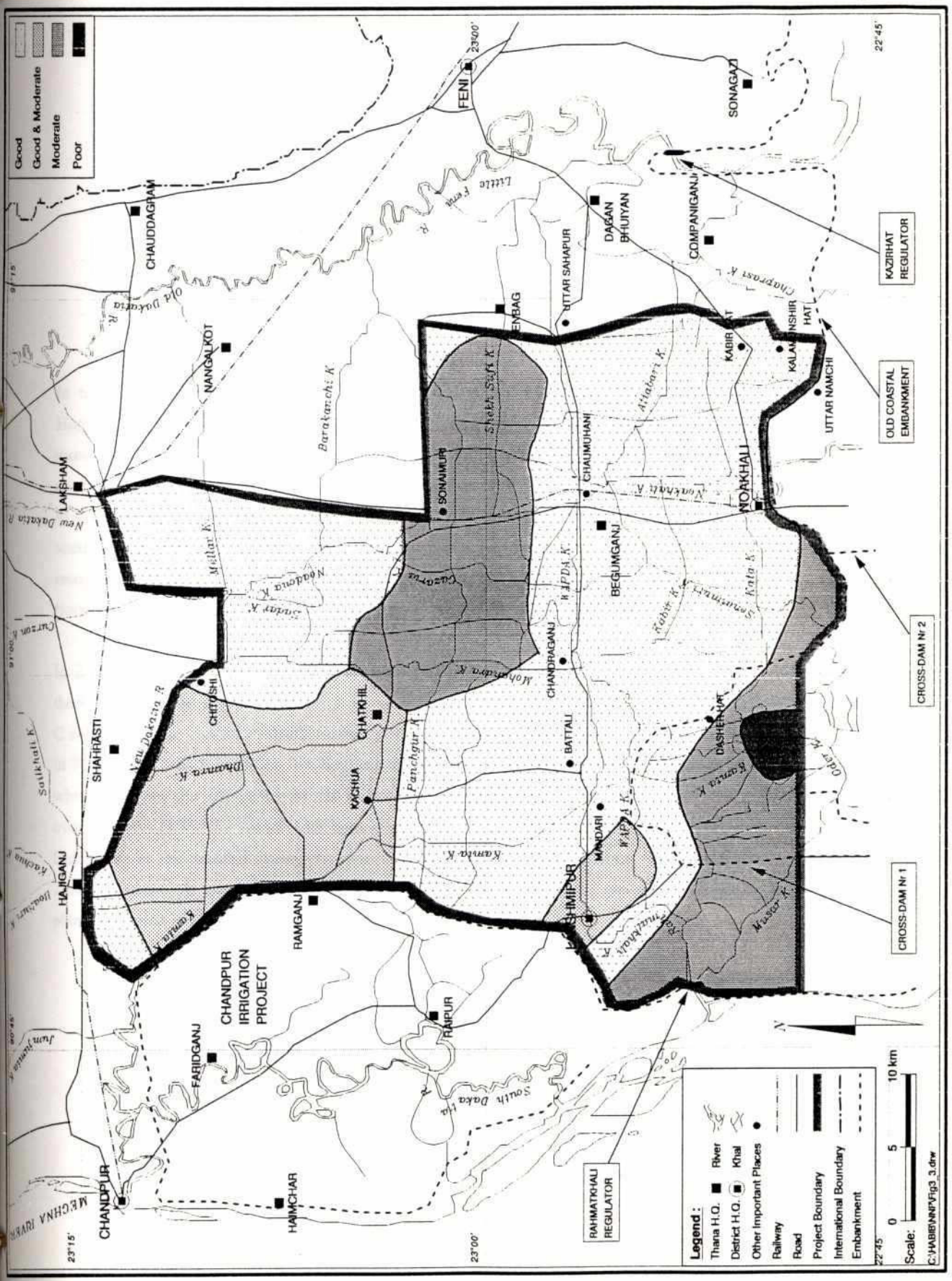


TABLE 3.1

Gross Area and NCA by Planning Zones

(unit: ha)

Item	Planning Zones				Total
	A	B	C	D	
Gross Area	29,332 (18%)	35,553 (22%)	32,769 (20%)	63,160 (39%)	160,814 (100%)
NCA	22,956 (21%)	21,115 (20%)	22,107 (20%)	42,450 (39%)	108,628 (100%)
Ratio to Gross	78%	59%	67%	67%	68%

Source: Study Estimates.

In terms of flood phases, 24% of the area is Highland:F0 (flood depth of 0 to 30 cm), 20% Medium Highland:F1 (30 to 90 cm), and 56% Medium Lowland and Lowland:F2&F3 (over 90 cm). Floods are mainly caused by rainfall during pre-monsoon and monsoon seasons, but overspill from the Dakatia and Little Feni rivers which is caused by flash runoff from the Tripura Hills situated in the north-east of the area also contribute to drainage problems. In addition to this, cyclones damage crops with high winds and tidal surges in the southern parts of the area. As for irrigation, LLPs are the main irrigation mode and shallow groundwater resources are limited to the small north-eastern part due to salinity. The planning zones show the different flooding and inundation conditions according to the flood phase characteristics.

In Zone A which is located in south-western part of the project area, most of NCA is F0 with some F1, and there is no F2 and F3 land. Zone A is not affected by severe flooding in the monsoon season Zones B and C extend into the central to south-eastern portion of the project area, and over half (53%) of the land is situated in F2 and F3 which includes the Begumganj depression in the north-western corner of Zone B. In Zone D which occupies the northern part and is bounded by the Dakatia river, 90% of the area is flooded to depths of over 90 cms (F2&F3) where Laksham depression is located. This zone is subjected to flooding from the Dakatia river and rainfall during the monsoon season. Accordingly, Zone A may be classified as higher land, Zones B and C as medium to lower land and Zone D as low land, generally. Area by flood phase in the planning zones is summarized as in Table 3.2.

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TABLE 3.2

Net Cultivable Area by Present Flood Phase in Planning Zones

(Unit:ha)

Flood Phase	NCA in Planning Zone A		B		C		D		Total	
Highland F0 < 30 cm	20,890	(91%)	845	(4%)	3,758	(17%)	425	(1%)	25,917	(24%)
Medium Highland F1 30 to 90 cm	2,066	(9%)	6,968	(33%)	8,622	(39%)	3,821	(9%)	21,476	(20%)
Medium Lowland & lowland F2&F3 > 90 cm	0	(0%)	13,302	(63%)	9,727	(44%)	38,205	(90%)	61,235	(56%)
Total	22,956	(100%)	21,115	(100%)	22,107	(100%)	42,450	(100%)	108,628	(100%)

Irrigation conditions change every year depending on the rainfall and flooding condition as well as distribution of irrigation equipment. Irrigation coverage has expanded recently through development of STWs, DTWs and LLPs. Irrigation in the area is estimated using data obtained through farmer surveys and AST data. Irrigation water is applied mainly for boro crops, although supplemental irrigation is used for rabi, aus and aman crops. Coverage of irrigation is high with approximately 49,900 ha or 46% of the total NCA. Zones B, C and D are irrigated at around 50%, however, Zone A is presently irrigated less than 20%. Irrigation condition by the flood phase generally indicates that the irrigation rate is higher in the lower land levels. Main mode of irrigation is LLPs, however, shallow tubewells are also utilized in the north-eastern part where groundwater is not affected by salinity severely and more recently in the south-west DTWs have been introduced. Irrigated area by planning zone and flood phase are shown in Annex E and summarized in Table 3.3.

TABLE 3.3

Irrigation Area by Planning Zones

					(Unit:ha)
Condition	Planning Zone				Total
	A	B	C	D	
Irrigated	3,295 (17%)	10,769 (15%)	10,611 (48%)	24,673 (58%)	49,978 (46%)
Rainfed	19,031 (83%)	10,346 (40%)	11,496 (52%)	17,777 (42%)	58,650 (54%)
Total	22,956 (100%)	21,115 (100%)	22,107 (100%)	42,450 (100%)	108,628 (100%)
Mode of Irrigation					
LLP	16	30	32	50	35
STW	0	0	4	1	1
DTW	0	0	3	2	2
Traditional	1	21	9	6	8
Total	17	51	48	58	46

Source: Estimation by Farmers Survey and AST data.

Irrigation Area by Flood Phase

				(unit: ha)
Condition	Land Type			Total
	FO	F1	F2 & F3	
Irrigation	3,449 (13%)	6,115 (29%)	40,414 (66%)	49,978 (46%)
Rainfed	22,468 (87%)	15,361 (71%)	20,821 (34%)	58,650 (54%)
Total	25,917 (100%)	21,476%	61,235 (100%)	108,628 (100%)

Source : Estimation by Farmers Survey and AST data (1991).

3.4 Farm Size, Fragmentation and Land Tenure

Farm sizes have been classified as follows:

Farm groups	Farm size (ha)		
Marginal	0.02	to	0.2
Small	>0.2	to	1.0
Medium	>1.0	to	3.0
Large	>3.0		+

Farm land distribution in the area is highly skewed. Large and medium farmers who constitute nearly 17 percent of farm households own about 55 percent of the land.

Percentage of holding					Overall %	
Farm size	A	B	C	D	Area	Number
Marginal	3.8	6.6	5.6	4.5	5.1	27.9
Small	40.1	46.0	39.1	34.7	40.4	55.2
Medium	34.4	28.8	45.0	48.5	38.3	14.0
Large	21.7	18.6	10.3	12.3	16.2	2.9

Source: Estimation from Farmers Survey.

Since the 1983/84 Agricultural causes, the pattern of land ownership has not changed significantly.

District	Small farms >0.02 - 1.00 ha		Medium farms >1.0 - 3.0 ha		Large farms >3.0 ha +	
	Nos.	area	Nos.	area	Nos.	area
Noakhali	84.4%	44.4%	13.1%	35.0%	2.5%	20.5%

The survey records average farm size as 0.81 ha against a corresponding figure of 0.91 ha for Bangladesh as a whole

When the landless are brought into the picture, the pattern of household distribution between the survey and the census is as follows:

Farm groups	Noakhali survey	Census
Landless	24.3%	22.4%
Marginal	21.1%	25.5%
Small	41.8%	39.2%
Medium	10.6%	11.0%
Large	2.2%	1.9%

The two sets of data are remarkably close to each other.

Table 3.4 presents information on land tenure arrangements from the farmer survey. A sizeable proportion, about one-third of farm households, rent-in land which accords with the census results.

Small and medium farmers account for 61 and 25 percent respectively of all rented in land and the rest is more or less equally shared by the marginal and large farmers. Small and medium farmers again account for about 85 percent of the rented out land with nearly equal shares and the remainder by marginal and large farmers with the latter accounting for twice the area of the former.

TABLE 3.4

Farm Size and Land Tenure - Results of Farmer Survey

	farm size (cultivated land) - ha				All farms
	marginal 0.004-0.20 ha	small >0.2-1.0 ha	medium >1.0-3.0 ha	large >3.0 ha	
Proportion of all farms	28.0%	54.4%	14.7%	2.9%	100.0%
Proportion of farms in class that : own land	100.0%	100.0%	100.0%	100.0%	100.0%
rent out land	5.9%	16.9%	49.7%	35.3%	19.2%
rent in land	20.9%	43.7%	22.0%	8.6%	33.1%
Average area for all farms land owned	0.27	0.73	2.53	5.01	0.99
- not cultivable	0.12	0.15	0.30	0.44	0.17
= cultivable owned	0.15	0.59	2.24	4.57	0.82
- land rented out	0.04	0.18	0.62	0.84	0.22
+ land rented in	0.03	0.12	0.18	0.23	0.11
= net area cultivated	0.14	0.53	1.80	3.97	0.71
Average for farms that rent land					
- land rented out	0.47	1.12	1.31	1.71	0.98
- land rented in	0.12	0.27	0.70	0.46	0.30
Proportion of land owned	7.6%	40.2%	37.6	14.5%	100.0%
not cultivated	19.7%	47.3%	25.6%	7.5%	100.0%
rented out	4.8%	43.6%	40.9%	10.8%	100.0%
rented in	7.5%	61.0%	25.3%	6.2%	100.0%
cultivated	5.6%	40.6%	37.6%	16.2%	100.0%

Tenurial arrangements are nearly always based on sharecropping where the yield is shared equally by the owner and the renter, the latter bearing all the costs of production except in the case of boro where owners often bear part of the costs of fertiliser and irrigation. Within the group of small farmers who rent land, the area contracted in constitutes about 50 percent of the area cultivated by these farmers. In the case of medium farmers, the corresponding number is nearly 40.

The average number of fragments per hectare of land was found in the survey to be four. which compares with seven for Bangladesh as a whole. Land holdings especially of smaller farmers are concentrated in fewer flood phases. On the whole 58 percent of the farmers' holdings are located in one flood phase and another 38 percent in two flood phases.

Farm Size	Holdings	Holdings in flood phases (% of farmers)		
	One	Two	Three	Four
Marginal	78.3	21.7	-	-
Small	58.9	38.4	2.7	-
Medium	41.0	50.6	8.4	-
Large	40.0	30.0	30.0	-
Overall	58.0	37.8	4.2	-

Source: Farmers Surveys.

3.5 Cropping Patterns

Cropping patterns for the present situation were derived from data collected by the farmer survey for each of the four zones. Comparison with DAE and BBS cropping patterns revealed some discrepancies between the three sources of data but this is not surprising given that all the Zones include at least three thanas and Zone D covers eight. A more serious discrepancy occurred with estimated access to irrigation between the survey and the Agricultural Sector Team's (AST) 1991 assessment of irrigated areas.

Compared with the AST data, the survey consistently overestimated the amount of irrigation and by fairly wide margins. However an adjustment, based on the pump operator survey which showed that 20-25% of pumps are used to irrigate two separate areas and consequently increases the area irrigated, brings the two figures closer together. As it is not known whether the AST data or the farmer survey are correct, a mid-way point between the two was calculated. As the mid-way point is close (ie within 3000 hectares) to the adjusted AST data there is reasonable justification for accepting the numbers. They are obviously very important because they determine how much benefit the project can claim by improving irrigation supplies. In this respect it is fortunate that the best correlation between AST data and the farmer survey occurs in Zone A as this is where the largest increase in irrigation supply is expected. Overall the area irrigated is expected to increase from 46% to 64% in the future. Present cropping patterns obtained from the farmer survey were adjusted for lower levels of access to irrigation by reducing areas of boro and increasing areas of aus and b. aman such that the cropping intensity did not change significantly. "Future with" cropping patterns are derived on the basis of increased irrigation and changes in the flooding regime which permit increased areas of T. aman to be grown, often at the expense B. aman or mixed aus/aman. The extent to which increased areas of T. aman are incorporated in "Future with" cropping patterns are based on an analysis of present cropped areas of both LT and HYV aman and projecting current planting strategies into the future. This severally restricts the area of HYV aman in relation to the area which could be "theoretically" planted but it would be unrealistic to do otherwise. Whilst farmers seem happy to grow areas of LT aman up to a theoretical one in two year prediction, they are far more conservative with HYV aman.

Details of how cropping patterns in the future were derived are presented in Annexes E and J. A summary of the proposed project cropping pattern is presented in Table 3.5.

TABLE 3.5

Summary of Cropping Pattern Changes

(% of NCA)			
	Present	Future w'out (1) and (2)	Future with (1) and (2)
B Aus, local	10.8%	10.8%	8.0%
B Aus, HYV	4.6%	4.6%	4.6%
T Aus, local	3.6%	3.6%	3.2%
T Aus, HYV irri	0.3%	0.3%	0.4%
T Aus, HYV in-ir	8.4%	8.4%	8.2%
Mixed aus/aman	7.6%	7.6%	5.6%
B Aman local dw	26.3%	26.3%	19.6%
T Aman local dw	4.5%	4.5%	4.0%
T Aman local	32.2%	32.2%	39.6%
T Aman HYV irri	0.0%	0.0%	0.0%
T Aman HYV n-ir	5.7%	5.7%	12.7%
Boro, local	0.0%	0.0%	0.0%
Boro, HYV irrig	46.0%	46.0%	63.0%
Boro HYV p-irr.	0.0%	0.0%	0.0%
Wheat irrig.	0.0%	0.0%	0.0%
Wheat unirrig.	0.1%	0.1%	0.1%
Potato irrig.	0.1%	0.1%	0.1%
Patato unirrig.	0.2%	0.2%	0.2%
Jute	0.7%	0.7%	0.0%
Pulses: ave.	8.9%	8.9%	8.5%
Mustard	2.1%	2.1%	1.7%
Spices (chilli)	3.2%	3.2%	3.2%
Veg. (brinjal)	0.8%	0.8%	0.8%
Total	166.3%	166.3%	183.5%

3.6 Yields

Yields in the present "future without" and "future with" project situations are assumed to be the same for each crop grown under the same conditions. Where project interventions reduce flood damage, yields are of course effectively increased in the "with project" situation (but as the analysis includes these benefits separately it is not immediately obvious). Yield assumptions are based mainly on the results of the farmer surveys but have been adjusted where necessary with reference to BBS, DAE, and other sources of information. In general the farmer survey indicated higher yields than either BBS or DAE for the major crops, and where these were supported by other studies they have been accepted. This is in accordance with the FPCO revised Guidelines for Agricultural Impact Assessment (February 1993) page 16.

Future yields have not been increased in either the without or with project analyses as there is little evidence to justify such increases on either a national scale or within FCD/FCDI projects. FAP 12 has in some cases identified yield improvements inside FCD projects but their main conclusion was 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". Yield assumptions adopted in this study are presented in Table 3.7.

TABLE 3.7

Crop Yields in the Project Area

	Noakhali			
	Farmer Surveyy	DAE	BBS	Used in Budgets
B Aus, local	1.69	1.34	1.57	1.60
B Aus, HYV	2.6	2.78		2.40
T Aus, local	2.25		2.98	2.40
T Aus, HYV irri				3.25
T Aus, HYV n-ir	2.88		2.30	2.85
Mixed aus/aman	2.29			2.30
B Aman local dw	1.56	1.63	1.71	1.60
T Aman local dw	2.19			2.00
T Aman, local	2.14	2.20	2.0	2.10
T Aman HYV irr				3.75
T Aman HYV n-ir	2.90	3.74	2.63	3.55
Boro, HYV irrig	5.08	4.46	4.17	5.00
Wheat irrig.	1.38	-	-	2.25
Wheat unirrig.	1.29	-	-	1.80
Potato irrig.	24.25	12.24(1)	10.28(1)	15.00
Potato unirrig.	11.96	5.51(1)	7.65(1)	10.00
Jute	1.69	1.53	1.72	1.90
Pulses: keshari	0.57	0.63	0.70	0.70
mung	0.62		0.60	0.60
masur	0.59		0.73	0.50
mash	0.61			0.70
Mustard	0.84		0.69	0.75
Spices (chilli)	2.62		2.76	4.00
Veg. (brinjal)	10.59		7.19	8.00

Note (1) BBS and DAE potato yields are for HYV and local and not by irrigation status.

3.7 Crop Inputs

Crop inputs have been based on both the farmer and farmer case study surveys, the Gumti Phase II 1990 study and MPO Technical Report No 14. These are presented in Table 3.8.

TABLE 3.8

Physical Input Quantities and Production per Hectare

Crop	Labour days	Draft Animals pair day	Seed (kg)	Fertiliser (kg)			Animal manure (kg)	Pesticide (kg)	Production (t/ha)	
				Urea	TSP	MP			**Main Crop**	**By-product**
B Aus, local	138	45	85	60	30	0	1000	0.25	1.60	3.20
B Aus, HYV	144	45	85	80	40	0	1000	0.25	2.40	2.50
T Aus, local	154	47	30	80	40	0	1000	0.25	2.40	4.80
T Aus, HYV irri	178	47	30	140	50	10	1000	0.50	3.25	3.25
T Aus, HYV n-ir	174	47	30	140	50	10	1000	0.50	2.85	2.85
Mixed aus/aman	165	44	83	80	40	0	0	0.13	2.30	2.30
B Aman local dw	108	44	83	40	0	0	0	0.13	1.60	1.60
T Aman local dw	130	40	44	90	0	0	0	0.13	2.00	2.00
T Aman, local	141	40	44	80	40	9	0	0.25	2.10	4.20
T Aman HYV irri	170	43	30	120	90	25	700	1.16	3.75	3.75
T Aman HYV n-ir	166	43	30	120	80	25	700	1.16	3.55	3.55
Boro, local	118	25	40	120	0	0	0	0.00	2.80	5.60
Boro, HYV irrig	210	43	30	170	140	30	1000	1.00	5.40	5.00
Boro HYV p-irr.	205	43	30	193	160	45	1000	1.00	0.00	0.00
Wheat irrig.	127	45	130	115	80	30	0	0.30	2.25	2.25
Wheat unirrig.	102	45	130	80	50	24	0	0.30	1.80	1.80
Potato irrig.	194	44	1000	277	290	102	1500	3.00	15.00	0.00
Potato unirrig	175	44	1000	277	290	102	1500	2.00	10.00	0.00
Jute	215	45	9	89	67	9	2000	0.00	1.90	3.80
Pulses: ave.	50	30	31	0	0	0	0	0	0.68	0.68
Mustard	58	37	10	192	144	40	750	0.40	0.75	0.75
Species (chilli)	157	30	1	100	180	90	2500	0.00	4.00	0.00
Veg. (brinjal)	270	44	1	100	60	40	2500	0.30	8.00	0.00

3.8 Farming Requirements

3.8.1 Crop Inputs

The supply of fertiliser and chemicals is now in the hands of the private sector. Bangladesh Agricultural Development Corporation (BADC) no longer has any responsibility for procurement or distribution of fertilisers. Fertiliser prices are no longer subsidised but despite a sharp rise in prices, consumption had continued to grow at about 10 per cent per year, partly because of more efficient distribution by the private sector and partly because its cost relative to the price of rice remains favourable compared with other countries in the region.

Seeds for major crops are provided from the farmers' previous harvest or purchased in the local market. Improved seed production under the auspices of BADC account for less than 5 per cent of requirements.

3.8.2 Labour

Although most of the work on smaller farms is done by the farmer and his family, shortages of labour are recorded by all groups of farmers. Delays in farming operations caused by lack of labour were registered by 23% of marginal farmers, 57% of small farmers, 65% of medium farmers and 80% of large farmers in the farmer survey.

About 80 percent of the farmers hire labour and 18 percent hire women as well. Women do most of the post harvest work : grain drying, crop cleaning, par-boiling and storing. Most of the par-boiled paddy is husked by rice mills. Women are generally paid considerably less than men. However, the trend in hiring women should be a positive development in solving, to some extent, the problem of delay currently reported in farm activities.

3.8.3 Draught Power

Less than 30 percent of the farmers own draught animals but over 80 per cent of the farmers use animals for farm works, especially for land preparation and for threshing, weed control and transport. Ownership of animals is positively related to farm size with relatively few smaller farmers owning their own animals. Shortages of draft power are reported to be widespread and consequently a large percentage of farmers, about 60 percent in Zone B and C and 30 per cent in Zone A and D make use of power tillers. Boro and to a lesser extent B. aus (local) and T. aman (local/LIV) are major crops affected by power shortages.

3.8.4 Credit

Most of the finance for growing crops comes from retained profits earned on previous crops or from other family owned enterprises. Credit from banks' money lenders, input dealers and other sources excluding relatives is very limited and as such no seasonal credit charge has been included in the crop budgets. This is discussed in Annex E.

3.8.5 Markets

The marketing system in Noakhali is largely traditional and in the hands of small traders many of whom are also farmers. Products which are marketed are channelled from the grower through primary markets and secondary markets to the terminal markets of Dhaka and Chittagong.

a) Primary markets

Rural people sell surplus crops and procure the necessities of life and agricultural inputs in rural primary markets which generally sit twice a week. These markets are operated by growers, local traders and small retailers. About 90% of the paddy and 70% of milled rice marketed in primary markets is sold directly by farmers, the remaining being undertaken by traders.

Most rural primary markets are long established and have not expanded even where marketed amounts have increased considerably. They suffer from extreme congestion, products being assembled on roads, lanes and pieces of waste ground. Inadequate space in the market limits entry by newcomers and concentrates marketing power in the hands of those with permanent stalls and processing facilities. Most markets have few permanent structures, and lack warehousing, basic amenities and sanitation.

(b) Rural Assembly Markets

Rural assembly markets gather small volumes of produce from farmers and intermediaries for export to other regions or main centres. Traders travel from outside to procure local surplus production. These markets often have permanent structures, rice-husking mills, agricultural input merchants, wholesalers and banking and communication facilities. Some of the principal rural assembly markets are those in Begumganj, Chandraganj, and Mandari.

(c) Secondary Markets

Commission agents, merchants, wholesalers, processors and exporters operate from secondary markets. They are generally connected to other main centers by national highways, railways and all weather waterways.

Secondary markets in surplus areas sell foodgrains to other districts, retaining only small amounts for local sale. They mostly handle aman and boro rice, with only negligible quantities of aus, reflecting the shift from aus to boro cropping in surplus areas, and the fact that most of the remaining aus would be consumed within the district. The main secondary markets are in Chandpur, and Chowmohani.

Local self-sufficiency in wheat is unusual; even foodgrain surplus areas tend to import wheat from other districts and re-distribute it within the area.

(d) Terminal markets

Terminal markets are large processing, export and distribution centres which receive their supplies from secondary markets. The south-east region lies between the two terminal markets of Dhaka and Chittagong. Traders usually buy rice directly from mills and transport it to terminal markets where they sell to retailers through wholesalers. Wholesalers have their own premises in the terminal markets and act as agents for both buyers and sellers and provide temporary storage for rice. They sell to local retailers and wholesalers from district markets or distributing traders. Some of the wholesalers in the terminal markets buy rice directly from the millers.

7.8.6 Marketing Margins

Price differentials between primary markets and the farmgate are generally 3-4%. Margins between primary and secondary markets are typically of a similar level. The price spread between farmgate and retail prices varies according to location, season and other factors, farmgate prices of rice generally being between 73 and 85% of retail prices. The rice market in Bangladesh is reasonably competitive and efficient, the profit margins are not excessive.

3.9 Agricultural Extension and Research

3.9.1 Agricultural Extension

The Department of Agricultural Extension (DAE) of the Ministry of Agriculture is responsible providing farmers with technical advice and training.

In each district agricultural extension work is controlled by a Deputy Director of Agriculture (DDA). He is supported by Subject Matter Specialists (SMS) in crop production, pest control, and training. At the Thana level staff includes a Thana Agricultural Officer (TAO) supported by a Subject Matter Officer, an Assistant Agricultural Extension Officer and a Junior Agricultural Officer. The grass roots level extension agent is the Block Supervisor (BS) who is responsible for a block, typically comprising about 1000 farmers.

Agricultural Extension is organised through the Training and Visit (T&V) system. This involves a programme of regular visits by the BS to 8 sub-blocks according to a fortnightly programme. At each sub-block there are 10 contact farmers through which messages concerning improved practices are passed on to the farming community. In addition the BS attends one training and one conference session during the fortnight where he is given the next fortnight's messages and farmers' problems are discussed. He also maintains demonstration plots in farmers' fields.

Experience of the T&V system has highlighted a number of weaknesses, in particular the relevance of simple messages for the varied and sometimes complex problems faced by farmers, and the high cost and management problems in maintaining 12,000 Block Supervisors in the field. The T&V system is now being overhauled under the Agricultural Support Services Programme (assisted by World Bank, ODA and USAID) which aims to concentrate activities in key areas including minor irrigation operation and on-farm water management.

3.9.2 Agricultural Research

Research is coordinated by the Bangladesh Agricultural Research Council (BARC) and carried out through five major research agencies, each specializing in a particular crop or crops.

The Bangladesh Rice Research Institute (BRRI) is responsible for research into rice, and provides comprehensive training on rice cultivation to officials of various agencies. It has two Regional Research Stations in the study area, one at Comilla and one, for saline conditions, at Sonagazi near Feni.

3.10 Constraints on Crop Intensification

In the densely populated Noakhali Study area, farmers need to maximise the productivity of their very limited areas of land. Cropping intensity is limited by widespread flooding which also constrains the use of short strawed HYVs, and means there is a significant risk of crop damage. In the dry season lack of irrigation is also a constraint, although nearly half of the cultivable area is now irrigated.

Future water resource projects may control flooding, reduce monsoon water depths, and add to the irrigated area. This would help reduce the land and water constraint on agriculture, but benefits for farmers pre-supposes that they have the resources available to utilise the improved agricultural environment.

There are a number of perceived constraints to agriculture, that are not water related, and may mean that farmers are unable to respond to improved land and water conditions. In particular they may lack the labour, power and inputs needed to increase cropping intensity and switch to HYVs. The farmers' surveys identified shortages of draught power (especially for small farmers who do not have their own animals), and labour (especially for medium and large farmers who rely more on hired workers). The institutional credit system is totally inadequate to help provide capital for inputs and irrigation equipment. Small farmers in particular may lack access to the resources they need. Support services for agriculture are also inadequate, with weak agricultural extension and research, overcrowded and ill-equipped rural markets, and rural roads in poor condition.

However there is little evidence that these factors will prevent farmers from exploiting improvements to land and water resources. Rapid expansion of minor irrigation has taken place, along with the adoption of HYVs (where flooding permits), and fertiliser use has increased, despite the lack of formal credit. There is no evidence from the farmer surveys that marginal farmers lack resources. In fact they use the same, if not more, fertiliser than other farmers, and get similar yields. Even though they are less likely to own irrigation equipment, there is no evidence that they irrigate a smaller proportion of their land or pay excessive irrigation charges.

Shortages of draught power is often cited as a factor that may limit cropping intensity through an extended turn-round time between crops. There is evidence of a growing shortage of draught animals as pressure on land squeezes out space for grazing. Animal populations appear, at best, to be static and due to a worsening feed situation, their capacity for work may be falling. FCD/I projects, by increasing the amount of crop cultivation may add to the problem by reducing fallow land available for grazing, switching land out of pulses into HYV rice (with a consequent loss of high quality crop residue), and increasing the need for cultivation. This would be a serious constraint were it not for the introduction of the power tiller, which although not yet in widespread use, is rapidly becoming popular.

Trend data on the use of power tillers is not available but many farmers have reported rapid increases in their availability. Even though it has been suggested by farmers that power tillers do not achieve such good weed control as repeated ploughing with draught animals, it is most unlikely that their use will not expand even more rapidly in the future. Apart from being quicker than animals, the case study results also suggest that they are cheaper:

Despite the high population density, farmers can still be short of labour at key times. This problem is likely to be alleviated by use of power tillers, although farmers may eventually have to switch to labour saving techniques such as direct seeding of paddy and use of herbicides. There is some evidence that, labour and power constraints discourage the growing of deepwater B. aman in rotation with boro. With irrigation in deeply flooded areas farmers frequently switch from a B. aman - rabi crops rotation to a single boro crop, possibly preceded by oil seeds. It may in fact be possible to grow B. aman after the boro has been harvested, especially if the onset of flooding is delayed or the deepwater aman is transplanted rather than broadcast. However farmers, having switched to the substantially more productive boro crop seem unwilling to invest in the effort to grow still more rice, especially as there are risks associated with late planted aman crops and considerable labour would be needed for seedbed preparation and transplanting at a busy time of year. However with increasing population pressure, and if the risk of abnormal flooding can be reduced, farmers may in time increase cultivation of boro - deepwater aman in more deeply flooded areas.

Perhaps a more serious constraint in the utilisation of improved land and water resources is that posed by short/medium term self-sufficiency in rice and the resulting fall in rice prices. This will reduce incentives to expand production, especially in irrigated crops using high levels of inputs. Although falling paddy prices will give farmers more incentives to grow other crops, most of the south-east region is more suited to rice production and prices would need to change dramatically to get farmers to increase the areas of pulses and oilseeds.

With this background it is important that future irrigation development is low cost with minimal pumping and investment in infrastructure.

CHAPTER 4

FISHERIES

4.1 General

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.

4.2 Data Collection

4.2.1 General

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, as stated earlier, 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.

4.2.2 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 4.1 shows details of these results per zone.

4.2.3 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.

TABLE 4.1

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.

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.

Fish Market Survey Twelve fish markets in Planning Zones A,B,C and D were surveyed during the same field visit as for the catch assessment (see Figure 4.1). This has allowed for some fish price analyses and fish availability levels to be detected as well as the type of operators.

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. Details of the surveys are presented in Annex E.

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.

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

Public Participation Meetings Public participation meetings were also held at the village level. Proposed project development strategies and options were discussed with fishermen and local people in relevant areas. Details of these meetings can be found in Annex G.

Sampling Programme Four sampling sites (N1 to N4) were selected in the main floodplain area (Figure 4.1) of the Noakhali North Project area, which includes Zones A,B,C and D. Field visits had a duration of 4 days during which information on fish catch was collected.

4.3 Methodology

4.3.1 Analysis for Estimating Impacts on Capture Fisheries

The analysis of the potential impacts on the fisheries of the Noakhali North 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 analyses of fisheries impacts, the minimum water level in three values per decade (10 day period) were 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 FO (30 cm). The hydraulic model results were mapped to provide a spatial distribution to changes in the extent and duration of the floods in the Noakhali North study area. Model runs were carried out for a 1 in 2 year flood (a mean or 'normal' year) from a 25 year period of record. Results of the rising and falling 1 in 2 year flood patterns are shown in Figures 4.2 and 4.3.

Model results clearly indicate that approximately 45 % of the project area is under water during the wet season. These conditions remain fairly constant for approximately two to three months, after which the basin drains quite rapidly. However, in addition to the peak flood attained, the timing, rise and duration of the flooding are very important factors influencing the environment, and particularly, the fisheries.

Figure 4.1

Sampling Sites and Planning Zones

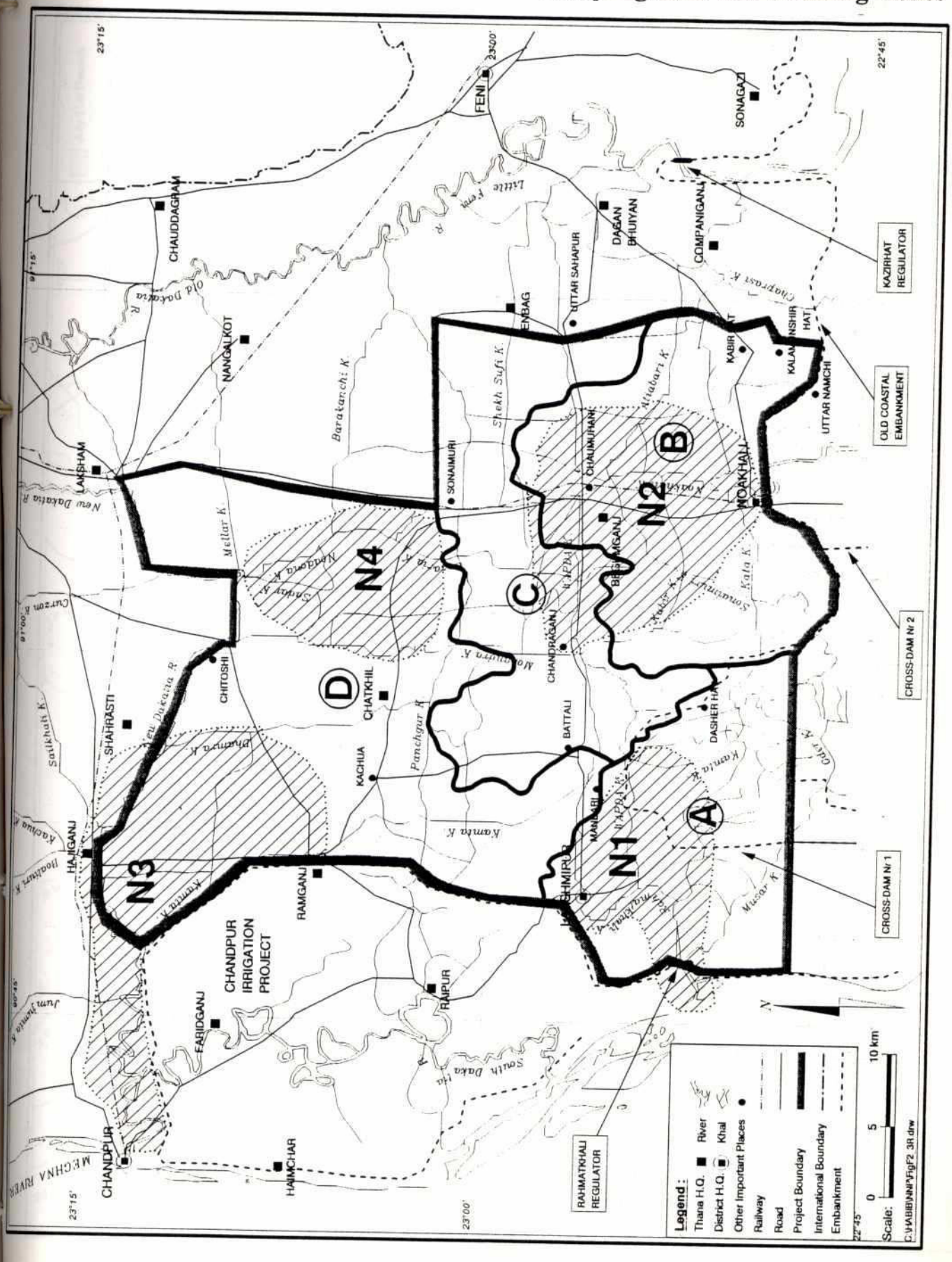


Figure 4.2

Extent of Rising Flood, 1 in 2 Year

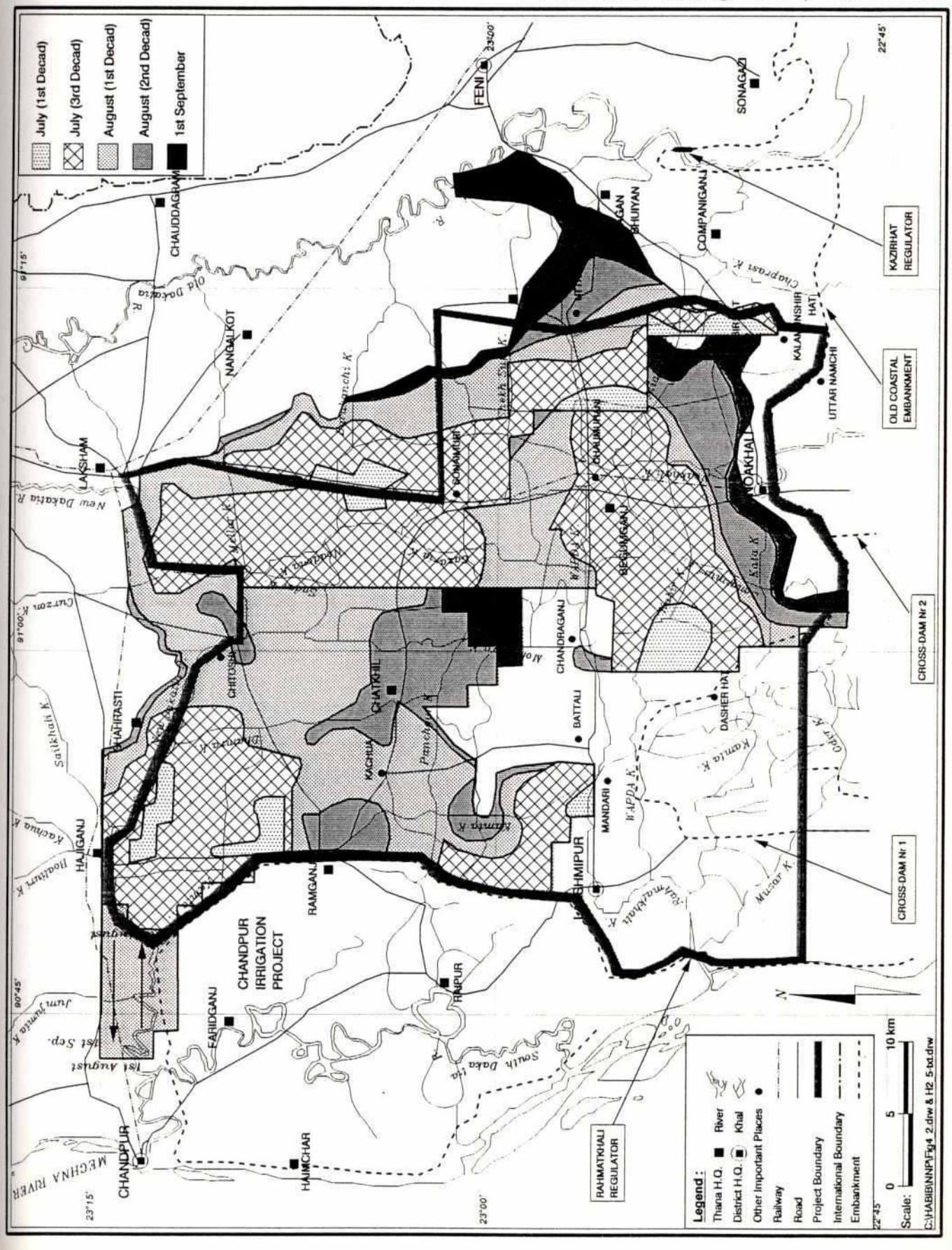
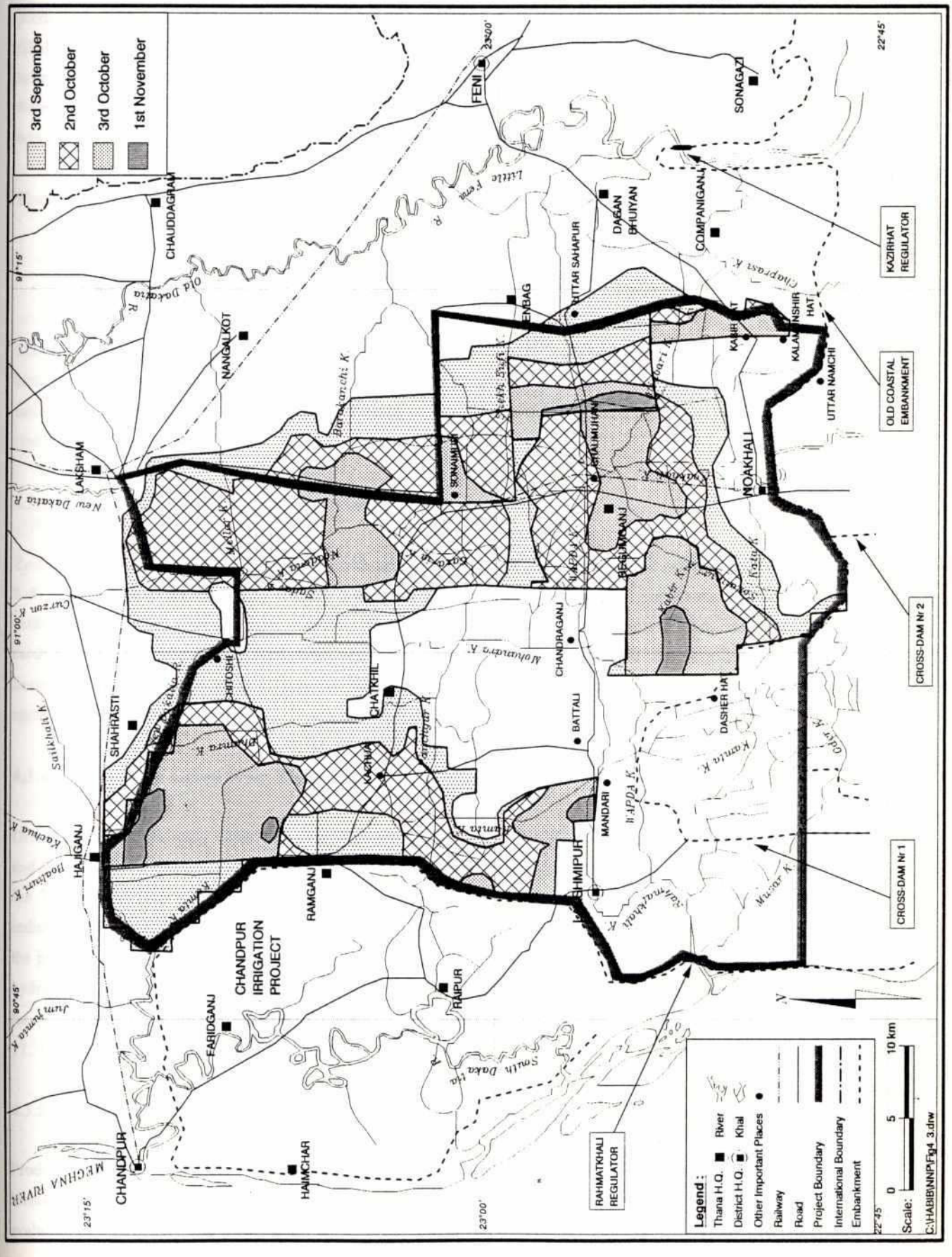


Figure 4.3

Extent of Falling Flood, 1 in 2 Year



4.3.2 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 and Khals) were 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 Noakhali North Project area was calculated from the catch assessment questionnaires and was used for the analyses.

Thus:

$$P = \frac{\text{catch on sample day/area surveyed x No day per fishing gear}}{\text{total area of system}}$$

This procedure was followed for each zone, fishing system and gear. In addition, it was decided to analyze the katta catches separately as they were fairly 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 (see Annex F Table F.4.2).

4.3.3 Estimated Catch per Zone per Fishing System Sampled

Zone A had the largest catches (28.9 MT) with approximately 92% coming from the Meghna River and nearly 8 % from Rahmatkhali Khal. The riverine catch from Zone D was also important contributing 85% to the total catch in that zone. In addition, approximately 50 % of the riverine catch was harvested from Katta fishing. The catches in Zones B and C were fairly poor and may be explained on the grounds of the very limited floodplain during the year and or possibly to poor enumerator procedure. However it may also be pointed out that these catches tend to correspond with the Thana information.

4.3.4 Production Levels from Thana Data

Given that 1992, the year when this study's short fishery survey was carried out, was an unusually dry year and the floodplain in the Noakhali North Project area was nearly non-existent resulting in extremely low catches, the Thana catch for 1991-92 reported in the Thana Fisheries Office survey has been used to provide an indication of more 'normal' yields in the study area. For this analysis, only the catch from open waters within the project area was used and was related to the area of floodplain estimated from the output of the MIKE 11 hydraulic model. Since the Thana catch was expected to only represent the subsistence catch in accordance with the rest of the DOF statistics, these were adjusted to include the commercial catch as reported by FAP 17 (FAP 17, 1993). This resulted in a production level of 109 kg/ha.

4.3.5 Estimated Production Levels from Catch Data

Production levels per system surveyed (internal rivers and Khals) per zone were calculated. The production levels in Zone A were the highest, although it must be pointed out that it was extremely difficult to attempt to evaluate the catch from the Meghna River. For this reason and also because the Meghna River is outside and

separated from the project area, those results were not included in the analysis. Also the project intervention is most unlikely to affect the Meghna catch. Overall, the floodplain (which included internal rivers/khals and all land flooded to a depth greater than 30 cm) production was estimated to be 33.5 kg/ha over an area of peak floodplain (in a normal year) of 74,000 ha. However, as it has been mentioned previously, during 1992, when these data were collected, there was very little floodplain and thus, the area of floodplain was assumed to represent at most 30 % of a 'normal' year, which was considered a more realistic situation. The resulting production level of 112 kg/ha compared very favourably with that from the Thana catch which was 109 kg/ha. Therefore for the purpose of the impact analysis, a production level of 110 kg/ha for the floodplain was utilised. Since internal rivers and Khals are components of the floodplain, the same figure was used for these systems.

4.3.6 Estimated Fish Production in the Noakhali North Project Area

Using the production levels for floodplain estimated during this study 110 kg/ha) and the average pond production levels reported by the TFO (1,914) kg/ha), the results are very different. The overall estimated fish production in the Noakhali North Project area including ponds was 25,688 MT in a total area of water bodies of 94,560 ha, which includes a portion of the Meghna River, resulting in a production level of 272 kg/ha (Table 4.2). If only capture fisheries are considered, the estimated total production is 10,349 MT (includes Lower Meghna catch) over an area of 86,546 ha, resulting in a production level of 120 kg/ha. These levels of production are comparable to other yields reported for other tropical countries (Lower-McConnell, 1987).

4.3.7 Catch Species Composition in the Noakhali North Project Area

Of the 260 species of freshwater fish reported for Bangladesh, approximately 30 (11.5 %) were observed in the catches 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 76 species which represent nearly 30 % of the fish species reported for the country. Appendix F.3 shows the preliminary list of fish and prawn species occurring in the Noakhali North Project area.

In general, more species were recorded in Zones A and D than in Zones B and C, which was not surprising given that the main access routes for fish to the project area are in these zones. An interesting finding was the similarity in the number of species upstream and downstream of the Rahmatkhali regulator. The highest catch in this zone was for Hilsa, but again, this was expected since this migratory fish makes a large contribution to the catch at the national level.

4.4 Fish Marketing

A total of 13 markets were sampled in the eight week period. The thirteen Bazars (markets) sampled per zone were:

Zone A : Lakshmipur
Zone B : Choumuhani, Maijdee
Zone C : Sonaimuri
Zone D : Hajiganj, Bolakhal, Pal, Chandana, Bakila, Kalibari, Monoharganj, Sonapur, Bara Station.

TABLE 4.2

Fish Production per Zone in MT in the Noakhali North Study Area Using Production Levels Estimated During this Study

Fishery System	Zones (MT)				Production per	
	A	B	C	D	Total System (MT)	(Kg/ha)
Meghna River	1 045	0	0	1 061	2 106	176 #
Dakatia River	0	0	0	105	105	176 #
Int Rivers & Khals	27	29	25	53	134	110 *
Floodplain	0	1 841	1 441	4 723	8 004	110 *
Sub-total	1 072	1 870	1 466	5 942	10 349	
Ponds @	1 324	4 387	4 446	5 181	15 339	1 914 @
Total	2 396	6 257	5 912	11 123	25 688	

Production level estimated by FAP 17 based on DOF data for 1988-89

* Production level estimated from this study's catch assessment and Thana surveys (1991 and 1992)

@ Average Pond Production from Thana Fisheries Office Survey. Includes 'Cultured' Ponds only.

There were approximately 50 species being sold as fresh produce. Overall, the largest number of fish species for sale was found in Zone B which had 41, with Zones D and A selling 34 and 30 species respectively, while Zone C only had 22 species for sale in the eight week period.

4.5 Estimated Market Value of the Fish Catch

To obtain an estimate of the market value of the catch in the Noakhali North area, the information collected during the eight week market survey was linked by species to the catch data. Following this procedure, it was possible to separate the fish data from the catch assessment survey into three categories: high, medium and low value fish. From the market price survey, an average price for fish was obtained for each of these categories as follows: high value: 75 Tk/Kg, medium value: 40 Tk/Kg and low value: 22 Tk/Kg.

Therefore, the current market value of the capture fisheries production including Lower Meghna (10,349 MT) can be estimated to be Tk. 526 Million, of which Tk. 272 million was contributed by the high value species, Tk. 236 million by the medium value species and only Tk. 18 million by the low value species.

It is thus clear that any proposed intervention will need to take into account the loss of income to the members of the fishing community including 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 have already been performing several of these tasks themselves. However, it is unquestionable that any disruption created to the fishing system and hence to its dependent community will have consequences for the local economy.

4.6 Proposed Intervention and Impact Assessment Rationale

The proposed intervention seeks to build on the works carried out in the early 1970s under the Noakhali Comprehensive Drainage Scheme by deepening and widening the main Khal system and also by enlarging the Rahmatkhali regulator. The design of the scheme is based upon a completely free flowing 'natural' drainage system so that there is minimal opportunity for obstruction and misoperation.

Under this intervention it is intended to ensure that drainage is balanced so that no area suffers higher water levels as a result of improvements elsewhere. Increased drainage will be achieved mainly through lower water levels which will achieved by flattening water gradients.

In addition, part of this intervention includes re-excavation of the larger secondary Khals to provide a more comprehensive drainage system which will assist in drainage of a wider area within the study boundaries, which for the fish populations and the fisheries, as well as the rest of the aquatic flora and fauna, in the area will represent serious disturbance and loss of the floodplain and key breeding, feeding and nursery areas for fish and crustaceans. Figure 4.4 shows the proposed intervention.

The proposed scheme will also allow water from the Meghna River into the Khal system during the dry season on a massive scale to provide increased areas of irrigation. The Khal system is intended to operate as a tidal storage system allowing maximum water entry and the widest distribution possible.

This seasonal operation would be arranged to provide unrestricted access for fish during April and May up until rising water levels in the Meghna require the operation of the drainage flaps.

This situation will allow better access for fish while the gates are opened (over 90 % of the time) but this access will only be secondary to the agricultural demands of the area. Therefore, although access for fish might be improved through better gate operation, it will be limited and subject to agricultural activities in the area. More importantly, although the fish will be able to enter the Khal system, they will be less able to reach their breeding, feeding and nursery grounds on the floodplain since this would have been largely drained. Under this situation, it is debatable that there can be any benefits to the capture fish production accrued from this intervention.

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LIBRARY.
DHAKA

Figure 4.4

Proposed Intervention

4.7 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 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.

4.7.1 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.

4.7.2 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.

4.7.3 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.

4.7.4 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.

4.8 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.

4.9 Estimated Fisheries Benefits and Disbenefits under the Khal Re-excavation Scheme

4.9.1 Introduction

Table 4.3 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).

4.9.2 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 4.3 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 4.3

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

4.9.3 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.

4.9.4 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 chapter 12 and 13). 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.

4.9.5 Fish, Nutrition and Diet

These aspects are described in the Environment Annex H and summarised in chapter 12.

4.10 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.

4.10.1 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.

a) 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.

b) 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.

4.10.2 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:

a) Restocking with Fry and/or Fingerlings

Restocking of suitable areas such as specific sections of Khal with fry of fingerlings. However, this will need to take into account the ecology of the existing resident species in the area so as to prevent 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.

b) Improvement of Culture Fisheries

Pond culture improvement, especially of those ponds at present under utilised. Leasing of existing ponds to fishermen groups, especially displaced ones. Use of borrow pits by displaced people who are the groups most likely to suffer the nutritional losses resulting from any reduction in their ability to fish. Training and extension programmes to ensure that suitable technology becomes available and to provide alternative sources of income for fishermen. Promotion of integrated farming schemes such as those underway in Comilla, as well as those such as the small/seasonal pond project in Mymensingh carried out by the Fisheries Research Institute (FRI) and ICLARM. The incorporation of local NGOs into the setting up and management of fishing groups could be instrumental in these types of fisheries projects.

c) Enforcement of Existing Fisheries Regulations

The enforcement of existing regulations should particularly be carried out in relation to important areas such as the Dakatia, Begumganj and Laksham floodplain along with any known breeding, nursery and feeding areas for fish and other commercially important groups such as shrimps.

4.11 Conclusions and Recommendation

It is clear that there is a conflict between agricultural development and existing capture fisheries in Bangladesh. The scope for developing these two activities conjunctively is difficult, if not impossible to achieve since the more efficient an FCD/I scheme is, the more damaging will be the result for the capture fisheries. In addition, the scope for mitigating against capture fisheries losses is limited because these losses do not only represent a decline in overall production in actual metric tonnes, but can also affect (sometimes seriously) biodiversity.

Furthermore, even if increased aquaculture activities are able to boost culture fisheries, they mainly produce high value fish that poor people cannot afford. Restocking certain areas with fry and fingerlings is potentially feasible, but great care should be taken when doing so as they may unbalance existing fishing systems with detrimental results to the ecology and the people of those systems.

It should be realised that there are some areas which are suitable for agricultural growth but there are also others which are highly productive fisheries grounds and should be managed only for this purpose. Decisions will need to be made at the highest levels to try and reach a compromise and a balance in future development.

It may be noted that the estimated fisheries production in the project are during this study area partially based on a very short field survey which took place during an unusually dry year and thus, are likely to represent an equally unusual situation both in terms of catch and price. Even so, it is clear that the fisheries production of the area is higher than was previously thought. Results from this study confirm that since the Noakhali North Project area is located in the catchment area of the Lower Meghna River, the most productive river in Bangladesh, there is potential for increased open water fisheries by careful management of the water and fishery resources. Therefore, further studies should be carried out on the capture fisheries production of the project area targeted to mitigation measures for the proposed intervention as a matter of the highest priority and before the intervention takes place. The fisheries impact analyses, results and their financial valuation have been integrated into the overall economic analysis of the studied intervention.

A series of recommendations have been put forward regarding some of the main issues considered in this study.

4.11.1 Fisheries Management Programme

A Fisheries Management Programme should be developed jointly with the leading fisheries organizations in the area, such as the District and Thana Fisheries Offices and fishermen's cooperatives. Such a programme should include provisions for proper management of water bodies, fishing gears including minimum mesh sizes, closed fishing seasons and fishing quotas. The actual details for these proposed provisions would need to be finalized after a more detailed study is carried out. The full implications of these management measures would have to be understood by the fishing community, including part time and occasional fishermen, if the scheme is to be successful.

4.11.2 Surveillance of Important Fishing Areas

It is obvious that under the present situation in the project area, any protective measures will not be respected by the local population. Thus, a system of patrolling important natural fish breeding, nursery and feeding areas, will be needed. Such systems already occur unofficially in the project area, especially regarding Jalmahals, where the lease holder may have a group of fishermen patrolling the area before harvest time to ensure high catches. Surveillance will be most effective if carried out by local fishermen's groups.

4.11.3 Involvement of Local NGOs

In addition, the involvement of the various NGOs (such as the Comilla Rotary Club) in future activities should be an important factor in any future planning of the fisheries and aquaculture activities in the area. The development of projects targeted towards women, such as the Mymensingh Aquaculture Extension Project run by FRI and ICLARM should be promoted.

4.11.4 Aquaculture

Regarding aquaculture activities, it is important to note that substantial benefits may be obtained by improving pond culture, especially since there is already a large number of ponds currently under utilised. However, it must be emphasised strongly that pond culture should be an additional activity to the existing open water fisheries, and not a replacement of the latter.

Pond culture may help in reducing the overall losses in fish production in the project area, and indeed, of the region or the country as a whole. Nevertheless, by and large, it does not address the issue of displaced occasional fisher-persons (which may include women and children) or the nutritional loss to the poor. Furthermore, aquaculture per se will never compensate for the loss of habitat and species diversity, which in the case of the floodplain in the Noakhali North Project area, could be severe (Plates F.5 and F.6).

4.11.5 Seasonal and Small Ponds for Aquaculture

The use of seasonal ponds to increase fish pond production has been tried successfully in the area of Mymensingh. They could provide alternative sources of income and protein to the landless people. Results from the FRI and ICLARM show that small ponds of approximately 0.032 ha stocked with Tilapia and Rajputi in July and harvested in December yielded 100 kg. Under the same scheme, seasonal ponds holding fish for six months may yield an average of 1500 kg/ha, while perennial ponds may yield 1000 kg/ha.

This type of venture should certainly be promoted to use those seasonal and/or small ponds which are currently under-utilised in Noakhali North Project area.

4.11.6 Rice-fish Culture

The activities of the Comilla Rotary Club in this respect will be important for the development of integrated farming in the region. In addition, trials for direct rice-fish culture have been carried out by the FRI and ICLARM in other parts of the country (Mymensingh), with promising results. The possible development of this activity in the Noakhali North area should be considered. However, it must be pointed out that results per hectare from this activity tend to be low (average of 92 kg/ha) and that production cannot be guaranteed. Detailed knowledge of local hydrology is also required and this activity should thus be viewed as a complementary exercise mainly for farmers who will not suffer if the yields fail due to a bad year.

4.11.7 Improved Knowledge on the Biology and Ecology of Fish Species

It is extremely important that research into the biology and ecology of at least the key species is carried out in order to provide specific information at the design and construction stages for wholly effective water resource management practice in this country.

4.11.8 Sustainable Use of the Biodiversity of the Area

Despite the short period of time allowed for this study, it was possible to establish that the Noakhali North Project area is a productive floodplain region. This is not surprising given its proximity to the Meghna River, the most productive main river in the country (FAP 17, 19993). It is apparent, that besides utilising the fish resource available in the Noakhali North study area in a commercial and subsistence manner. The people in Noakhali North use this ecosystem in a variety of ways. Fish is not only sold commercially and used for domestic consumption but also crustaceans and molluscs are fed to poultry, aquatic plants provide food, animal folder, manure and construction materials.

It is also clear that at present, these natural resources are being utilised intensively by the human population in the region, as is the case throughout Bangladesh. Obviously, a considerable proportion of the people in the area are relying on their ability to use these free resources, especially fish, which are presently within their reach for their every day needs. Any intervention which may substantially alter this pattern will undoubtedly have consequences to their health and nutritional status, as well as their economic stability and livelihood.

It is important to establish that **'conservation'** of such resources needs to be considered as a philosophy for the **'sustainable use of the resources'**. Due to the high levels of human dependency on these resources it is thus imperative, that any developments in the region, and in the country as a whole, consider conservation as an intrinsic part of development. Interventions should not take place without due consideration to changes to the environment.

Therefore, the integration of conservation and development activities in Bangladesh has become one of the greatest challenges for the international and national communities.

CHAPTER 5

DEMOGRAPHY AND SOCIO-ECONOMY

5.1 General

In order to fully assess the demography of the area, the results of the 1991 BBS census data relevant to the Noakhali area are required. Unfortunately, this data has not yet been made available for any of the new districts except Noakhali which includes 49.8 % of the project area. Further attempts to obtain this data were made shortly before writing this Report, but unfortunately they have been unsuccessful.

Therefore, the data presented in the following sections are from 1981 BBS census adjusted by using the 1991 data for Noakhali though some information from the Upazila Development Monitoring Project (UDMP) was collected to give an idea of some key socio-economic variables such as income and poverty levels. Also, quantitative information was extracted from the project agro-socio-economic surveys whenever deemed relevant.

Some of the main socio-economic features of each mouza (literacy, landlessness, type of house, economic activities, sanitation) were obtained from the communities series of 1981 BBS census and have been used to prepare union-wise distribution tables. The crude union-wise data are presented in Annex G, Appendix G.I.

5.2 Population Estimates

The Noakhali North Project, which covers a gross area of 168,814 ha, has one of the highest population densities in rural Bangladesh. The returns from the 1981 BBS census show that the four zones of the project had an average of about 1,150 persons per square kilometre, the highest density being found in Zone B (over 1330) and the lowest in Zone A (809).

Over 1.9 million people were living in the project area in 1981, corresponding to over 350,000 households. Assuming a 1.51% annual growth rate since 1981, as in Noakhali, the population is now about 2.3 million and the average density over 1,370 per sq.km.

With the same annual growth rate in the project area for the next 30 years, the population would be over 3.6 millions in 2023, with a density of over 2,150 persons per square kilometre. The population figures are summarized below in Table 5.1.

With respect to gender differentials, there is a greater number of men than women in the project area (sex ratio 103.8) which is consistent with the general pattern of Bangladesh. However, this is at variance with most international figures which show that women generally enjoy a numerical superiority explained by the greater physical strength of the female child at birth. Cultural practices have been used to explain why the reverse is the case in Bangladesh; for example, boy children being better fed and looked after immediately following birth and in times of food crisis.

TABLE 5.1

Estimated Population Figures in Noakhali North Project Area
(Area in Ha, Density in No./sq.km)

Zones		Zone A	Zone B	Zone C	Zone D	Total
Area (in Ha)		29,332	35,553	32,769	63,160	160,814
1981	HH No	44,824	99,320	78,269	129,296	351,709
	Pop. No	239,166	550,624	431,188	711,283	1,932,261
	Density	815	1,549	1,316	1,126	1,202
1993	HH No	52,300	117,863	90,123	150,279	410,565
	Pop. No	286,628	666,129	513,927	845,458	2,312,144
	Density	977	1,877	1,568	1,339	1,438
2023	HH No	81,990	184,775	141,287	235,595	643,645
	Pop. No	449,349	1,044,296	805,687	1,325,431	3,624,763
	Density	1,532	2,937	2,459	2,099	2,254

Source : Consultant Estimates based on 1981 BBS census data and 1991 BBS census data for Noakhali district.

The distribution of unions by levels of population density gives precise indications with respect to the nature and extent of variations within the project area. Though the distribution follows a "normal" pattern, the range of variations among the different unions is quite wide, less than 750 in four unions and over 2 000 in three others. It may be noted that Zone B has a particularly high population since it contains both Chaumohani and Sudharam Pourashavas.

5.3 Socio-Economic Characteristics

5.3.1 Household Size

The average household size in the project area varies relatively little from a minimum of 5.25 to just over 6.00 at the union level. The household size has risen slightly over the last decade from 5.5 in 1981 to 5.7 in 1991.

5.3.2 Literacy and Education

Literacy rates and education are important indicators of the "level of development" of a given area and of the extent of the poverty as well. Areas characterized by low literacy rates are usually more remote and isolated from more developed areas such as urban centres and poverty is usually more acute.

The average literacy rates (number of literate persons divided by the population over 5 years) in the project area vary from 30.2% in Zone A to 49.3% in Zone D. This is not surprising considering that Zone A is not only the least populated but also the most remote zone of the project. As shown in table 5.2 the differences between zones were not only preserved between 1981 and 1991 but actually widened substantially with much slower progress in zone A which probably reflects greater poverty in this zone.

TABLE 5.2

Literacy Rates by Zones

Zone	1981	1991	Increase
A	25.5	30.2	4.7
B	27.0	39.5	10.5
C	29.9	45.2	15.2
D	31.9	49.3	17.4
Project	29.3	41.8	12.5

Source : 1981 and 1991 BBS Census Data

Overall, it seems that the levels of literacy and education decrease as poverty levels increase.

This assumption is supported by the fact that in spite of all the school development efforts made in the last decades, the rate of student enrolment at schools at all levels has been steadily falling over recent years (BBS, socio-economic indicators of Bangladesh, 1981). This decline may have been caused by the increasing inability of the vast majority of the population, particularly the rural population, to send their children to schools due to difficulties in meeting educational expenses. Also, deepening poverty obliges parents to force their children into wage employment at an early age so that they can contribute to the family's struggle for survival.

However there has been a significant advance over the last decade and even zone A is above the project average of the previous decade.

5.3.3 Housing and Sanitation

To assess the socio-economic position of a household, the type of its dwelling unit as well as the source of its drinking water are useful indicators. Assuming that these basic facilities improve with the increase in the level of household income, an idea of the social inequality prevailing in the area can be obtained by classifying the households according to the type of roofing material used in their dwelling units. Also, the number of households with no access to potable water will give a good picture of the extent of the sanitation and health related problems.

Surprisingly, as shown in Table 5.3, the proportion of houses with straw/bamboo roofs has increased in Zone A but has significantly decreased in all other zones. This indicates that, Zone A which is more remote and less educated also has a poorer general standard of housing than other Zones. This suggest household income is lower than elsewhere in the project area.

TABLE 5.3

Percentage of Households with Bamboo Roof Material of their Dwelling Units

Zones	1981	1991	Increment
Zone A	51.7	59.4	7.7
Zone B	47.7	39.4	-8.3
Zone C	37.4	22.0	-15.5
Zone D	34.5	14.7	-19.8
All Project	41.1	30.2	-10.9

Source : 1981 and 1991 BBS Census Data

As for access to potable water (tubewell and tap water), the pattern is very similar. There has been a market improvement over the 1981-1991 period with overall levels of those without access down to 20.9%.

However the situation in Zone A is much worse since nearly 40% of the households rely on surface water for their drinking needs. Once again zone A can be seen to the poorest zone.

5.3.4 Income Distribution and Poverty Line

At this stage of the study, the statistics on income which are available are all from secondary sources (Thana Development Monitoring Project) and cover only two Thana of the project area Chatkhil and Faridganj. Because significant differences have been noted in the project area in each socio-economic variable analyzed, these Thanas are very unlikely to represent all thanas as far as income distribution is concerned. Therefore, the following information is purely indicative.

As shown in Table 5.4, the income distribution in Faridganj closely follows the average pattern of the overall country with a majority of households earning less than 3,000 Tk per month the situation in Chatkhil is different with the model group having on income of Tk. 4 000-5 000 per month. The incidence of such an income distribution on the extent of poverty is straightforward and it is estimated that less than 30% of the households of these two Thanas live below the absolute poverty line as defined by a joint WHO/FAO expert group. (This is quite positive when compared with the national average of over 43%). This means that the average per capita daily intake of calories in these households is below 2122 kilo calories and 48 grams of protein.

The poverty line expenditure was calculated by the Household Expenditure Survey (HES, 1989) by relating per capita calorie intake to the per capita expenditure for different expenditure groups, and then estimating the required level of per capita expenditure for the calorie line (2122 k.cal).

The results show that, in rural areas, the per capita poverty line was Tk 370 per month (1988-89). Assuming an average household size of 5.5, this would mean a monthly household expenditure of Tk 2,035 or Tk 25,000 per annum.

TABLE 5.4

Distribution of Monthly Household Income

Income Group	Faridganj % of HH	Chatkhil % of HH	Bangladesh % of HH
< 1000	5.7%	10.2%	13.0 %
1000-2000	10.2%	22.7%	22.9 %
2000-3000	11.4%	23.3%	25.9 %
3000-4000	22.7%	14.8%	16.1 %
4000-5000	28.4%	7.9%	6.3 %
5000-6000	5.1%	5.7%	4.0 %
6000-7000	4.0%	4.6%	3.1 %
7000-8000	3.4%	3.4%	2.6 %
8000-9000	3.4%	2.8%	2.4 %
> 9000	5.7%	4.6%	3.8 %
Average	4,417	3,216	2,766

Source: UDMP (1990)

5.3.5 Land Distribution and Landlessness

The most important factor causing rural income inequality is the pattern of land distribution and access. Agriculture being the mainstay of the rural economy, the area of owned land is the most crucial factor in determining employment of family workers and, hence, of family incomes. The amount of owned land is strongly correlated to the level of household income and landownership distribution is therefore a key variable in explaining the disparities in income distribution among rural households. Land ownership is not only a key-determinant of the economic position of a household but also of its place within the patron-client relationship system which determines the access to government supplied resources.

Elsewhere in the study, the landownership distribution has been ascertained, based on a sample of households drawn out of land tax lists. This approach has some limitations and the results should be used with great caution. However, using data from 1981 and 1991 BBS census it has been possible to assess the extent of the landlessness phenomenon within the project area and to present it in Table 5.5.

TABLE 5.5

Proportion of Landless Households (owning less than 0.02 ha of Agricultural Land)

% of Households	1981	1991	Increment
Zone A	30.6	41.1	10.4
Zone B	33.1	37.5	4.4
Zone C	28.1	33.6	5.5
Zone D	25.2	33.0	7.8
Project Average	28.8	35.6	6.8

Source : 1981 BBS Census Data

In 1991, 35.6% of the households living in the project area owned less than 0.02 ha (5 decimals) of agricultural land and are therefore considered landless. As shown above there are significant variations among zones (41% in Zone A, around 33% in Zones C and D and 37% in Zone B).

5.3.6 Activity Status and Employment

Beyond the base of land ownership, the other essential source of income in rural areas is employment of varying forms and durations. However, accurate and recent employment statistics are difficult to find but within the data contained in the 1981-1991 BBS population census, activity rates can be calculated at the union level.

The activity status of the population can be measured by the "Refined Activity Rate" which measures the proportion of economically active population (persons either working or looking for work) among the population. In Bangladesh the age of working is taken as 10 years and above, as per BBS standard.

In the project area, the rate stood at 35% in 1991 though slight differences occurred among zones with variations ranging from 39.7% in Zone A to 32.8% in Zone D. (Zone A also has the highest rate of increase in landlessness) but generally the rate of increase is slow being only 2% over the last decade.

The higher participation in economic activities observed in Zone A could mean that children there are entering paid employment earlier than in other areas due to the following three phenomena:

- employment opportunities are greater due to fisheries, so the incentive to work is higher than in areas where cultivation is the major source of activity
- lack of educational institutions in the zone which will mean that household heads have less incentive to send their children to school
- widespread poverty which would explain why the poorest households are mobilizing their children for wage employment earlier than in other zones.

The last point can be supported by the fact that the percentage of the active population engaged in crop cultivation (self-employment and wage employment combined) which is much lower in Zone A. In this zone, a larger part of the active population is engaged in other economic activities probably less remunerative than crop cultivation.. This would explain why household heads of the poorest strata have to mobilize more members to sustain their livelihood than in other areas.

In the project area as a whole, crop cultivation provides employment to some 54% of the economically active population (1981) and is therefore the economic activity which absorbs the majority of the active population.

However, as shown in Figure 5.6, significant variations among zones may be noted, particularly in Zone A where the importance of cultivation is significantly higher than elsewhere in the project area.

The changes over time of the importance of cultivation as the main source of employment in rural areas must also be ascertained to obtain some idea of the likely future trends.

TABLE 5.6

Percentage of Active Population Engaged in Crop Cultivation (as main activity)

Zone	1981	1991	Decrease
A	62.8	52.9	9.8
B	50.5	45.1	5.4
C	50.0	39.5	10.5
D	56.5	42.5	14.0
Total Project	54.1	43.2	11.0

Source: (BBS : 1981/1991)

The information available suggests that agricultural employment opportunities are declining while other rural employment opportunities are not growing fast enough to cope with the growth of the rural labour force. Indeed nationally between 1961 and 1981 there has been a decline in the amount of employment available (less days worked per year) while the activity rate for agricultural work fell from 34.2 to 26.5 percent of the total population (BBS ibid).

This has taken place against a background of increased agricultural productivity with the population increasing by approximately two per cent per annum. While it is accepted that definitions of economic activity may have changed over the period, the drop in agricultural employment opportunity is drastic for landless people. It goes a long way towards explaining the large numbers of rural men who now migrate, permanently and seasonally, to urban areas for work.

Recent BBS figures taken from the census of 1991 indicate that between 1985 and 1990 the in-migration rates in urban areas rose from 17.2 to 31.2 per thousand population. Increases in rural employment as a result of the Noakhali North Project may assist in stabilising the rural population and prevent the social and psychological strain imposed on families in the absence of the male household head.

5.3.7 Conclusions on Socio-Economic Characteristics

The picture drawn above shows that poverty is the dominant feature of life in the project area with Zone A and to some extent zone B seeming to be the most severely affected. This becomes more evident when looking at Table 5.7, which lists the most disadvantaged unions based on 1981 BBS data.

TABLE 5.7

List of the Most Disadvantaged Unions in the Project Area (1981)

Thana	Union	Zone	Population Density
Ramgati	Charlawrence	A	565
Lakshmipur	Babaniganj	A	724
	Shakchar	A	498
Noakhali	Dadpur	B	1311
	Ewasbalia	B	858
	Goshbagh	B	760
	Kaladaraf	B	451
	Niazpur	B	1146
	Noakhali	B	603
	Sundalpur	B	535

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The criteria used to identify the unions where poverty is more widespread are as follows:

- literacy rates below project average (29.3%);
- % of households without potable water above project average (42.9%);
- % of landless households above project average (28.8%);
- refined activity rates above project average (33.2%); participation in economic activities is higher because children have to work earlier to contribute to the household's struggle for survival;

5.4 Description of Livelihood of Typical Social Groups

The purpose of this section is to give an outlook on the way of life of typical social groups, what they do and how they manage to survive. Here, only a few cases have been presented while a more complete picture is given in Annex G.

5.4.1 Landless

To earn a living, landless people depend mostly on the sale of their labour. As shown in Table 5.8, wage employment is the main occupation of the landless in each of the 4 zones of the project, while the proportion of landless with fishing as the main source of income is lower everywhere and zero in Zones B and C. Besides wage employment, rickshaw pulling was found to be the second most important primary occupation of the respondents to the landless survey.

Wage employment is dominated by agriculture related works including paddy planting, transplanting and harvesting. During the dry season, other opportunities for employment are available in construction works, especially in earth cutting schemes and in brick fields.

TABLE 5.8

Primary Occupations of Landless People

Occupations	Zone A	Zone B	Zone C	Zone D	Total
Labourer/Casual Worker	45.8 %	58.3 %	45.8 %	58.3 %	52.1 %
Shopkeeper/Trader	16.7 %	12.5 %	0 %	4.2 %	8.3 %
Rickshaw Pullar	20.8 %	25.0 %	20.8 %	16.7 %	20.8 %
Fishermen	8.3 %	0 %	0 %	8.3 %	4.2 %
Others	8.3 %	4.2 %	33.3 %	12.5 %	14.6 %
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0%

Source : Project agro-economic surveys

Employment opportunities in agriculture are limited throughout the year except during the planting (December-January) and harvesting (April-May) seasons of the boro crop, which is the main crop in the project area. In places where boro cultivation is limited, labourers quite often migrate to more intensive areas, such as Comilla sadar, where the demand for labour is quite high during the boro harvesting season.

Later, from October to November, the harvesting of aman crops provides some employment opportunities, either locally or by migrating to other areas where the cultivation of aman is more significant.

During the monsoon period, virtually no agricultural work is available and this is the most difficult time of the year for landless labourers. In most cases, they are not self-sufficient and are dependent upon others (relatives or friends) for their survival. To supplement their diets, most of them fish in the floodlands, especially in Zones C and D (70-90%). A substantial number find employment as rickshaw pullers.

Low employment opportunities in the agricultural sector are a problem for the landless in all zones, between 40-50 % of the respondents indicated that employment opportunities were declining. One of the reasons given is that only one significant paddy crop is grown in these areas (boro) during the dry season while limited cultivation of aman takes place during the monsoon. Moreover, the standing crop is frequently damaged by flooding, reducing still further the scope of employment. Drainage congestion during the monsoon is quoted as an issue since it is perceived as a limiting factor for the cultivation of an aman crop and for the generation of additional employment opportunities in the agriculture sector.

5.4.2 Full-Time Fishermen

Full-time fishermen often belong to the most deprived sector of rural society in Bangladesh depending mainly on fishing for their survival. However, the results of the fishermens survey conducted within the course of the study show that over 80 % of the sample have other sources of income than the sale of fish. Of this total 61% gave fishing as the main source of their household income with farming cited as the major second source. Thus, out of 96 fishermen interviewed, 57 (59 %) are therefore mostly dependent on fishing for their livelihood. (see table 5.9).

Fishermen fish throughout the year though the most productive period is from October to December, when the water recedes and fish migrate back to the rivers. For the fishermen, the most critical period is before the monsoon (March to May), at a time when less fish are available.

However in the Noakhali area most full time fishermen are those involved in main river fishing in zones A and D.

There is also evidence that a substantial number of full time fishermen are in fact, engaged in cultivating fishponds on a leasehold basis.

TABLE 5.9

Main Source of Income of Full-Time Fishermen

Sources of Income	Zone A	Zone B	Zone C	Zone D	Total
Fishing Only	15 %	38.5 %	11.8 %	0 %	17.9 %
Fishing Main	45 %	61.5 %	41.2 %	47.6 %	50.0 %
Other Main	40 %	0 %	47.0 %	52.4 %	32.1 %
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Source : Project fishermen survey

The main problems indentified by fishermen were as follows:

- non accessability to capital (boats and gear)
- fish diseases (zones B, C and D)
- Obstruction of migration (zone C)
- Decline in flood plain (1992 all zones)
- Pollution (zone D).

5.4.3 Farmers

The living conditions of farmers are directly correlated to the amount of land owned and cultivated. It is broadly accepted that on average, at least two acres of land are required to enable a family to depend solely on farming to make a living. Those households holding less are usually also engaged in other activities such as wage employment or petty business and increasingly in fish pond culture.

In a "normal" year (with no crop damage) food shortages occur during the monsoon, just before harvesting the aman crop (October to November) when the cash earned from labouring in the winter season starts to run out. During that time they eat one meal of rice for 1 or 2 days and regularly wheat chapattis every morning. During the rest of the year they can afford two meals of rice per day.

Farmers identified several problems which adversely affected their livelihood:

- drainage congestion in the monsoon season reducing their opportunities to plant aman crops
- irrigation from surface water is unreliable due to insufficient water in the Khal system.
- ploughing costs are increasing because there are less and less farmers who are financially able to maintain draught animals; therefore the number of ploughing animals is decreasing but there are more farmers now using power tillers.
- lack of employment opportunities in the monsoon season
- sharecropping system is unfair, 50% of the harvest goes to the landlord while all input costs are born by the sharecropper. This is quite different in some part of zone A (see annex G).
- there are not enough institutional services from GOs (banks, agriculture extension, BRDB) or NGOs.

For farmers with bigger holdings, the situation is different and they usually do not need to engage themselves in wage employment to sustain their livelihood.

5.5 Women's Roles and Activities

5.5.1 Introduction

Objectives and methodology employed to identify womens roles in the society of the project area are described in annex G section G.2.4.1

This section identifies some of the most important aspects.

5.5.2 Women in the project area

The sex ratio in Noakhali zila is 98.3 (M/F) for 1991 which may be compared to the national figure of 106. The sex-ratio of all the other three districts of the project area, which are available from 1981 BBS census data, i.e. Comilla (101.8), Chandpur (99.6), and Lakshmipur (100.7) are also below the national average. This is because many males of this region have migrated to the Middle East and other European countries to earn a living, leaving their families behind, at least temporarily.

It is generally held that a woman has to be protected by male members of her family at every stage of her life: during her childhood, she has to be looked after by her father, after marriage, by her husband and in her old age by her son. The family, which can protect and maintain its female members with honour, is still seen as an ideal family. Women are expected to live in seclusion and to observe **Purdah**. **Purdah** system is a kind of mechanism through which the honour of the woman and of her kin-group is observed. In Noakhali district women observe more of **Purdah**. While doing the field visits both men and women were found stressing on the point that it is honourable to be able to keep the women in seclusion. Even while passing through the main road one can see a portion of a pond is fenced for use by women only. Thus the perceived ideal behaviour of women is to stay at home, though the situation is gradually changing with the course of time.

Literacy rate is higher in all the four districts of the project area than the national average of 24.82 percent. The literacy rate of all these four districts are Comilla (25.28), Chandpur (29.02), Lakshmipur (25.54) and in Noakhali (28.00). From observations and discussions with the people of the project area it is understood that increase of female literacy rate is higher than the increase in the male literacy rate in Noakhali district. This can be testified from the table below.

TABLE 5.10

Literacy by sex and locality 1981-91 (Noakhali)*

Locality	1981			1991		
	Total	Male	Female	Total	Male	Female
All area	27.16	34.38	20.22	33.7 (37.1	38.7 (42.9)	28.2 (31.5)
Rural	25.95	32.77	19.52	32.1 (35.5)	37.0 (41.1)	27.5 (30.1)
Urban	34.55	43.42	24.79	46.6 (50.5)	52.3 (56.6)	40.2 (43.6)

Source: BBS 1991

* (The literacy figures in 1981 and 1991 for "5 years and over" are shown outside parenthesis and those for "7 year and over" are shown within parenthesis).

The above table shows that the increase in literacy is more rapid for females than males in Noakhali district. It is apparently difficult to make correlation between more migrant family, more **Purdah** or seclusion and increase specially in female literacy.

Woman's mobility is very much restricted, in her parental home, after her puberty till marriage and after marriage, in her affinal home as a new bride till she is the mother specially of son. Jean Ellickson remarked in her village study, "The only relative independent woman is the middle aged or elderly widow and divorced or abandoned women without adult male sons to support them" (Ellickson, 1975:82). Generally destitute women without kin-support are the only independent women in the village.

There exists a clear cut gender-specific division of labour in the project area as in Bangladesh. To be specific men work in the field and outside home compound while women work in the home compound which is not visible and remunerative and thus considered as normal house work. Whether rich or poor all women have to do the household chore. A Woman of a rich household can afford to keep some one to help her in domestic work. Only the destitute women work in other's houses during post-harvest period and when they are asked by rich neighbours to do some job.

From UDMP Report (1990) it is evident that in Chatkhil Thana of Noakhali zila only 5.2 percent rural households have more than 2.5 acres of cultivable land per family which is far below the national average of 15.9 percent. It indicates that most of the farmers household own small holding not enough to maintain the family. Except the rich and middle households, women manage the post-harvest work by themselves.

In a **Purdah**-ridden society with comparatively high rates of female literacy the role the women of the project area perform is analyzed below.

5.5.3 Socio-Economic Roles

In rural Bangladesh most of the women's activities are performed within the homestead area and not remunerated. Their activities are often considered as 'housework' and not given proper emphasis at national level. In B.B.S. data only the people engaged in productive market-oriented activities of agricultural and non-agricultural works are counted as labour force.

TABLE 5.11

Percentage Distribution of Population 10 Years & Above Male & Female by Economic Category

Zila	Thana	Population (age 10+)		Economically Active			Not Economically Active
				Total	Employed	Unemployed	
Noakhali	Chatkhil	Male	68.05	52.26	50.99	1.27	15.19
		Female	67.72	5.07	4.68	0.40	62.65
Bangladesh		Male	68.12	52.94	51.75	1.19	15.18
		Female	67.62	5.10	4.64	0.46	61.52

Women's activities and employment patterns are very much influenced by the socio-economic condition of their families and by their husbands' main occupation. It also depends on their domestic cycle, i.e. whether they are daughters of the house, wives, mothers or mothers-in-law. In rural Bangladesh, men generally take the productive and community politics role while women play two vital roles: reproductive and productive. The list of reproductive and productive roles generally performed by the women of Noakhali North Project Area is given in Table 5.12.

TABLE 5.12

Women's Roles and Activities

Reproductive Role	Productive Role
Rearing children and caring for the sick and older members of the household. Tending and feeding livestock and poultry. Collecting leafy vegetables (sak) from own or communal land, collecting fuel, collecting drinking water. Preparation for cooking,i.e. cutting vegetables, fish etc, pasting spices, cooking, feeding all family members, cleaning utensils, house and homestead area, grazing and milking cows and goats, final checking of the household before going to bed.	Bari-based post harvest work like threshing crops, (in some parts of the Gumti Project area wheat is threshed by women) winnowing, parboiling, drying and storing crops. Making and repairing fishing nets, drying fish, making handicrafts, poultry and livestock raising, kitchen garden, mending and repairing the houses (especially mud houses), making 'Chira' 'Muri' (flat rice and puffed rice) for sale, picking chilies in the field. **Note:** Today, husking of paddy is generally done in rice mills.

TABLE 5.13

Non-remunerative productive activities

Zone	A		B		C		D		Total	
	#	%	#	%	#	%	#	%	#	%
Work in field and garden	20	80.0	23	95.8	24	96.0	19	76.0	86	86.9
Handicrafts/weaving/sewing	12	48.0	4	16.7	14	56.0	9	36.0	39	38.4
Poultry/livestock/fishpond	24	96.0	19	79.2	20	80.0	21	84.0	84	84.8
Fishing for own use	0	0.0	1	4.2	1	4.0	0	0.0	2	2.0
Make nets/dry fish	0	0.0	2	8.3	3	12.0	2	8.0	7	7.1
Post-harvest work	16	64.0	17	70.8	17	68.0	17	68.0	67	67.7
Collect/make fuel	24	100.0	19	79.2	23	92.0	21	84.0	87	88.8
Other	2	8.0	0	0.0	1	4.0	1	4.0	4	4.0
Total	24	100.0	24	100.0	25	100.0	25	100.0	98	100.0

Source : Woman Survey 1992

TABLE 5.14

Remunerative productive activities

Zone	A		B		C		D		Total	
	#	%	#	%	#	%	#	%	#	%
Handicrafts/weaving/sewing	4	66.7	5	83.3	2	100.0	1	14.3	12	57.1
Poultry/livestock/fishpond	1	16.7	5	83.3	0	0.0	0	0.0	6	28.6
Collect/make fuel for sale	0	0.7	3	50.0	0	0.0	0	0.0	3	14.3
Work outside the home	2	33.3	0	0.0	0	0.0	5	71.4	7	33.3
Other	0	0.0	0	0.0	0	0.0	1	14.3	1	4.8
Total	6	100.0	6	100.0	2	100.0	7	100.0	21	100.0

Source : Woman Survey 1992

All women are doing domestic/family work in the household, i.e. participate in the productive role. 89% collect and make fuel, 87% of women work in own kitchen garden (Table 5.16). If nothing else, they will grow pumpkins, chilies, beans, etc. by the side of their house. 85% women participate in poultry or livestock raising and 68% in post-harvest work. It is also evident in both the above tables that a good number of women are engaged in more than one works.

In the women's survey, only 8 women reported working outside their homes for remuneration. Among them only one has a salaried job, while the remaining 7 are employed in domestic and post-harvest work. All these women are paid in kind depending on the nature of the work. There is no hard and fast rule as regards food. Generally they get food twice or thrice during post-harvest time and get about one maund to half a maund paddy after the job is done.

Among the poor and destitute, those who do not have family and kin-group support, go for work in other people's houses. Rich farmers' wives say there is scarcity of female labour. Poor women say remuneration is so little that it is not worthwhile to work for others. Only those who do not have a husband or son to support the family, go for work (Appendix G. 2, Case 4. Amena).

There is not much work available in the villages. Only a few middle income and rich farmers employ women to work for them during post harvest or in other times of the year as required by them. The Table below gives a picture of seasonal work availability, duration, and remuneration pattern in Noakhali North Project area where more than one crop is grown.

TABLE 5.15

Probable Availability of Post Harvest Agricultural work

Seasonal work availability	Duration	Remuneration Pattern
Processing of rabi crop in Chaitra.	About one month (Chaitra).	Two meals and 1½ Kg wheat or rice per day.
Processing of irri crop.	About a month (from middle of Baishak to middle of Chaitra).	Half to one maund of paddy,and two three meals a day; depending on work.
Processing of aus.	One month (from middle of Asar to middle of Sraban.)	Food twice and paddy depending on work.
Taking out fibres from jute.	7/8 days in Ashwin and Kartik.	About 12 to 16 Tk. per day.
Processing of aman.	About two months (Agrahayan to Poush).	Two Three meals and about a maund of paddy.

5.5.4 Role in Household Management

Management of the household is also gender specific. Women will manage inside the household while men take care of outside work. But often in absence of the main male earning member it is the woman who has to do everything. Here are some illustrations of few common problems faced by women of Noakhali area, showing how women try to face those problems.

(a) Drinking Water

Providing potable water to the family members is one of the prime reproductive role women have to perform. As mentioned earlier 80 percent of households have access to potable water within the project area. The increase is 22 percent in Noakhali North Project area over the decade 1991/1981.

The causes of increase identified by villagers are stated below:

- Govt. and Non-govt. organisations encourage villagers to install tubewells on easy terms and conditions.
- Migrants send money to install tube well. It not only provides potable water but also enhances family status.

The women provide drinking water to the family where there is no tube well. In Char Darbeshpur, there are only about 20/22 tube wells in the village with population of about 9000 and so they drink pond water. From Falgoon to Jaistha (four months) they use a special stone in the drinking water for purification otherwise they use straight pond water for drinking.

When saline water from Little Feni river overflows the ponds, women of the area go to the other side of the embankment and bring drinking water from a tubewell. They go to others' houses after sunset in a group, take a bath and bring drinking water. Due to **purdah** they do not go to other's house in the day time.

(b) Fuel Collection

Generally straws of paddy, mustard and dried leaves are used as fuel. Dried up small branches of trees, dried leaves and bamboo sticks are used as fuel in Noakhali North Project area. Children and women can collect them by the side of homestead and gardens. They use 'Mutha' made of cow dung, coconut and betel nut leaves, dried shells of green coconuts, etc. as fuel. Many of them have to buy firewood from market.

Poor and marginal farmers' wives generally cook once in the afternoon and eat twice or thrice according to availability.

Women are anxious to collect and store some fuel before monsoon sets in. During monsoon periods, fuel is costly and it is difficult to get hold of dry fluel. From the women surveyed it was found that 100 per cent of respondents in A and D and 96 per cent in Zone B and C collect and store fuel in preparation for the monsoon flood.

c) In times of crisis during short term migration of household head

Women have to manage the household when the household head migrates to find work. Among 98 sample households, 28.0% of respondents in Zone A, 40.0% in Zone C and 16.0% in Zone D migrate to find work, spending an average of 77 days per year away from home. No migrants were found among the sample taken from Zone B. In Zone A average days per year for migrants away from home is 127 days. In Zone A living conditions are more difficult and household income is lower in comparison to other parts of the project area.

TABLE 5.16

Management of Household Migrant Family.

Zone	A		C		D	
	No	%	No	%	No	%
With money sent by household head	7	71.4	8	88.9	3	100.0
Borrow from relative, neighbours, moneylender	2	28.6	1	11.1		
Total	9	100.0	9	100.0	3	100.0

Source: Women Survey 1992

All the migrants send money to their families left behind. What the poor labourers send is neither sufficient non very regular. At the time of crisis women often borrow money from shops, relatives and neighbours.

5.5.5 Women's felt need, Issues and problems

Women's needs and problems in the Noakhali North Project area have been identified through people's participation meetings, discussion with women, visit to different households, in-depth case studies and focused interview.

Water logging as a result of drainage congestion and dry season paucity of water are considered as main problems in the project area. Both men and women are aware of the situation. Even heavy rain water can not pass away and create problems in the day to day life. Due to stagnant water during the monsoon, women cannot grow vegetables, papaya trees and jack fruit trees suffered as well. Also, it is very difficult to collect fuel. Cowdung cannot be accumulated and "mutha" cannot be made during this season. Landless, marginal and poor people cook only once in the afternoon in order to save fuel.

From December onwards paucity of water starts becoming a great problem. February and March are the two most difficult months for all the villagers. Women mentioned about the difficulties faced in getting water for bathing, washing and cooking as well as for livestock. Due to scarcity of water, more health and sanitation problems occur. Skin diseases are very common. Diarrhoea frequently breaks out at that time as well.

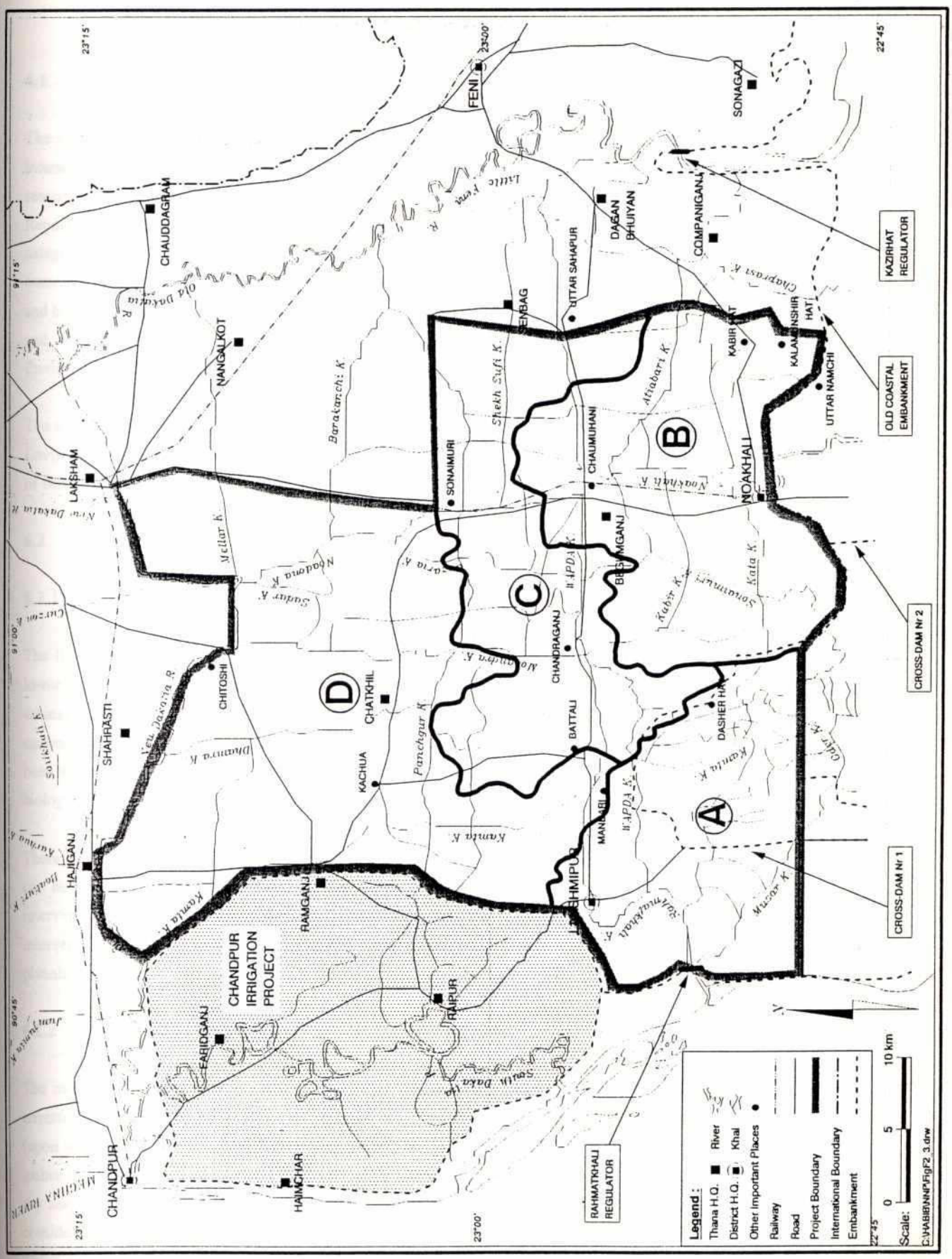
Thus July to Sept./Oct. stagnant water and from January to March paucity of water affect not only cultivation, it affects badly on women's reproductive role. Also, health status is badly affected.

Dowry is a great problem. In arranging marriage of girls many people have to borrow money and sell property.

The rate of education among women is much better in the project area in comparison to national level. But there are not many opportunities for educated women to get income-earning jobs. They prefer teaching in schools, working in Banks or working in offices. But availability of such jobs is very limited.

Only destitute and poor and low-caste hindu women work in CARE/RMP programmes. As they have broken Purdah once, they have showed their eagerness to do any kind of earth work. They have contact with other destitute women who want to do such jobs. U.P. Chairman and local elites informed that if any project wants to engage women labour, it will not be difficult to find them. But the general view is that there are plenty of unemployed men to work, so why invlove women ?

Figure 6.1
Planning Zones



CHAPTER 6

ENVIRONMENT

6.1 Introduction

The scope of environmental studies includes both the natural and human environment and the nature of their interaction. The present situation in the study area with regard to many of these aspects, for example water resources, agriculture and socio-economics, has been outlined by discipline in other sections of this Main Report. However there remain some fields and issues which do not easily fit into these rather rigid discipline categories. These include ecology (both terrestrial and aquatic), including flora, fauna, wildlife and conservation, along with water quality, water supply for domestic use, health and nutrition as well as culture and heritage considerations. The present baseline situation for these issues is covered in this section of the report and in more detail for ecology in Annex D and health and nutrition in Appendix D of Annex H the Environmental Impact Assessment.

The way in which the proposed interventions alter these environmental components is addressed in detail in the Environmental Impact Assessment work for the study written up as Annex H and summarised in Chapter 12 of this report.

6.2 Ecology

6.2.1 Introduction

The floodplains of Asia have been inhabited and modified by man for a considerable period of time and the lower Meghna area is no exception, having been subject to recent interventions. These include flood protection, drainage and irrigation works, particularly the construction of river bank and coastal flood protection embankments. This is in addition to the very dynamic processes of erosion and accretion that the area has also been subject to. All these have had significant effects on the hydrology of the area and the development of biological processes, leading to changes in the flora and fauna found there.

There has been growing local and international awareness in recent years that the effects of these developments can be very significant and in some cases detrimental to the point when they question the viability of the intervention. For this reason it is important to assess the current ecological status of any area where interventions are being proposed, so that major issues can be identified and considered as part of the inter-active planning process.

6.2.2 Data Collection

The most useful information outlining the historical situation with regard to the occurrence of aquatic and terrestrial flora and fauna in the area was gained from the Noakhali District Gazetteer, the previous edition (upon which much of the information was based) being dated 1911. A short field programme was devised to gather information on the present and past distribution, abundance and species diversity for both the wet and dry seasons. The data collection exercise also relied upon interviewing inhabitants of the area who displayed considerable indigenous knowledge, both on species availability and their use and importance to local people. This aimed to identify habitat zones in the area and, using the hydraulic modelling work, see how these were

likely to be changed as a result of any proposed intervention. The 10 major sampling sites were chosen to provide appropriate coverage across the study area in all planning zones (shown in Figure 6.1) and possible broad ecological habitat types (originally based on the FAO 1988 Agro-ecological Zone mapping given in Figure H.2.11) as shown in Figure 6.2. The results from the survey work are given in detail in Annex D.

6.2.3 Terrestrial Fauna

In all 98 fauna species were recorded in the study area, 21 of which are classed as nationally threatened and 16 of these 21 being rare in the study area. Of the 98 species, 16 were mammals, 60 birds, 17 reptiles and 5 amphibians. Of the mammals both the Gangetic dolphin (found in the Dakatia river), and also the Bengal Fox are recorded on the international list of threatened species. There appear to have been major losses of species in the area over the last 70 years, particularly the larger land mammals, due to habitats being reduced by human activity. Of the 60 bird species recorded, 36 were terrestrial and 24 water dependent. Most were resident species with very few migratory species recorded, but this may perhaps be due to the time of year that the work was carried out. Water birds are generally in decline as habitats are reduced due to increased farming activity and also hunting. Many bird species act as useful biological control of insect crop pests. The 17 reptile species included turtles and snakes, some of the latter, whilst being highly poisonous (they area particular problem for humans during peak flood times when they move to higher land) they also act as major predators of the main rodent crop pests. Amphibian species include frogs, which are also major controllers of pests, but their numbers are reportedly in sharp decline.

The most diverse habitats (i.e. showing the greatest number of species) were road sides and land on other embankments, particularly those that are tree covered. The next most important habitat was river banks followed by single species woodland. However many of the habitat areas are highly mixed and these divisions would appear to be rather artificial. The most significant pests were reported to be rats, the Indian Crested Porcupine, Parakeets and the Purple Moorhen. As indicated above, these have natural predators and it is important to establish if the balance between the numbers of pests and predators will be changed as a result of any intervention.

6.2.4 Terrestrial Flora

In all 97 terrestrial plant species were recorded which included 47 trees, 22 shrubs and 28 herbs. The most important habitats were road side corridors followed by homesteads with Khal and river side banks being next important followed by pond and seasonal water-body edges. However there is great seasonality in the availability of some of these habitats due to the very variable extents of floodlands in the study area, both within an annual cycle and from year to year. Of the 97 species, 70 were used as fuel, 51 for medicinal purposes, 33 for timber, 28 as food and 14 as construction materials. Many of these are of highly significant economic use to the local community, especially as some are naturally replacing common access "free goods". Further details, including species lists and a list of medicinal plants, their active chemical ingredients and medicinal uses are given in Annex D.

6.2.5 Aquatic Ecology

Some 110 aquatic species were recorded in the study area with 50 at one sampling site on the Dakatia river and surrounding floodlands, ditches and ponds. The two main seasonally flooded depressions have fewer but very different habitats and species than the surrounding areas. This is particularly the case with aquatic plants with species being similar to those found on the Gumti flood plain. These depressions create good habitats for food sources for fish and also vegetation species, such as grasses and reeds which are widely used as construction materials for many differing articles.

It was noted that plankton transmission from the river Meghna into the mainland area appeared to be prevented by the Rahmatkhali regulator and fluctuations in Khal and drain water levels due to irrigation abstraction disturb habitats in the dry season and make it difficult for species to establish themselves.

Some 56% of the country's recorded algae species were found in the study area but there was insufficient seasonal data to get a balanced picture of the algal situation. However all Khals, drains and ponds were found to contain algae and the Noakhali Khal had different, salt tolerant species.

The major pest to man is water hyacinth (Eicchornia crassipes) which covers the surface of many open waterbodies, choking them and making waterborne navigation difficult as well as inhibiting water flow. In addition it reduces sunlight penetration and inhibits the biological productivity of the water. However the species is capable of removing toxic materials from the water and can be used as a raw material for paper manufacture and also wound into rope for use as a construction material, particularly for furniture manufacture. Some algae are toxic but are often controlled naturally, however if the water chemistry were to change (particularly if nitrate levels increase due to the use of agro-chemicals) then this process can break down and toxic blooms result.

6.2.6 Fish Ecology

The main fish habitats are shown in Figure 6.3 and comprise internal rivers (of which the Dakatia is the most important), large seasonal flood plains and Khals and drains, some of which are perennial. Some 45% of the gross study area goes under standing water in the monsoon season in a 1 in 2 "normal" year, due to local rainfall and drainage constraints, the latter having mainly been caused by construction of the coastal cross dams resulting in land accretion now inhibiting drainage outflow. Ponds are also important habitats, many of which are now stocked and managed for capture fisheries.

In all 76 fish species were recorded in the area (30% of all the recorded national fish species) and 37 of the 76 species were recorded as having been caught by fishermen during the fish catch survey work. This is a remarkably high number considering the very dry situation when the survey work was carried out and the fact that the area has already been heavly impacted by embankment construction work. In addition to the fish species, 8 invertebrates were recorded, two of which were found in fisheries catches. The highest number of fish species (28) were observed in Zone D, which includes the Dakatia system and some of the most deeply and longer flooded land. Zone A, which lies at the downstream end of the drainage system and has some all year inflow from the Meghna river (although this is greatly inhibited by the Rahmatkhali Regulator), had the second highest number of species. Small shrimps were found to be the dominant species in Zone B and overall species diversity in Zone C was found to be low, however this could be due to the exceptionally dry year in which the data was collected being very unrepresentative. The dry conditions during the survey period are likely to have

seriously curtailed the dispersion of migratory species into the main part of the study area and the availability of floodplain habitats resulting in these areas being relatively under recorded in comparison to a "normal" flood year.

Overall Hilsa were the main species recorded as being caught, even though they were only recorded in Zone A. They are a migratory species moving from the Meghna river through the Rahmatkhali regulator, however it is possible that their dispersion into other zones was highly restricted due to the untypically dry year and this situation is not representative. Due to the restrictions of time and the fact that it was such an untypically dry year it was not possible to ascertain the fish dispersal and migratory patterns. A major study is needed on this to understand the movement and hence the implications of drainage interventions on the fish ecology and production system.

The fisheries yields were found to be roughly half that of Gumti on an area basis for vertually the identical time period. However the Gumti figure is high compared to the national average, an accurate indicator of its importance and the fact that the Meghna river system is the most productive of the large rivers in Bangladesh. The total capture catch in the Noakhali study area was estimated to be 10 349 metric tonnes with a market value estimated to be worth Tk 526 million. Capture fisheries are estimated to be only 44% of the total study area catch, cultured fisheries accounting for a further 15 338 metric tonnes with an mean value per kg higher than capture fisheries.

6.2.7 Ecological Issues

The study area has already been heavily impacted by human intervention, especially the construction of the old coastal embankment which forms the southern boundary of the area. The exception is a small part in the south west corner which is recently accreted land. In addition the encircling embankment around the Chandpur project area has effectively cut off the study area drainage system from the Meghna river system except through the controlled Rahmatkhali regulator to the south and the uncontrolled Dakatia river to the north. Even the latter system has been constricted into an area bounded by the road and railway embankment to the north and the Chandpur embankment to the south. However the study area still has significant rain-fed floodplains covering nearly half of the study area in the peak of a 1 in 2 "normal" flood year as shown in Figure 6.4. This increases still further in a 1 in 5 high "normal" year.

There is at present no set of agreed national policy aims and objectives with regard to ecological issues and particularly management and conservation for sustainable resource use, let alone a structure for implementing this. There is a Draft National Conservation Strategy and this is in the process of being reviewed by Central Government as part of NEMAP. There is as yet no unified body of environmental legislation and it is likely to be some time before this is in place, let alone enforced. What is important for the study is how any national environmental policy guidelines are to be adopted at the regional and sub-regional level. Specifically what are to be the priorities for the area and is this reflected in the proposed intervention for the study area? The central issue is likely to be if the seasonal floodland losses caused by a drainage improvement intervention are considered justifiable due to the agricultural benefits that are likely to result. It is a matter of priorities and specifically whether the government considers the seasonal floodlands of the Noakhali North area to be of relatively low ecological and economic value within the national context. This should consider the issues of loss of economic use of resources as well as wider concerns as to ecological sustainability and changes in bio-diversity.

The real problem is the lack of hard ecological data, particularly with regard to trends over time and also an understanding of the very complex linkages within the natural ecological system and how these interface with the human use of these resources. Significantly more data collection is needed to do this, spread out over a minimum period of a year to reflect the full seasonal cycle. In addition, longer term trend data is required and this is especially the case with the fish system which is of major economic and nutritional use to the people of the study area. Clearly this is not appropriate for a limited duration feasibility study.

6.3 Water Quality

The situation with regard to surface water quality, in both the wet and dry seasons in the study area, is shown from field data collection results displayed in Tables H.2.1 and H.2.2 with the locations of these being shown in Figure 6.5. This data is interpreted in Section H.2.1.5 of Annex H and compared with national standards for water quality shown at the bottom of the two tables.

The situation in terms of groundwater quality has already been outlined in Section 2.1.5 of this report and also in Annex C.

The broad conclusions of the surface water analysis are that the overall levels of minerals and nutrients are very low, indeed to the point where the use of maximum allowable levels as permitted use parameters should be questioned. The real issue in terms of use is that the water has inadequate levels of many components which could limit its usefulness for both human potable consumption (although this is undesirable because of the high bacterial counts) and irrigation. Combined with the fact that the level of nutrients in the soil is also low, this would seem to indicate that the biological processes are what allow the area to be as agriculturally productive as it is. This has implications for future agricultural productivity in that there would seem to be even more need to diversify crop types to reduce the risk of soil depletion and resource decline due to continuous mono-cropping.

The one sample taken for ago-chemical testing was shown to have relatively high levels of DDT residuals, although these were not above the national standards. It was taken from the Laksham Depression, an internally draining basin that is only connected to the main drainage system and floodland in high "normal" flood conditions. It would appear that the lack of through flooding to dilute and disperse the residuals is a major factor causing the concentration.

High salinity levels were reported in the Noakhali Khal at the south of the study area during the public participation part of the study. In response to this, EC measurements were taken along the Khal during the two sampling periods. These results indicated that, although the salinity levels at the southern end of the Khal on the edge of the study are high relative to other parts of the study area, (indicating some limited sea water intrusion up the Khal), they fall to similar low levels as the rest of the study area within a northerly distance of 5km. It would also seem that this problem is decreasing over time as southward land accretion continues. The levels of salinity in the main Meghna river at the Rahmatkhali regulator are actually significantly lower than the fairly low levels found within the study area, even in the dry season. This would seem to indicate that there should be little problem in allowing inflow of this water as part of an irrigation supply intervention.



Source: District Gazetteer Map, Surveyed 1893-98, 1913-1916, Additions 1931

Figure 6.6

The Study Area in 1931 with Overlay

6.4 Water Supply

The 1981 BBS data indicating the proportion and spatial distribution of households having access to potable water is shown in Figure H.2.31. The available data for 1991 is given in Figure H.2.32 and the change between the two dates in Figure H.2.33. The low levels of water supply provision have been confirmed through the public participation work. This showed that in 10 of the 13 responses, local people cited that there were difficulties in provision of domestic water supply. Of these there were severe all year difficulties being experienced in the south west of the study are (Zone A), dry season difficulties in Zone C and overall low levels of provision due to an inadequate number of tubewells. The 1981 BBS data confirms very low levels (between 10% and 25% of households) of provision in the south western part of the study area, with the highest provision levels (over 85%) in the north west. The general level of provision in 1981 appears to be around 69-70% although the spatial variation in this is considerable. However comparisons with the 1991 data where this is available (mainly for the south eastern part of the study area) indicate that there have been quite dramatic improvements in provision during this time, with overall increases in provision of between 20 and 30%. However again there is enormous spatial variation in this pattern and a few Unions actually report decreased provision, possibly as a result of population in-migration. Importantly there is no data yet available for the most critical area in the south west of the study. Overall it would thus appear that there are still problems of poor water supply provision, particularly as deep tubewells are required. This makes provision difficult and expensive, especially when compared to the north of the country where shallow tubewell water is easily available with simple technology down to household level. The inadequate all year provision of groundwater sources means that use is made of open standing water. This creates a very serious health hazard, as the organic pollution levels in the sampled sites were so high that they were unmeasurable. The health surveys have also confirmed that diarrhoeal disease is the biggest health hazard in the area and a significant cause of mortality. The quality of groundwater has been assessed in Section 2.1.5 and Annex C of the report.

6.5 Health and Nutrition

A reconnaissance level baseline assessment of the health and nutrition status of the population in the study area was carried out as part of the study. This is included as Appendix IV of the EIA Annex H. The findings of the study were that overall the area has slightly lower disease rates than the national average, however these are still significant and vary greatly within the study area. There are problems with waterborne disease related to poor water supply provision, sanitation and lack of health education. Diarrhoeal disease outbreaks, including cholera, occur particularly after the monsoon period and are a cause of death, especially amongst children. The incidence figures for diarrhoeal diseases and malaria by zone are shown in Figures H.2.34 and H.2.35 respectively.

The findings of the nutritional survey indicated that fish is extremely important indeed throughout the study area, providing by far the greatest proportion of protein in diets, being much more significant than pulses and meat. The possible loss of free-good or affordable fisheries resources as a result of any intervention is therefor likely to be a significant issue. Whilst the overall nutritional levels were little different than the national average (which are well below WHO minimum standards), significant differences were found to exist across the study area. Incidences of malnutrition and vitamin deficiency were much higher in Zone D than elsewhere in the study area. More details are given in Appendix IV of Annex H.

6.6 Culture and Heritage

6.6.1 Settlement History

The history of human settlement in the Noakhali North area appears to be very long indeed, however the physical evidence for this is relatively limited. This is partly due to the dynamic nature of the natural environment (large scale river and coastal erosion and accretion along with cyclones and seismic activity have possibly destroyed much evidence) and also because of the high density of human population which has meant that the materials from any substantial construction that has been abandoned have often soon been reclaimed for re-use. This is particularly the case in many parts of Bangladesh where sources of durable building materials are hard to find and also means that the number of sites constructed from such materials are in any case likely to be small, irrespective of the size and sophistication of past human settlement.

Despite this, there is evidence from inscribed pillars that there was known and well organised human settlement within the area that now comprises Noakhali District as early as the years 340AD to 380AD, when it was a tributary state of the Samudragupta period. It is thought that the area was first settled sometime between 1400 and 1000BC by the Vedas. It would appear that there were sophisticated and stable Buddhist dynasties governing the area from the 9th Century AD up until 1150AD when the Hindu Senas took over much of Bengal, including the area east of the Meghna river. The Turkish invasion at the end of the 13th Century AD led to the establishment of a main administrative area called Bhulua with a main town of the same name located 8km south of Lakshmipur, close to the present day position of the Rahmatkhali regulator. This remained the main administration town up until the creation of Noakhali in 1821, when reference to the town rather mysteriously seems to disappear, perhaps because it may have been eroded away by the Meghna river, possibly linked to the change in flow patterns caused by the shift of the course of the Brahmaputra and creation of the Jamuna River.

The study area appears to have suffered from being caught between two powerful states, the Arakan based in Chittagong (assisted by Portuguese pirates from 1600), and the Moghul empire. The area ocellated between their control until the two combined to invade the area in 1614 and then fought each other with the Moghuls eventually taking control. The northerly adjacent area became the separate state of Comilla (then known as Tippera) in 1519 and also invaded the study area in 1578, controlling it until 1593. The area remained under the Moghuls until 1756, long after the decline of the centre of Moghul power in India. The study area was administered from Dhaka from the 1730's, having previously been under the control of Delhi from 1325 followed by Sonargon in 1349.

The East India Company moved into the area in 1757 and after first using the Zamindar system for indirect rule of the area, took over revenue collection in 1772. Bhulua became a District under Mymensingh until Tippera District was created in 1790 which sub-divided the present day Noakhali District. In 1821 a separate District of Bhulua was created under Chittagong. This became Noakhali in 1868, presumably when a new District Headquarters town was established on what was then the coast, possibly because Bhulua was lost to Meghna river erosion, although its site is presently well inland. There were boundary adjustments with Comilla in 1873 and 1875 and the Feni river became the eastern limit of Noakhali District in 1881. There was a major change in administration structure in 1905 when Bengal was divided, with East Bengal and Assam being split from West Bengal and administered separately. This was amended in 1911, partially as a result of it proving so divisive.

The anti-British nationalist movements that were active in Comilla from 1820 seen to have been absent from Noakhali and even the major uprising in 1857 seems to have had little effect in the area. However the non-co-operation movement was active from 1920 onwards. There was presumably, like surrounding areas, serious disruption to the area in 1942 due to mobilisation for fighting during the 1939-1945 Second World War. This was a contributory factor to a major famine in 1943. Independence was gained from Britain in 1947 which resulted in partition from India which split Bengal and created East Pakistan. This resulted in major movements of population, both into and out of the area. The liberation war with West Pakistan occurred in 1971 resulting in the formation of Bangladesh as an independent state.

In 1961 88% of the Noakhali District population were recorded as being Muslim whilst the equivalent figure for 1872 was 75%. The remainder of the population are Hindu with a very small christian minority and no tribal/animist people recorded.

6.6.2 History of Hazards

There appears to have been a steady increase in population in the study area which is more densely populated than the other parts of Noakhali District. This is particularly in comparison to the area to the south of it where the land is relatively recently accreted coastal polders created by the construction of cross dam embankments.

The most serious hazards are cyclones which cause heavy rain, high winds and tidal waves. The destruction caused by tidal waves in the study area was previously dependent upon the effectiveness of the coastal protection embankment. However as the land has accreted dramatically on the seaward side of the embankment during the last 30 years, the destruction and loss of life caused by cyclones has declined dramatically. The worst cyclone recorded to have hit the area was in 1797 and there was also a serious one in 1876 in which all buildings of any substance were destroyed. In the 1876 event 36 000 people were drowned and a further 49 000 died as a result of the consequential cholera epidemic. This was 12% of the then total District population. There were also cyclones in 1895, 1941, 1958, 1960, 1961, 1965, 1966, 1970, 1985 and April 1991. The 1960 event caused 3 000 deaths and in 1970 38 000 people lost their lives in the District. Cyclones occur in October/November and also April/May and despite the severity of the April 1991 event deaths were low in the study area due to the fact that it was not in the direct path of the cyclone and also as the accreted land now offers considerable protection from any tidal wave.

The major flood risk to the District is due to flash flooding from the hills on the Indian border in the east. By far the majority of this is collected by the Feni river system which runs southwards along the foot of the hills to the sea. It appears that only in exceptionally high local rainfall years does this spread west of the Feni river into the study area. The risk of this happening may have been marginally increased since the construction of the coastal cross dams as the drainage distances become longer and the gradients shallower. Peak floods in the Feni system have been recorded in 1822, 1825, 1848, 1965, 1966 and 1975. A localised tornado was recorded in the study area in 1968 and whilst these are not widespread they can be very severe locally, causing considerable destruction.

Erosion has historically been a major threat for the present study area, both from the Meghna river in the west and the coast to the south. This has resulted in the need to move major towns in the past. It would appear that the District Headquarters town of Bhulua dating from the 13th Century was lost to the Meghna river around 1820 and the original site of Companyganj (present site just outside the eastern edge of the study area) was lost

to the sea in 1911. Conversely the area has recently had considerable accreted land attached to the south and this has rendered many ports and Ghats inoperative. When the new District Headquarters was established at Noakhali in 1821 it was a railhead coastal port, where as now it lies over 30km from the coast. This accretion has recently been considerably hastened as a result of the construction of coastal cross dams and polderisation which have sometimes been made prematurely, causing land to be settled before it has had a chance to accrete to a safe level and making it dependent upon the coastal embankment for protection from tidal waves. It has also caused drainage difficulties, particularly in the study area. A map of the area dated 1919 with amendments in 1931 (some 25 years before the start of coastal cross dam construction) is shown in Figure 6.6.

The study area lies in a low to medium level earthquake risk area and even the most serious recent event in 1897, which whilst quite severe, caused little damage. However it maybe that the nature of construction technology used then (mainly bamboo and lightweight, non-rigid materials) was a significant factor in keeping casualties low. If a similar occurrence were to happen today the situation may be very different. The effects of seismicity on any major embankment structure should also be considered, especially the risk of liquefaction. Both the 1762 and 1897 earthquakes resulted in changes in ground level which may have had consequences for the hydraulic system in the area as gradients are so slight. Historically all major earthquakes have occurred during the monsoon period when river water levels are at their highest and this creates an infrequent but major risk, especially to any embanked areas, including the road system.

Unlike some other parts of Bangladesh there have been no drought conditions recorded in the study area over the last 200 years. There have been cholera epidemics in 1875 and 1893 as a result of sanitation problems following cyclones. These actually killed more people than were drowned in the cyclone. The 1943 famine was accompanied by a cholera and smallpox epidemic and was caused by disruption due to the second world war, including problems with food distribution following flooding and a cyclone.

6.6.3 Archaeology and Cultural Sites

There are reasonable records of the archaeological sites in the study area given in the Government Gazetteers. These were summarised in the FAP 5 South East Regional Study Environmental Annex and further details are held by the National Museum and antiquities department. As explained in the settlement history section above, the nature of the climate, the lack of durable building materials, the density of human settlement and land erosion have all contributed to there being so few sites despite the very long period of human settlement in the area. This fact actually makes those that do exist even more valuable in terms of national heritage. The sites within and very close by to the study area include the following:

- Mira Shahetis Dargah (Islamic Holy Shrine) from the 11th Century at Kanchanpur in Ramganj Thana.
- An architecturally important 15th century mosque at Bajra in Begumganj Thana which is a major pilgrimage centre.
- Dargah of Bhuiya Anis Mohammad at Mohammadpur in Senbag Thana.
- A very ruined but ancient village with a temple at Amishapara in Begumganj Thana.

- The Asram of high saint Ram at Choumahani in Begumganj town.

- Dalak Bazar in Lakshmipur Thana is an old Zamindar headquarters with several fine buildings including temples, tanks and Khoasagar Dighi. It was important as a trading place for indigo during the British colonial period.

- Lakshmipur town was an important British colonial trading port and cloth production centre.

- Companyganj just to the east of the study area was an East India Company trading port originally on the coast.

6.6.4 Landscape and Recreation

The area has been highly impacted by a long period of human settlement and significant dynamic land erosion and accretion. The landscape itself is very flat and unremarkable in terms of topography but the aspect of Bhawaniganj south of Lakshmipur and apparently close to the site of the old District Headquarters town of Bhulua (established in the 13th Century but probably lost to erosion sometime before 1821), is reportedly of scenic beauty and attracts visitors. There appear to be no gazetted national parks or designated reserves in the study area. However there is at present no implemented national conservation and management policy, (although a draft is at present being reviewed by government as part of NEMAP) so this situation could change.

There has in the recent past been a low priority attached to the need for planning and provision of facilities for amenity and recreation in Bangladesh. It is despite, or perhaps because of, the high population densities. This is particularly an issue with some of the larger urban settlements and there would appear to be some need for its consideration in the context of urban expansion and perhaps some need for development control linked to provision of open space and "green belt" policies.

Figure 7.1

Transport Networks

CHAPTER 7

INFRASTRUCTURE

7.1 Introduction

During the public participation meetings there were some references to a lack of good communications. In particular in Zone A people were concerned about poor communications and in the absence of good roads requested navigation facilities through Rahmatkhali regulator.

Also there were complaints of poor communications in Zone D even for villages close to the Dakatia river and in some part of Zone C. Almost everywhere upgrading of electricity supply was requested.

In general the area appears to be quite well flood proofed but at present during even a 1 in 10 year event such as 1987 or 1988 (both similar events in Noakhali North area) there is some damage in Zones B and C.

An infrastructure survey was carried out principally to identify the infrastructure which might be affected by the proposals. In addition discussions were held with the roads and Highways Department (RHD) LGED, the Bangladesh Inland Water Transport Authority, the Rural Electricity Board and the Power Development Board.

The amount of traffic in the area is not considered to be an issue in terms of the proposed development and therefore no primary data (traffic survey) was collected during the study.

7.2 The Existing Transportation Network

The major highways, roads and railways within and adjacent to the project area are shown in figure 7.1. The principal components of the network are discussed in the following sub-sections.

7.2.1 Roads and Highways

The major routes under the responsibility of the RHD are:

- Dhaka-Comilla-Chittagong National Highway
- Comilla-Chandpur
- Comilla-Laksham-Sonaimuri-Begumganj-Noakhali
- Feni-Begumganj-Lakshmipur-Raipur
- Sonaimuri-Chatkhil-Ramganj
- Ramganj-Hajiganj (to be upgraded)
- Lakshmipur-Ramgati
- Ramganj - Chitoshi.

This is a substantial network and several works are ongoing or in the pipe line. The Sonaimuri-Chatkhil-Ramganj road is currently being upgraded with new bridges over all the major khals. A new road has recently started, which will provide a new access route from Lakshmipur to Mazimiarhat (Rahmatkhali regulator). This

7.3 Electric Power

The Power Development Board operate services in Lakshmipur Pourashava, Babaniganj Bazar, Rakhalia Bazar and Textile area, Mandari Bazar, Hajipara Bazar, Chandraganj, Begumganj, Laksham, Sonaimuri, Chaumahani and Noakhali.

A map of the existing distribution system and development under way for Bangladesh as a whole (33 kv to 230 kv) and for the Comilla, Chandpur, Lakshmipur and Noakhali districts (11 kv to 230 kv) was collected.

REB are active in all the Thanas where irrigation is expected to increase under the project plan. In Lakshmipur there are existing connections to 74 LLPs, 3 DTWs and one STW and there are plans for an additional 300 connections. REB provide electricity at favourable rates for agricultural uses and no payment is required for transmission lines.

7.4 Gas

There is an existing gas supply by 10" diameter pipe from Feni along the shoulder of the roads and branched via a regulator system to Senbagh, Chaumohani (east), Chaumohani (West) and Begumganj. This is planned to be extended to Lakshmipur. It is normal practice to lay the pipeline 5 to 6 feet below the existing canal bed level where such crossings occur.

7.5 Flood Protection Infrastructure

The project area is surrounded by either high ground (east) or by existing embankment. To the south the old coastal embankment originally protected the area from the sea. This embankment is now largely redundant and the existing structures are largely ineffective. The south western boundary comprises the main Meghna left embankment and contains the existing Rahmatkhali Regulator. The embankment condition is generally adequate and the regulator structure has maintained its structural integrity over the last 20 years despite its excessive overloading. As reported elsewhere the overloading has caused severe erosion downstream, and some upstream, of the regulator, both of the channel sides and of the bed. BWDB are currently undertaking some remedial measures to the sides of the channel and the development proposals include additional recommendations to prevent further erosion.

The main embankment has not suffered from public cuts and appears to be accepted by the local population. Further north the western boundary comprises the CIP eastern embankment so that the project area has a double line of defence against either flooding or erosion from the Meghna.

Just to the north of the project boundary the existing Chandpur to Comilla road and railway embankment provide major obstacles to movement of flood water. The combined effects of all these embankments both protect the area from severe inundation from the Meghna during high tides and they also contribute to the areas inadequate drainage.

The largely man made Khal system was mostly constructed when the area was nearer to the coast and the improvements made in the early 1970's have proved inadequate in the face of increasingly difficult drainage to the south.

is expected to be completed by 1995 and this 12 feet (3.65 m) wide road will therefore meet the requirement of the residents of Zone A who request navigation facilities at the regulator; with the road in place such facilities will not be required.

In addition, the Ramganj-Hajiganj road is to be upgraded as a regional road although it is not known if a bridge is to be provided over the Dakatia.

The RHD also informed the team that they propose to construct several new cross-drainage structures on the Laksham-Begumganj road similar to those currently under construction on the Ramganj-Sonaimuri section which are quite adequate in respect of drainage capacity.

The LGED is responsible for many roads. An LGED/ILO project is in the process of producing excellent Thana maps showing locations of all roads and embankments and the existing cross-drainage structures. Unfortunately only two of these maps were currently available to this study. However the complete set should be obtained for the final design work.

The infrastructure survey has identified all the existing bridges across the Khals which it is proposed to widen and or deepen and Annex I contains details of this survey and the proposed works.

7.2.2 Navigation

As already mentioned to above the only issue in this respect which was mentioned during the public participation programme was the possibility of incorporating navigation facilities in the Rahmatkhali regulator. The provision of the new road eliminates this requirement. It should be pointed out that there is considerable water borne traffic upto the regulator from the Meghna river but since the internal khal system is not suitable for year round transport it is more appropriate for the regulator to be the terminus and onward transport to be by an adequate road.

The existing traffic was reported to include approximately 100 private country boats per day from Chandpur, Bhola and Chittagong. Also a new passenger service has started.

The only other significant navigation route within the project area is the Dakatia river along its northern boundary. Since no proposals for the Dakatia are now incorporated in the recommended development no changes are necessary.

Within the project area the widening and deepening of Khals may permit wider use of small boats but it is not anticipated that this will be significant. The proposals will not affect water bome transport at any location.

7.2.3 Railways

The eastern part of the area is quite close to the main Dhaka-Chittagong railway and there is a branch line from Comilla through Laksham and Begumganj to Noakhali. No changes are foreseen but the railways could comprise a significant contribution to the efficient movement of any surplus produce.

CHAPTER 8

INSTITUTIONS

8.1 Introduction

In order to implement water resources development schemes, many government agencies need to be involved. Flood control, drainage and irrigation projects affect the local infrastructure, health and agriculture including livestock and fisheries. Major projects have to be approved by central government but successful implementation involves different ministries, local government and the community. At present, major water development projects are the responsibility of the Bangladesh Water Development Board, (BWDB), but small irrigation schemes (up to 1 000 ha) and small scale FCD projects (up to 4 000 ha) are undertaken by the Local Government Engineering Department (LGED). Agricultural extension is the responsibility of the Ministry of Agriculture.

For any intervention it is important to involve the local community and this cannot be done merely through civil servants and locally elected people, it is also important to seek the support of groups which may not be represented, this is particularly the case where a large proportion of the population are illiterate. One way to contact local people is through non-government organizations (NGOs); these organizations may also be of great assistance in operation and maintenance of schemes.

8.2 National Institutions

The relevant ministries and agencies involved in water resources development are described below.

(a) National Water Council

The National Water Council (NWC) is headed by the Prime Minister and is responsible for overall policy guidance for water resources development planning.

(b) National Flood Council

The National Flood Council (NFC), has two committees a Technical Committee and an Implementation Committee. The Technical Committee is headed by the Prime Minister and composed of selected Ministers. The Chairman of the Implementation Committee is the Secretary of the Ministry of Irrigation and Flood Control.

(c) Planning Commission

The Bangladesh Planning Commission comes under the Ministry of Planning. The Planning Commission has a three fold involvement in development planning; advisory, executive and co-ordination. The Ministry of Planning has to approve all projects costing up to Tk 50 million and all feasibility studies. Projects costing more than Tk 50 million must also be approved by the Executive Committee of the National Economic Council, (ECNEC).

(d) Ministry of Irrigation, Water Development and Flood Control

The Ministry is responsible for the assessment of water resources, and for implementation of major projects covering flood control, drainage and major irrigation schemes. The ministry supervises five agencies: the Joint River Commission (JRC), the Water Resources Planning Organization (WRPO), (formerly the Master Plan Organization) the Bangladesh Water Development Board (BWDB), the Flood Plan Coordination Organization (FPCO), and the River Research Institute (RRI).

(i) Water Resources Planning Organization

The Government created the Master Plan Organization (MPO) in 1982/83 to develop a comprehensive National Water Plan (NWP) covering the period 1985-2005. A second phase of the development planning was initiated in December 1988. The objectives of the NWP Project Phase II were:

- to develop a viable capability for planning water resources development;
- to produce an updated and upgraded NWP; and
- to plan development of water resources during the Fourth Five Year Plan.

In 1991 at the culmination of NWP Phase II, the name of the MPO was changed to Water Resources Planning Organization (WRPO) and the organization was to have a permanent role within government.

(ii) Bangladesh Water Development Board

The BWDB is responsible for all stages of development from design through to O & M of the following:

- schemes for the control of floods and the development and use of water resources including:
- construction of dams, barrages, reservoirs;
- flood control;
- drainage;
- improvements, and extension of channels;

(iii) Flood Plan Co-ordination Organization

The Flood Plan Co-ordination Organization (FPCO) is the unit which co-ordinates and manages the FAP, and all FAP related activities carried out by departments of other Ministries.

(e) Ministry of Agriculture

(i) Department of Agricultural Extension

The functions of the Department of Agricultural Extension (DAE) are as follows:

- to motivate and help farmers adopt improved production practices;
- to develop self-reliance and co-operation by training local leadership for organized group action;

- to provide efficient linkage between the various research institutions and the farmers;
- to serve as liaison agency between farmers and other organizations, both public and private concerned with overall socio-economic development of rural people;
- to help promote storage and fair price for farm produce.

The institutional foci for the management of the extension services are the Block (part of a Union), Unit (Thana), Zone (District) and the Headquarters (National level). The line functions over the field extension services are exercised by the Field Services Division of DAE.

The following staff are attached to all Thanas:

- Thana Agricultural Officer
- Additional Thana Agricultural Officer
- Subject Matter Officer
- Assistant Agricultural Extension Officer
- Junior Agricultural Extension Officer
- Plant Protection Inspector

At the Block (Union) level there is a Block Supervisor (BS) who provides extension services to farmers or groups of farmers. A Block Supervisor covers 600 to 1 200 farm families (an overall average of 900) depending upon the intensity of agriculture in a given area.

(ii) Bangladesh Agricultural Development Corporation

The Bangladesh Agricultural Development Corporation (BADC) was established in 1961 to promote the use of modern agricultural inputs among farmers. Section 13 of its Ordinance sets forth the functions of the corporation:

The corporation shall (inter alia):

- make suitable arrangements on a commercial basis for the procurement, transport, storage and distribution to agriculturalists of essential supplies such as seed, fertiliser, pesticides and agricultural machinery and implements;
- promote the setting up of co-operative societies with a view to handing over the supply function;
- encourage the development of co-operatives in other spheres.

The corporation may (inter alia):

- organize the supply, maintenance and operation of low-lift pumps and set up workshops for repairs;
- encourage the expansion and improvement of industries for the manufacture of diesel engines used in agriculture;
- make arrangements for servicing machinery; and
- provide and maintain transport facilities and assist other public or private agencies to provide such facilities for the use of the corporation.

The BADC has established a Unit Office in each Thana for the supply of irrigation equipment, fuel and lubricants. In every Thana, there is a BADC go-down for storage of irrigation equipment, seeds and fertilisers and a team of mechanics provides maintenance services to farmers. The distribution of seeds and fertilisers is done through private wholesale and retail traders. However, as the agricultural inputs and services develop, many of BADC functions are being transferred to the private sector. BADC is no longer the sole supplier of all recurrent agricultural inputs including the procurement and marketing of fertilisers, promotion of new irrigation technologies and the production and distribution of improved seeds. It no longer controls the sale and servicing of low lift pumps (LLP) and Shallow tubewells (STW) and has sold virtually all of the previously rented LLP and STW. Its main remaining function is now the installation, operation and maintenance of Deep tubewells (DTW). There are approximately 24 000 DTWs installed throughout Bangladesh and the process of turning these over to the private sector has already commenced.

(f) Ministry of Local Government Rural Development and Co-operatives (MLGRDC)

(i) Local Government Engineering Department (LGED)

The LGED provides technical support primarily to zila parishads and thana parishads. Zila and thana engineers are primarily concerned with roads, cross drainage structures and market developments but some water resources schemes are also undertaken in the construction, operation and maintenance of local civil infrastructure. In addition to their responsibilities to local water control facilities such as embankments and their appurtenant structures, the responsibilities of the department also extend to schemes transferred from the jurisdiction of BWDB.

(ii) Bangladesh Rural Development Board (BRDB)

The BRDB is the main government agency in charge of social and socio-economic aspects of rural development. It is also involved in the assistance to the rural poor and landless.

The BRDB is responsible for the supervision of Krishi Sambaya Samity (KSS) groups, farmers' cooperative and assisting and guiding Thanas Central Cooperative Association (TCCA). This involves:

- co-ordinating with concerned governmental organizations for mobilizing supplies, services and support for KSS and TCCA; including channelling institutional credit to KSS-TCCA organizations, while encouraging the accumulation of shares and savings by KSS members;
- promotion of intensive agriculture by farmers, particularly through the use of mechanised facilities and surface water, including liaison with BADC;
- provision of appropriate training to KSS managers, model farmers and other members to increase the technical and management skills;
- encouraging TCCA to expand their activities to include marketing the inputs and products of KSS groups and to diversifying into other kinds of business ventures.

The BRDB operates at three levels with a board of directors based in Dhaka, a deputy director based in each district and a Rural Development Officer and Assistant Rural Development Officer attached to each TCCA.

(g) Ministry of Fisheries and Livestock

Within the Ministry of Fisheries and Livestock (MOFL) is the Department of Fisheries (DOF), which is represented at district and thana levels. Other agencies of the Ministry are the Bangladesh Fisheries Development Corporation (BFDC), a parastatal fish marketing organization, and the Fisheries Research Institute (FRI).

(i) Department of Fisheries

The DOF is the principal organization responsible for fisheries development and management with marine and inland wings in four administrative divisions with a staff of over 2 500 individuals. In each Thana, there should be one Thana Fishery Officer (TFO) assisted by two field assistants.

8.3 Local Government

(a) Districts

Local Government is regulated by the Ministry of Local Government, Rural Development and Co-operatives. One of the main units of local government used to be the districts. These have now been replaced by smaller units called zilas of which there are four in the study area, namely Noakhali, Lakshmipur, Chandpur and Comilla.

The districts have now only minor importance, the authority having been transferred to the Thana, but in case of staff shortages the district officer may have to take the part of the thana officer when the latter post is vacant.

(b) Thana Parishads

Thanas generally cover an area of between 150 and 400 km^2 and a typical population is about 250 000. The Thana Chairman used to be directly elected but in November 1991 the government published a decree delegating the Chairman's powers to the senior local government officer, the Thana Nirbahi Officer (TNO). The thana is highly influential in all decision making related to rural development; members of the parishad are frequently related in some from or other to the rural elite. The delegation of powers to the thana level is part of a policy to decentralise, these responsibilities are summarised below:

- Preparation of all thana level development programmes/projects
- Implementation and evaluation of all development programmes projects
- Preparation of thana development projects based on development projects prepared by and for the union parishad, within the thana
- Providing help and encouragement to the activities of the Union Parishad (UP)
- Advancement of health, family planning and family welfare programmes
- Looking after the environment management work
- Training for thana chairman, members and secretaries
- Implementation of government policies and programmes in the union parishad
- Supervision, management and co-ordination of deputed officers to union parishad

- Strengthening social and recreation activities
- Encouragement of employment generation/programmes
- Extension and expansion of co-operative movement in the union parishad
- Helping zila parishad (district) in development programmes
- Planning and extension of all construction work in the UP
- Strengthening agricultural activities for increased production
- Expansion of educational and skilled jobs
- Development of livestock, fishery and forest resources
- Implementation of other programmes/tasks assigned by the government
- Rural water supply and sanitation
- Rural construction work
- Food for works
- Natural calamity relief
- Co-operative and co-operative based rural development
- Fishery development
- Livestock development
- Social welfare service.

As stated earlier, union parishads are responsible for many of the functions assigned to thana parishads, but to a limited extent, and only within their respective jurisdiction. Thana parishads also have supervisory and implementing responsibilities for projects approved by the thana parishad.

(c) Union Parishads

The unions are the divisions of rural areas (villages) within the police jurisdiction of a thana. A Union Parishad is constituted by a chairman, nine elected members and three women from each ward nominated by the responsible thana parishad.

The civic functions of the union parishads include:

- implementation of development schemes in agriculture, irrigation and flood protection
- protection and maintenance of public property such as roads and bridges, canals and embankments.

8.4 Rural Development Organizations

(a) Farmer Co-operative Society/Krishak Samabaya Samity

Krishak Samabaya Samity (KSS) are village based farmers' groups, the membership of which comprises farmers with land holdings of more than 0.2 ha. These groups are formed into co-operative societies to derive benefits from large scale operations by organizing joint services, input supplies and output marketing through collective strength and bargaining power. KSS groups are able to secure cheap institutional credit and are provided with regular training by officials of various government departments involved in rural development. Their ultimate goal is self-reliance in terms of their own funds and management capabilities.

The key objectives of the KSS groups are to:

- increase crop production and yield levels;
- expand irrigation;
- organize the mechanization of irrigation.

Individual KSS groups elect a management committee consisting of six to twelve members, including a chairman, vice-chairman and secretary/manager.

(b) Thana Central Co-operative Association

Thana Central Co-operative Association (TCCA) has been established as a central institution in individual thanas to co-ordinate, support and supervise the activities of the village based primary societies (KSS). Their main functions are to:

- train and educate KSS members in new skills, attitudes and motivations necessary to successfully attain the goals of the KSS; particular emphasis being placed on developing leadership and management skills;
- organize procurement and supervise the distribution of production inputs and services (e.g. fertiliser, credit, irrigation equipment);
- assist with the marketing of outputs;
- provide servicing centres for repair and maintenance of machinery operated by KSS groups;
- operate central co-operative banks owned and managed by the KSS members.

A TCCA has an elected management committee of 12 directors, inclusive of a chairman and vice-chairman.

8.5 Non-government Organizations

Non-government Organizations (NGOs) play a significant part in the country in all aspects of community life, and are both national and international. NGOs who are represented in the area include: BANDWAN, MCC BRAC, NRDS, GANDHI ASHRAM TRUST, ASA and UPOMA.

8.6 Conclusions

Any major water resources development in the area is likely to be implemented by BWDB but from the previous sections it is clear that there are major tasks for the Ministry Of Agriculture (BADC and DAE) and the Ministry of Fisheries and Livestock. There will also be a considerable role for local government and such bodies as co-operatives. Finally it is important to consult with all people who are directly affected by the project and in this respect the NGOs could be of considerable assistance.

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Figure 10.1

Post-Processing Analysis

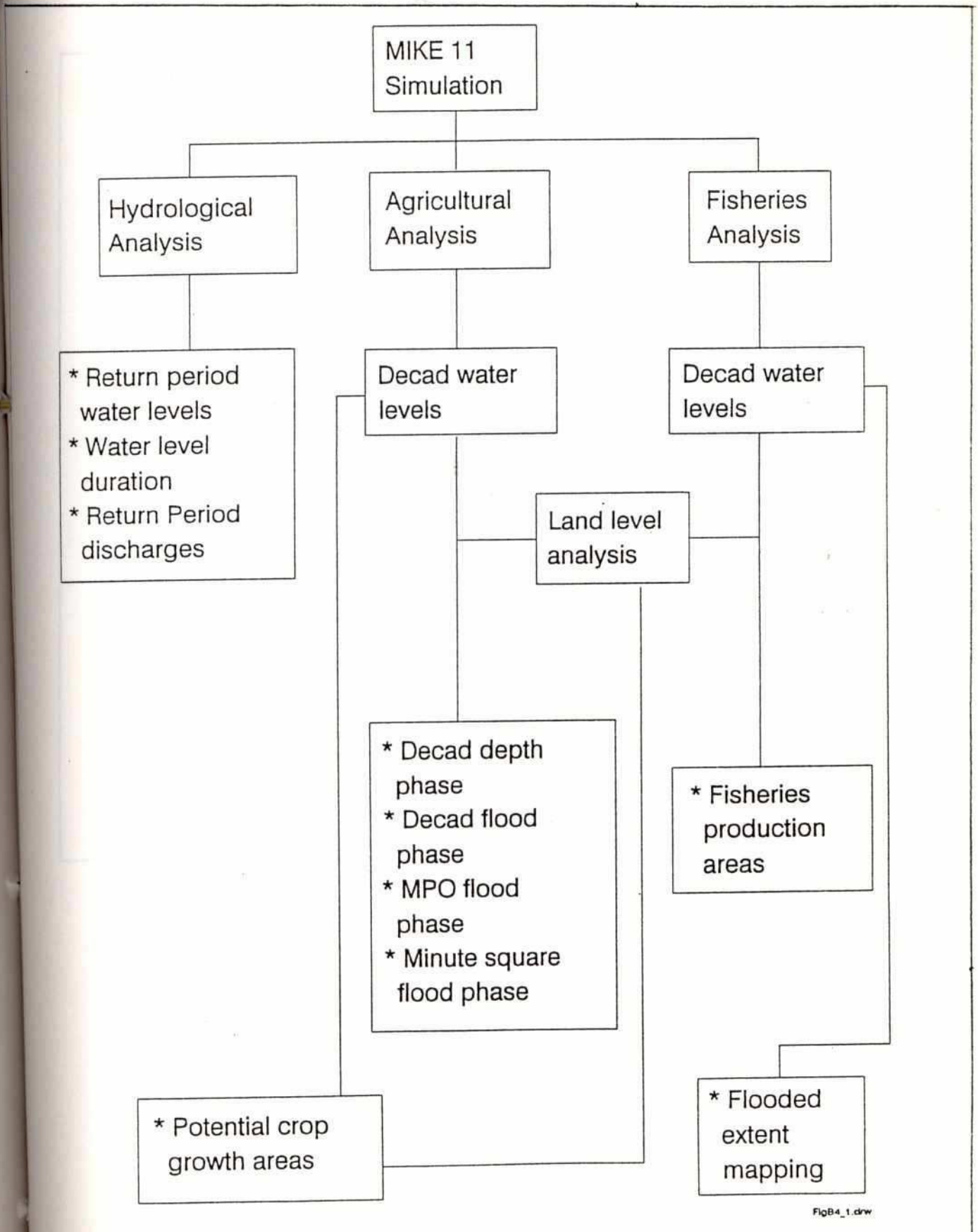
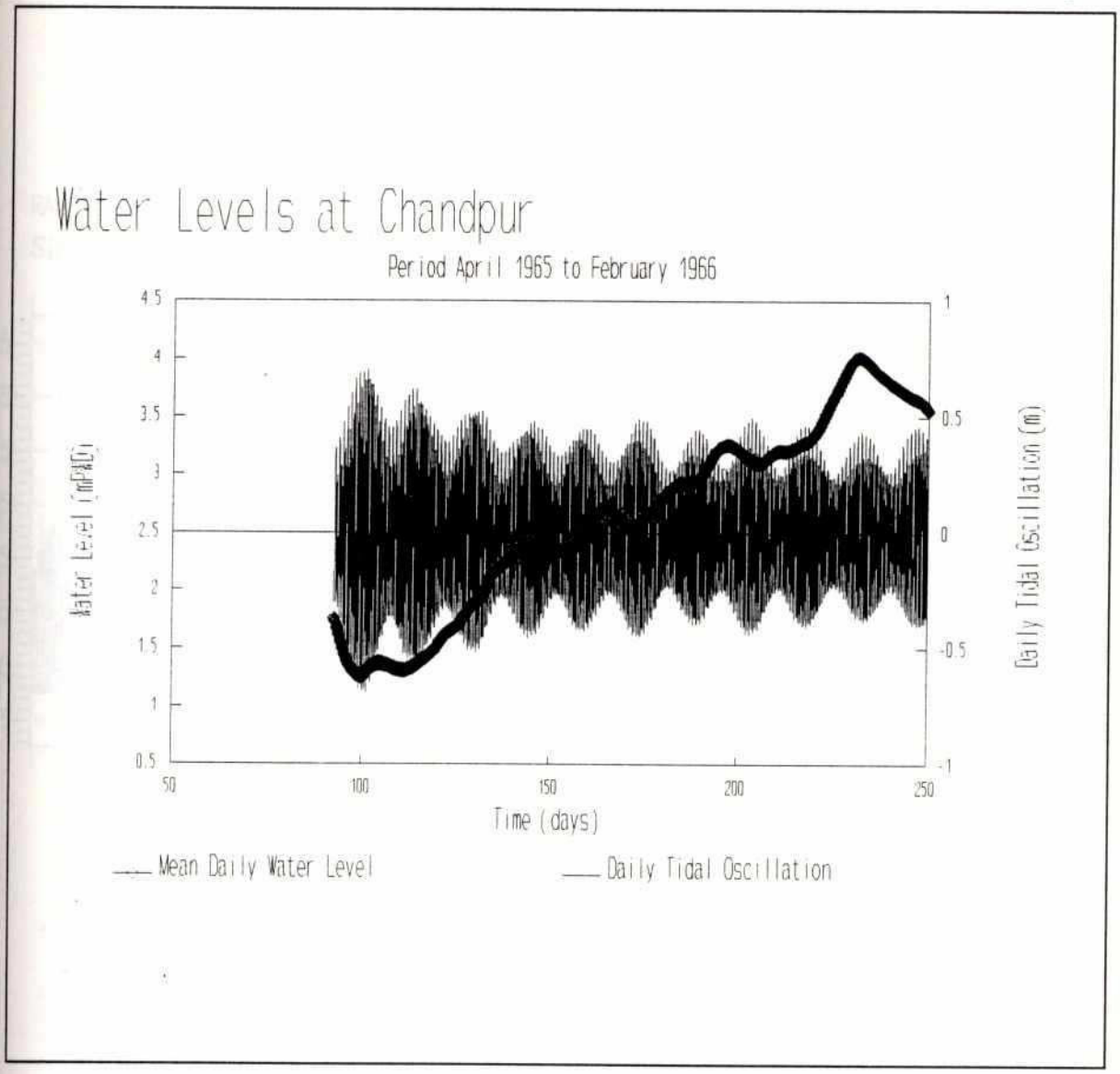


Figure 10.4

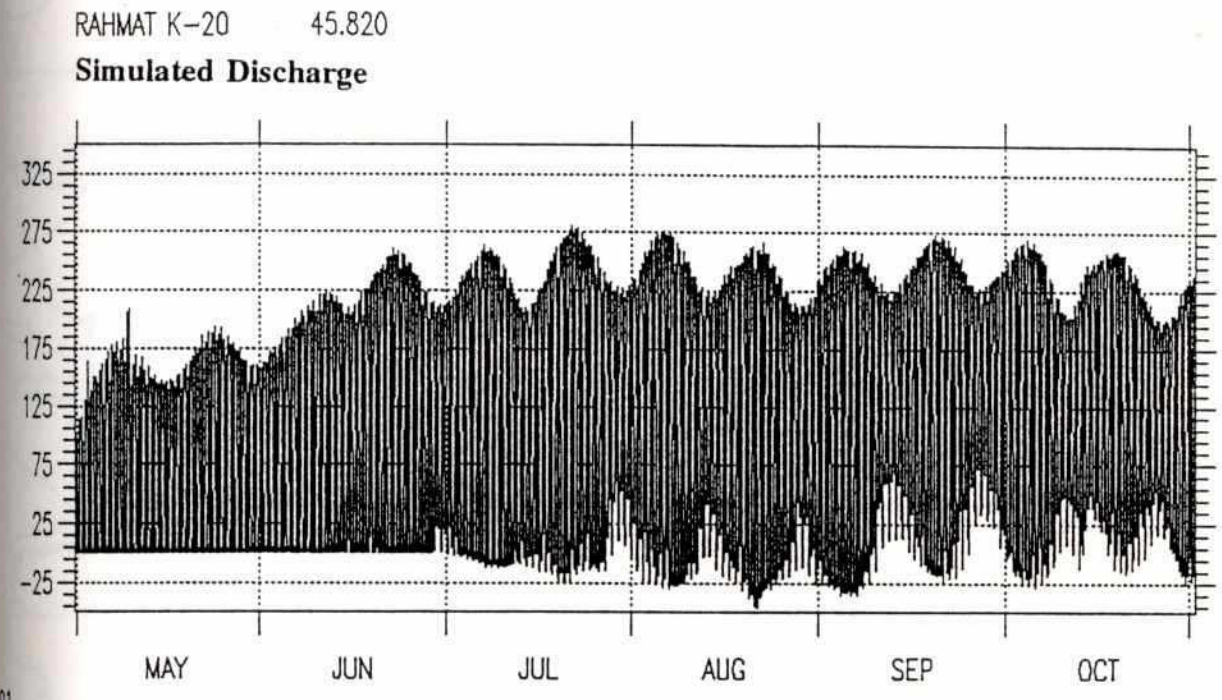
Simulated Tidal Fluctuations and Mean Daily Water Levels at Chandpur



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Figure 10.6

Discharge Hydrograph Through Rahmatkhali Regulator for Existing Condition



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Figure 6.2

Ecology Habitat Zones and Sampling Sites

Figure 6.3

Fish Systems

Figure 6.4

Rising Flood Map - 1 in 2 "normal" Year

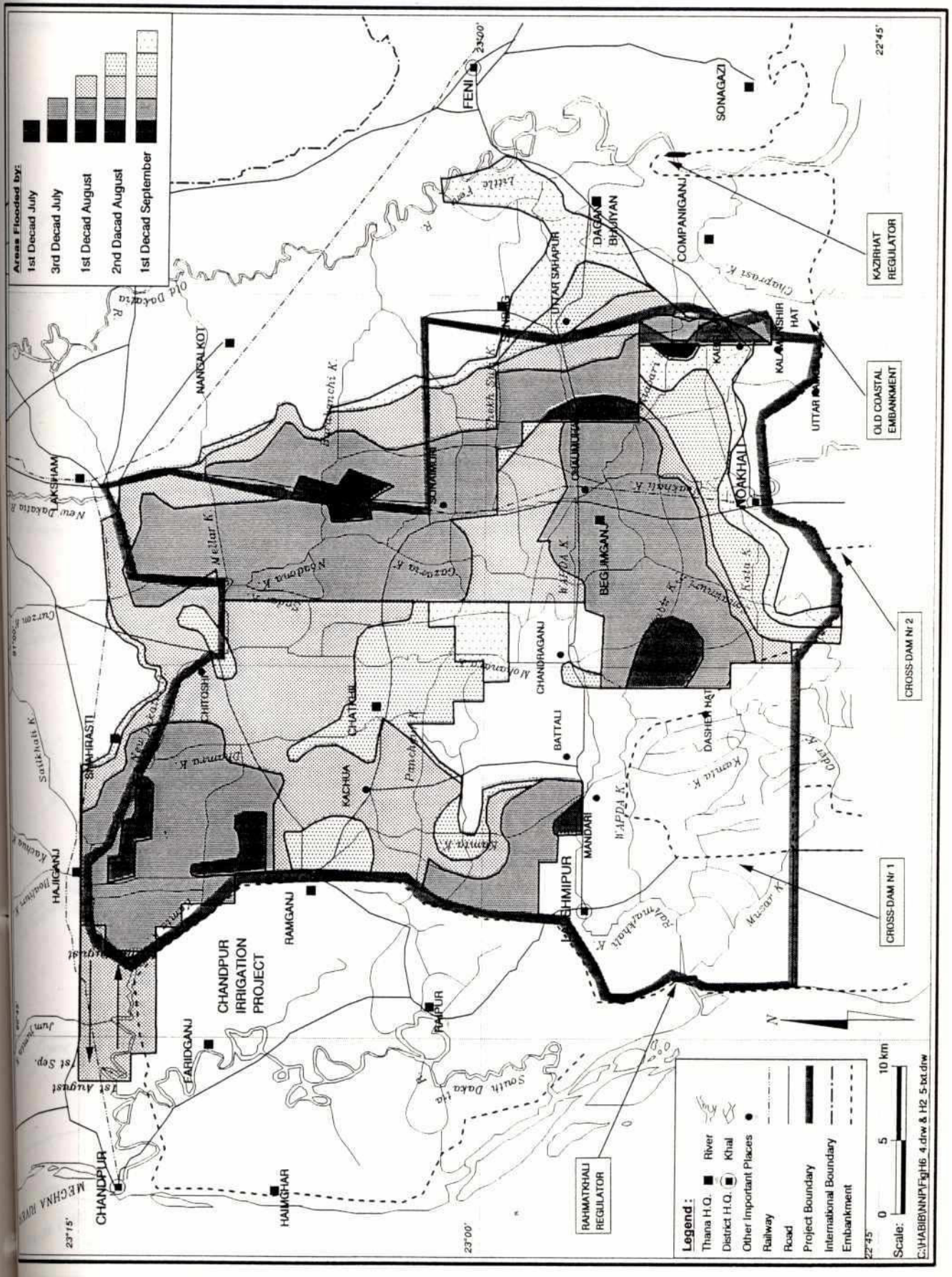


Figure 6.5

Water Quality Sampling Sites

Figure 9.1

Location of Public Participation Villages

CHAPTER 9

PEOPLES PARTICIPATION IN FEASIBILITY STUDIES

9.1 General

To achieve the long term sustainability of flood control and water management projects it is important to have the active participation of the affected social groups in all phases of the project - feasibility, design, implementation and operation and maintenance.

People's participation at feasibility level planning is a vital process to ensure that different socio-economic interest groups gain a sense of commitment to development, by sharing responsibility for key decisions starting from a preliminary need assessment.

The programme of public participation has focused on local problems and needs. The main purposes of the intensive public participation were to improve knowledge of the area and to consult with and inform local communities of the possibilities and limitations of proposed works.

Villagers in Bangladesh have extensive knowledge of the behaviour of water on the floodplain. Indeed they have a vested interest in understanding the problems and the benefits that water holds for them since their lives depend upon this knowledge.

Union and thana officials live very close to the villagers they serve and come into daily contact with the villagers' problems. Therefore they too are an indispensable element in any public participation exercise. Imams, local school teachers and kobiraj (village doctors) can also be a source of valuable information at village meetings. Ultimately, however, the greatest knowledge about local water behaviour will come from the people who farm and fish the floodplain.

9.2 Methodology

To facilitate the process of village-level participation the following contextual model was drawn up by project staff, and as far as possible, follows the guidelines prepared by FPCO, although these were only in draft form when the programme started.

a) Select a manageable number of sample villages in which to carry out the participation meetings;

b) Ask communities in pre-arranged meetings what their particular water problems are and how they would solve these based on local knowledge of the hydraulic regime. In addition to meetings, discussions were held with various members of the community during transectional walks;

c) Take the findings of these meetings back to the office for consideration, analysis and comparison with the findings of the hydraulic model and engineering concepts;

d) Conduct a second series of meetings in the same villages as before where project options were presented to local officials and villagers for discussion and comment. Also, ask additional questions and attempt to resolve seemingly conflicting information;

e) Analyse the findings once more and test various options based on both sets of findings i.e. from both specialists and villagers;

f) Present the findings, options and conclusions to public officials. This was done at meetings in thana headquarters with the TNO, relevant thana officers, Union Council Chairmen and representatives from NGOs, Agricultural Cooperatives, and Fishermen Societies.

The villages in which first and second round meetings took place were chosen randomly from four mouzas from each agro-ecological zone in the project area, taken from the sample of 48 mouzas randomly selected for our agro-economic surveys.

The teams conducting the first and second round meetings were multi-disciplinary but included skilled Bangladeshi animaters who ensured that all sections of the village community (fishermen, landless, farmers etc) would have the opportunity to present their views, without the meeting being dominated by representatives of the influential. As wide a range of opinion as possible was encouraged from the meetings.

A typical team comprised:

Sociologist/Animateur (m) (Local)
Sociologist/Animateur (f) (Local)
Engineer/Hydrologist/Planner
Agriculturist or Fisheries Specialist
Economist/Sociologist

One of the three last categories was an expatriate specialist who was present as much for exposure to life in rural Bangladesh as for his or her knowledge of a particular discipline.

The female sociologist carried out separate meetings or interviews with village women ensuring the process was not gender blind. The same objectives applied to the women's meetings. The problems they faced with water management and control and how they would solve these problems were the prominent features of the meetings.

To analyse the results of the first series of meetings, the Team Leader convened a meeting of engineers and hydrologists in the project office. The problems and solutions offered by villagers, both male and female, were discussed village by village and issue by issue. This was to ensure that all opinions were fully taken into account before options were shaped to take back to the villages for the second series of meetings. The same process was carried out between the second and third series of participatory sessions. In the case of the third round, meetings were held in nine thanas with representatives listed in (f) above.

For the Noakhali North Project the randomly selected villages are shown in Table 9.1 and their locations are illustrated in Figure 9.1.

TABLE 9.1

List of Public Participation Villages

Zone	Thana	Union	Mouza
A	Lakshmipur	Bhabaniganj	Bhabaniganj (Char Mansha)
A	Lakshmipur	Bhabaniganj	Binod Dharmapur
A	Lakshmipur	Dighali	Dighali
A	Lakshmipur	Shakchar	Old Shakchar (Khash Mahal)
B	Noakhali Sadar	Noakhali (Paurashava)	Hari Narayanpur
B	Noakhali Sadar	Noannai	Ratanpur
B	Senbagh	Nabipur	Bishnupur
B	Begumganj	Rasulpur	Latifpur
C	Senbagh	Kabilpur	Khanpur-Purba Lalpur
C	Chatkhil	Nayakhola	Nayakhola
C	Lakshmipur	Charsai	Rampur
C	Lakshmipur	Hajirpara	Hasanpur
D	Begumganj	Nadana	Hatgaon
D	Ramganj	Darbeshpur	Darbeshpur
D	Laksham	Purba Baisgaon	Pearatali
D	Shahrasti	Uttar Suchipara	Chandpur

9.3 Analysis of People's Responses

9.3.1 General

Attendances were considered to be satisfactory for a balanced set of views. Attendance was much lower in the second round than in the first. There are two possible reasons for this. The first is that people would feel that they had explained the situation during the first meeting, so it was now up to the project to provide physical solutions rather than hold further discussions. The second, more pragmatic, reason was that farmers were busy with their boro crops at the time the second round of meetings were arranged. Female attendance was much lower than male attendance, which is not surprising in a society where purdah is enforced in some instances.

The meetings were lively, and contributions came from people from all walks of life. Where specialised knowledge about a particular problem was sought the animater would invite contributions from people with that specific knowledge.

9.3.2 Results from the First and Second Round of Meetings

A summary of the main water related problems given in the first and second round of public participation meetings is given in Table 9.2. The main points of the meetings are also given in detail in Annex G, Chapter 3.

The most common problem stated at village level was a requirement for irrigation water in the dry season. This was evident in all four zones. It should be noted that 1992 was a very dry year, so it would be a problem freshest in the villagers' minds.

In none of the four zones was normal annual flooding considered to be a major problem although it was mentioned as a constraint to aman season cropping. (This corresponds with the farmer surveys where, except in Zone A about 75 % of farmers expresed dissatisfaction with the normal flood regime). In Zone D there was also concern about early flooding. It is generally referred to as congested drainage. Villages and infrastructure have been set at a sufficient level to receive no harm from normal floods. Also, farmers have come to terms with normal flooding and had adjusted their cropping patterns accordingly. In Zones B and C during the second round of meetings, when it was explained that by improved drainage areas of B aman could be replaced by T aman, the farmers were in favour of such a change. In Zone A navigation was considered of some importance owing to difficult communications with Rahmatkhali regulator.

The major problems highlighted by the women's groups was scarcity of tubewell water for drinking and washing and collection of firewood for cooking during the monsoon almost everywhere. Women also stated that they wanted remunerative work. There were differences of opinion about the suitability of Khal excavation work for women.

9.3.3 The Third Round of Meetings

The method of selecting sample villages for public consultation is a very cost effective way of determining public needs and thoughts on development and issues over the whole project area. However, it does have drawbacks. The first of these is that often villagers' problems relate to the immediate vicinity of their village and their suggested solutions could often be detrimental to other potential project beneficiaries. For example in several villages people wanted structures to hold up water levels for irrigation and in others to keep out flood water. In virtually every case these would cause problems to others upstream or downstream. The second problem is that the proposed scheme, has different effects in different villages.

The third round of public participation meetings took place at thana level, with Government Officials at thana and union level, as well as representatives from NGOs. This provides the opportunity to present proposals at a larger scale and to ensure that thana schemes are not in conflict with the project proposals.

It was unfortunate that because of delays in obtaining results from a reliable tidal model for the area it was not possible to take definite finalised proposals either to the second round of village level meetings or to the third round of thana level meetings.

TABLE 9.2
Noakhali North Project
Summary of Round 1 of the Public Participation Meetings

Issues/ Problems	Zone A				Zone B				Zone C				Zone D			
	Char manna	Dighali	Binod Dharmapur	Sakchar	Harinarayanpur Pourashava	Latifpur	Ratanpur	Bishanpur	Hasanpur	Purba lalpur	Nayakhola	Rampur	Hatgaon	Dharbenpur	Pearatali	Chandpur
Peak flood depth	2 feet	2 feet	2 feet	2 feet	3 feet	7 feet	3 feet	5 feet	4 feet	3–4 feet	2–4 feet	5–7 feet	5–6 feet	6–8 feet	3–5 feet	4–5 feet
Early flood damage	No	No	No	No	Because of earlier flood do not get time grow Aus/Aman	Early moonsoon prevent cultivation of Aman or Aus	No Problem	Part of it is problem	No	No	No	No	Early flood damage boro April–May	Early flood last accured in 1990	B Aman crop damage due to early flood	Pre–monsoon crop flooding damage in April
Early floods	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Drainage Congestion	No water Congestion	No drainageand Flood problem	No Problem	Khal are hewily silted.	Water logging poor drainage	Rain (July) water can not drain	Water lodging poor drainage	Siltation of Khals have caused drainage problem	Drainage congestion of water during moonsoon 4 month (July–Oct.)	No problem	Drainage congestion non–completion of Katcha (CARE) road	Water congreation during monsoon for 3 months (July–Sep.)	Drainage congestion from pre–monsoon rainfall some time	Water logging July–September	Not serious problem	Not serious problem
Irrigation facilities LLP DTW STW	600 feet below sweet water and excutive iron contect	LLP = 6; It has access to WAPDA khal	No irrigation equipment used	No irrigation equipment used	No irrigation facilities	100% with surface water. No STW or DTW	10% Land get surface water no STW & DTW	One in operative DTW reported in Bishnupur	DTW1 (508' deep)	No DTW/STW	No dry season irrigation	No DTW/STW	21 LLPs are in operation	LLP – 40	LLP – 6 Other – 5	LLP – 4
Ground water salinity DTW STW	No information	No information	Salinity problem to char area	Salinity in not in existence	No information	No information	Salinity found in ground water of Sayedpur	No information	No information	No information	No information	No information	Salinity down to about 650 feet	No information	Saline water at a depth of 80 feet	No information
Gas Problem DTW STW	No gas problem	No	No	No	No information	No information	No information	No information	No information	No information	No information	No information	Gas problem for DTW/STW	No information	No information	No information
Seasonal falling of water tables	Dry season water for irrigation is needed	Dry season problem is there	Feb to March no water	Dry season water shortage	No information	No information	No information	No information	Shortage of water (Jan.–March)	Scarcity of water in the branches and main Khal (Nov.–March)	Scarcity of water (Dec.–Feb.)	Scarcity of water (Dec.–March)	Water shortage for boro season	Non–availability of water at Khal	Non availability of surface water (Feb.–March)	Non availability of water (June–Feb.)

TABLE 9.2 (Continued)

TABLE 9.2 (Contd.)

Issues/ Problems	Zone A			Zone B			Zone C				Zone D			
	Char mauza	Dighali	Binod Dharmapur	Salchar	Harinarayanpur Pourashava	Latifpur	Ratanpur	Bishnupur	Hasanpur	Parbalapur	Nayakhola	Rampur	Halgaon	Dharbeshpur	Pearatali	Chandpur
Road communication	Culvert to be built in all the local roads	Bridge needed	Communication problem road needed	Road communication insufficient	No problem	No problem	No problem	No problem	Not a major problem	Not a major problem	Road construction is not complete	Poor road access	Communication a problem	Has to be improved	Bridges Culverts on road needed	Good road communication exists
Navigation	Wanted navigation facilities	Wanted navigation facilities	Wanted navigation facilities	Obstruction of Navigation by the existing Rahmatkhali Regulator	Less important	Less important	Less important	Less important	Less important	Less important	Less important	Less important	No information	No information	No information	No information
Electricity	Electricity required	Electricity required for LLP irrigation	Electricity needed	Problem electricity	Electricity exists	No electricity	Electricity needed	Need electricity	No information	No information	No information	No information	No information	No information	Lack of electricity	No information
Drinking Water	Not sufficient and excessive ironcontent	Dry season drinking water problem	Not sufficient	Not sufficient	No problem	Not so much problem	Wanted more HTW	HTW not sufficient	No information	No information	Shortage of water during dry season	No information	Among 40 HTW two unsatisfactory	More tubewell necessary	More tubewell for dringking water	Drinking water no problem
Fishing	Need for fisheries Extension hatcheries	Need for fisheries extension hatcheries	Need for fisheries extension hatcheries	Need for fisheries extension hatcheries	No information	No information	No information	No information	Fish disease no advice from fishery department	Water shortage	Water shortage	Lack of advice fromDept. of Fisheries	Water shortage in pond and Khals	No extension work Ulcerative disease	Shortage of water in Dalaia Khals and pond	No extension servise multiownership of pond is a problem
Education	More primary High school College Needed	High school Primary and Madrasa exist	One High and Primary exist	High school Madrasa needed Prymary school needs extension.	Good facilities are there	Primary school exists	No information	No information	High school, Primary school and Madrasa exist	No educational institution in the village itself	No primary/ Madrasha. One high school	One high school,2 Primary school and Madrasha exist	One madrasha and two primary school exist no high school	High school Primary and madrasha exists	Only one madrasha exist	No facilities 2 madrasha there
Health	Lakhnipur health centre	Lakhnipur HealthCentre	Health centre at Lakhnipur	Health centre at Lakhnipur	HealthComplex exist	No information	No information	No information	No information	No information	No information	No information	No health complex nearby	Difficult to available medical facilities	Difficult medical facilities	Medical facilities are in Shahrasti
Lack of wage paper opportunity	Women remunerative work wanted	Decreasing work Opportunity. Want remunerative work	Work is needed for women	Poor women want remunerative work	Allpoor women want remunerative work	Poor women want remunerative work	Poor women want remunerative work	Need remuneration work	Poor women want remunerative work	Women interested to remunerative work	Want work	Want remuneration work	Want work	Want remuneration work	Want job opportunities	Want remunerative work (educated non-educated)

Therefore the approach was to explain the options which were to be tested using the model and our expectations based on preliminary results from the non-tidal model.

The third round of public participation meetings started on 6th March and were completed on 16th 1993. The pattern of all nine meetings was the same with project staff giving a brief outline of the project and how it might affect the local Thana. Also the aims of the public participation programme were explained.

The results of the meetings are described in Annex G chapter G.3. Salient features by zone are discussed below:

a) **Zone A**

The was general satisfaction with the proposals for the regulator and channel improvements. One fishery officer wanted the regulator operated entirely in the interests of fishermen even during peak flood season. It was explained that the counter weighted gates proposed could improve rathers but that protection against peak tides is required.

Side slope of khal were reported to be collapsing in places. Investigation revealed this to be a self inflicted problem (raising embankments without widening the base).

b) **Zone B**

Many officials and villagers still remember drainage being effected through Noakhali Khal and expected new proposal, to re-excavate the khal. It was explained that this could not also bring any irrigation benefits and also would be difficult to sustain with continued accretion at the mouth. It was explained that most of the area would benefit from substantially reduced flood levels giving improved opportunities for aman cropping. Since the degree of benefit was not confirmed at the time of the meetings it was not possible to reassure officers of the extent of the benefits which some thana officials believed would be minor.

Any irrigation benefits would be widely welcomed but of course not all of Zone B would benefit.

It was explained that for areas beyond the limits of benefit that existing practices of cross dams construction could continue. The benefit of excluding saline water by the regulator at Noakhali will be appreciated by farmers in that part of the Zone. Local area drainage schemes can be fitted into proposed development but may prove unnecessary in many cases.

Zone C

This Zone has widely differing conditions in various parts but the effects of the proposed intervention were generally welcomed. Those areas in the east which will get no irrigation benefit were interested to hear of possible improved technology of SFMTWs and also of possible later development of Dakatia/Little Feni transfer which might benefit their area later.

Zone D

There is concern in some parts of Zone D over early flooding. However there is some conflict over how this should be dealt with. Full embankments were generally not welcomed but submersible embankments were considered more acceptable. However there would be major difficulties in maintaining these and there are doubts concerning their effects on fisheries. Also after the meetings the results of the model runs demonstrated that much of the flooding is due to collection of rainfall rather than overspill from the Dakatia and that in any case the proposed interventions succeed in lowering water levels in Zone D sufficiently to reduce the impact of early floods in May particularly in the southern part of the Zone.

Monsoon period benefits in Zone D are quite limited but since there are no direct interventions north of the Ramganj/Sonaimuri road and the Zone is relatively remote from the drainage outlet this is to be expected.

The proposals for future irrigation with a Dakatia regulator are widely supported provided they do not affect fish access to the area. These proposals are not now included in the feasibility study but are to be included in the regional plan.

9.4 Conclusions

The public participation programme is considered to have been of great value. It has provided the study team with the opportunity to learn at first hand from the people of the area how they view their problems and how they perceive possible solutions to those problems.

The process has demonstrated two principal aspects as follows:-

i) There is much to be learnt from formal contacts at the village level.

ii) There are distinct limits to people's understandings of how their locally perceived solutions may affect others. The inter village and inter thana options, solutions and problems are often not well understood.

For large scale projects such as this there are quite limited benefits from such initiatives. However as stated above, within those limits they can be most useful.

The formal participation elements described above are not sufficient on their own. It is also necessary to make additional investigations away from meetings. These investigations use small group discussions and individual interviews. These additional interviews are described in the Sociological Annex G. Chapter G.4. In this case they were combined with the social impact assessment. This seems a sensible approach because at this stage the interventions were known and quantified. Also the principal impact issues were known and therefore it is possible to focus on people's views on these aspects so as to gain an insight as to how approach the resolution of these issues during implementation.

Indeed the primary goal of these later discussions was to identify what the problems with implementation are likely to be and to identify methods to overcome them. This aspect is discussed in Chapter 12 and also in Chapter 13.

CHAPTER 10

HYDRAULIC STUDIES

10.1 Introduction

10.1.1 Objectives

The hydrological and hydraulic studies have a central role in the assessment of the impact of the river and drainage engineering proposals in the Noakhali North Project. These studies involve the use of the computer based hydrological model NAM and the hydraulic model MIKE11. The model studies are not an end in themselves but should be viewed as a tool to provide quantitative predictions of the changes in flow patterns, rates and levels that may arise from the implementation of the engineering proposals.

The objectives of the hydrodynamic modelling in the project are threefold,

i) to assess the nature and extent of the existing flood problem, and to provide the basis for quantifying present flood-depth-area-frequency relationships, which can be used in project planning and evaluation;

ii) to provide the basis for assessing the impacts of flood mitigation measures, both inside and external to the project area, and for comparing pre- and post-development conditions;

iii) to provide design characteristics in the form of peak flood levels, discharges and velocities, for flood mitigation measures.

10.1.2 FAP 25 Guidelines

Due to the complexity of the Bangladeshi Delta and the interaction of the various flood causing factors, the definition of design events of a given return period in terms of standardised boundary conditions is impossible. In an attempt to overcome these problems FAP-25 recommended a rationale which involves long term simulations of hydraulic models for the period 1965-89. In detail the rationale required,

- the preparation of boundary conditions required to run models for the period 1965-89.
- running the models for the full 25 year period, at least once for the present (baseline) conditions and once for the ultimately adopted scheme(s).

- combinations of various options to reach the final plan may be studied on the basis of simulations for a reduced number of selected seasons, the selections being based on the analysis of the 25 year baseline run.

- sensitivity analysis of ultimately adopted scheme considering changed boundary conditions in the major rivers due to proposed schemes outside the region.

- statistical analysis of the results, aimed at assigning return periods to historic peak, seasonal or sub-seasonal values of selected design variables.

10.1.3 Post-Processing Analysis

The 25 year MIKE11 simulations generate 25 years of daily water levels and discharges at the model nodes. This is a vast amount of information which in its raw form is of limited use, hence there is a need for post-processing. The output required from this post-processing will depend on the use to which it is to be put. The MIKE11 results are to be used for three forms of analysis; engineering, agriculture and fisheries/environment. Figure 10.1 is a flow diagram illustrating the procedure used.

The engineering analysis requires information at key points within the hydraulic system whereas for the agricultural and fisheries analysis information is required for areas. For this purpose the Noakhali North study area was divided into 32 analysis areas, see Figure 10.2. These analysis areas were based on the four zones of flooding and agricultural type; they also took into account the proposed interventions.

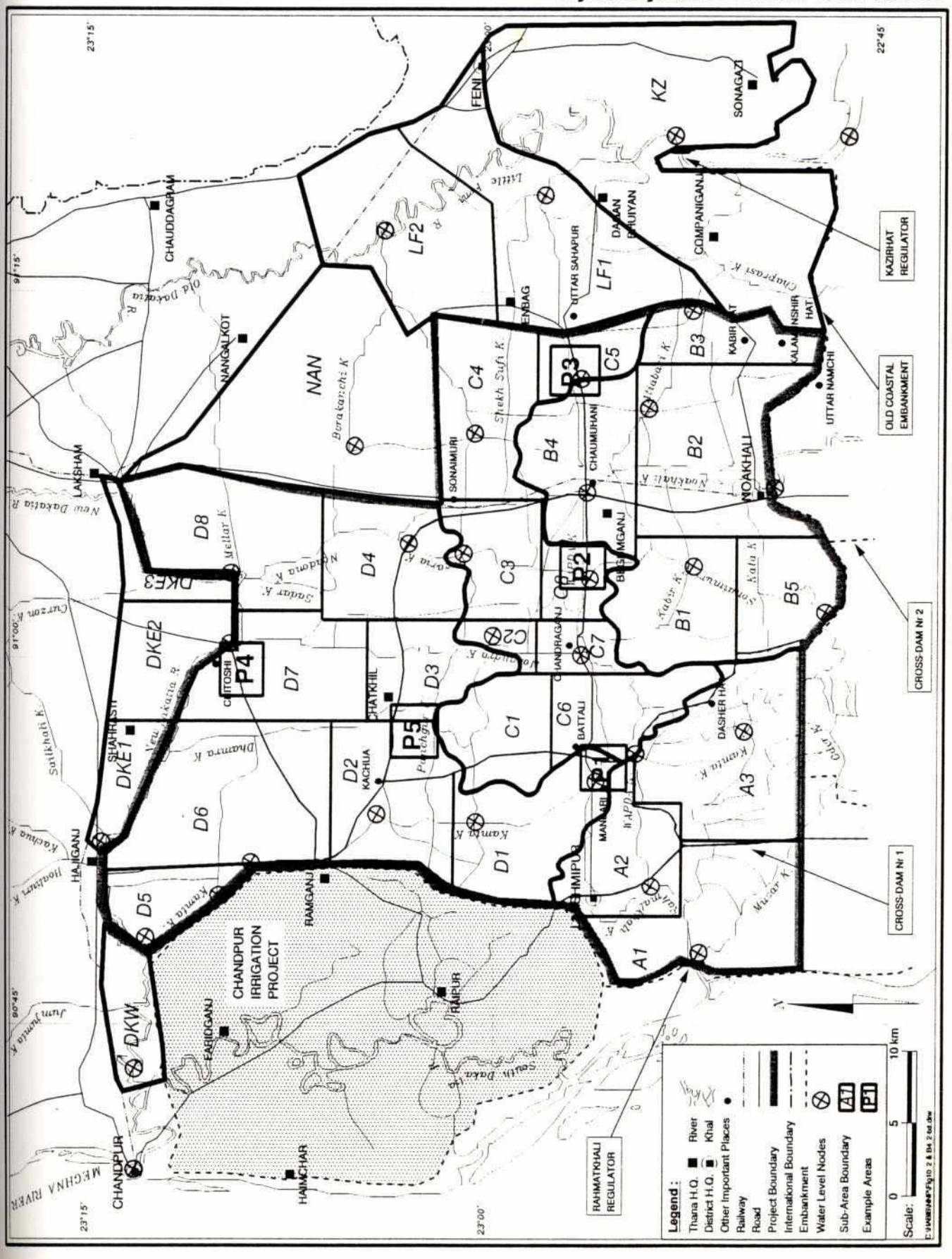
The post-processing involved the following analyses to be undertaken for the different disciplines:

Engineering : Hydrological analysis to give minimum, mean and maximum values for each decad. In addition, return period values of stage and water level for 2, 5, 10, 20, 50 and 100 year return periods for different durations (1 day, 3 day, etc.) and on a decad basis.

Agriculture : Decad analysis of water levels in terms of four-day exceedances. Depth phase analysis (based on the new draft rules issued by FPCO) which define depth categories for flooding analysis. Flood phase figures were derived from the depth phase analysis, equivalent to the MPO flood phase figures. Cropping analysis was based on agronomic principles of water depth limitations for each stage of growth in a crop's growth cycle. The potential cultivable land for each crop, at any required return period, was derived from the depth phase analysis and these tolerances.

Figure 10.2

Hydrodynamic Model Sub-Areas



Fisheries/

Environment : Decad analysis of water levels based on the minimum water level over the decad and return period analysis of flooded areas throughout a hydrological year.

Full details of post-processing analyses are presented in Annex B.

10.2 Noakhali Model Development

10.2.1 SWMC Model

The Noakhali model was based on the southern half of SWMC's SERM. This model was initially calibrated by the SWMC for the period from the monsoon 1986 to December 1987; calibration was against both wet and dry season conditions. Subsequently the calibration period was extended to the end of the 1988 monsoon season. The detailed results of the model calibration are presented in the SWMC South East Regional Model Verification Report (Ref. 5.1). The model was verified for the period January 1990 to March 1991. The model results, in general, showed a good comparison with the observations at most of the calibration points (Ref 5.1).

Much of this earlier work by the SWMC was based on non-tidal conditions. Recently, however, the SWMC have been working on the tidal calibration of the model.

10.2.2 Further Development

a) Meghna Tidal Boundaries

It is understood that the SWMC used Chital Khali with a positive datum shift of 0.15m as a basis for their tidal boundary condition at Rahmatkhali. Based on the General Model (GM) mean daily results along the Meghna, and the water surface slopes, this underestimates peak levels along the Meghna by about 45cm. This is likely to have a significant influence on the potential discharge through Rahmatkhali regulator and hence the internal calibration of the modelled area. An improved tidal boundary was therefore generated for the FAP 5 model, see Section 10.2.3.

Chandpur was included in the SWMC model as a mean daily level, based on GM results, as were Molakandi and Matlab. In the Noakhali (FAP 5) model all three boundaries were represented as full tidal boundaries as was that at the outfall of the Little Feni, see Section 10.2.3.

In the 25 year simulations of the GM, problems in calibrating the Lower Meghna reach were encountered by the FAP 25 team. A vertical shift of 25cm at the downstream boundary of the Meghna, Daulat Khan, was introduced and led to a much improved calibration in this reach.

The GM model simulation of the Lower Meghna assumed the length of the Lower Meghna to be 85km from its confluence with the Upper Meghna to its downstream boundary at Daulat Khan. River chainage measurements made by the study team indicated that this reach of the Lower Meghna should, in fact, be 90km. This is likely to be the reason that problems were encountered in calibrating the General Model and why a shift of 25cm in the downstream boundary was required. Assuming the river slope is in the order of 2-3cm/km the additional 5km of river reach would account for 10-15cm of the shift made by the SWMC. However, the SOB have also acknowledged that a datum error existed in the bench mark used at Daulat Khan of about 12cm. Together these lead to an overall shift of some 22-27cm correction which is of the same order of magnitude as that required to improve the General Model calibration, see Figure 10.3.

Mean daily data for the generation of tidal boundaries along the Meghna was taken from the GM results (Run 6/2) but with the locations of the boundaries adjusted so that they concurred with the correct chainage of their relative positions.

Based on the mean daily water levels from the General Model, tidal boundaries were generated at four boundary location; Molakandi, Matlab, Chandpur and Rahmatkhali. An additional tidal boundary at the outfall of the Little Feni was based on analysis of tidal records at Sandwip.

b) Channel Roughness

Channel roughness values were taken from the SWMC calibration runs. In general these vary between Mannings' n values of 0.025-0.033. Some of the Manning's n values associated with the lower regions of the WAPDA and Rahmatkhali khals may be slightly high. Investigation of these reaches suggests that the channel lengths used in the SWMC model under-estimate the actual channel lengths and that the roughness coefficient may have needed to be raised to compensate for this fact. However, no changes to the channel reach lengths were made for the Noakhali model studies but these should be verified and adjusted during any further model development (eg at design stage).

c) Rahmatkhali Regulator

Problems in the representation of control structures by making use of culvert routines in the Mike 11 system were experienced at both Rahmatkhali and Kazirhat.

Initially, Rahmatkhali was represented as a culvert opening with the valve operation set to give positive flow only, ie tide flapped. This gave a very peaky discharge response through the structure with high peak discharges not necessarily coinciding with the largest driving heads across the structure.

Desk calculations carried out as a check indicated that the discharges generated using the undershot gate (control structure) representation in Mike 11 gave much closer agreement. The undershot gate representation also allowed the failure of one or more of the tide flaps, which occurs annually in the prototype, to be included in the representation of the present conditions.

It was interesting to note that the volumes of water discharged through the structure in trial runs for both the culvert and undershot gate representation were very similar over the monsoon period. This would therefore mask the effect of using a culvert representation of the structure in the model as drainage rates and water levels further upstream would remain very similar.

d) Kazirhat Regulator

As with Rahmatkhali, Kazirhat regulator has been simulated by a control structure (undershot gate) as the peak discharges through the structure were over-estimated, double those expected, when using the culvert representation. The culvert representation was also found to be unsatisfactory because it gave negative discharges despite having a flap gate (ie valving set to positive flow only) and caused unrealistic water level spikes to be generated on the upstream face.

The headloss through the barrel of the culvert at Kazirhat is relatively small compared with the entry and exit losses, accounting for only 20% of the total losses, and could therefore be neglected in the simulations without significantly influencing the model results.

e) Kazirhat Blockage/Siltation

At Kazirhat regulator the pre-monsoon flows are restricted due to siltation on its downstream side. The siltation is eroded gradually during May and June before full discharge capacity is reached in July. This pre-monsoon blockage due to siltation was represented as a moveable weir in the Noakhali model. The crest level was reduced during the pre-monsoon period, to represent erosion of the blockage, before being finally lowered to the channel bed level.

f) Channel Downstream of Piarapur

During initial runs of the Noakhali model it was found that levels at Piarapur, and further upstream, were overestimated by about 0.5m despite a reasonable match being attained at the upstream face of Rahmatkhali regulator.

The SWMC channel cross-sections between Rahmatkhali and Piarapur were compared with those from the recent FAP 5 field survey. It was found that the SWMC sections and conveyances were much smaller than those indicated by the FAP 5 survey. Introducing the new sections in to the model greatly enhanced the model results and lead to a much closer correlation between modelled and observed levels in the reach from Piarapur to Begumganj.

g) Flows from the Gumti Area

Discharge boundaries in the northern half of the Noakhali model, immediately south of the Daudkandi-Comilla highway, were based on flows generated from the Gumti II model.

10.2.3 Generation of Tidal Boundary Conditions

Short tidal records are available at Chital Khali on the Meghna and at Sandwip south of the Little Feni outfall for 1990 and 1991. At Sandwip records do not cover the night periods. Sandwip tide is semidiurnal with an average tidal range of 5.5 m. The maximum spring tide level is +5.8-6.0 mPWD and minimum level -0.3 mPWD. At Chital Khali and Daulat Khan the average tidal range is 2.5 m approximately and the tidal range is not affected by flows in the Meghna. At the outfall of the Little Feni (Sandwip) there is very little variation in the mean sea level which remains at about 2.8 mPWD.

At Chandpur, the major drainage outfall route for the Dakatia, tide range and travel time are dependent on the flow conditions in the Meghna. Travel time between Daulat Khan and Chandpur is about 2 hours in the dry season and between two and a half to three hours during peak flood monsoon.

Prediction of tidal levels on the Meghna river needs to take into account the interaction between flow conditions in the Meghna and tidal oscillations in the Bay of bengal. Tidal components derived for Chital Khali are attenuated and delayed as they travel upstream the Meghna river. Such attenuation and lag are related to gradients in the Meghna and vary seasonally. In the dry period gradients are very small and difference in mean daily water levels between Chandpur and Chital Khali are of the order of 0.2 m. During this period the tide penetrates into Meghna system up to Nabinagar with spring tides of the order of 0.30 metres. In the monsoon season, tidal amplitudes are gradually reduced and delayed with the rising of water levels (and gradients) in the Meghna. Recorded levels show that tidal amplitude, for the same period of the year, reduce gradually moving upstream from the Bay of Bengal. At Chandpur wet season spring tide amplitude is about 60% of dry season values. Recorded mean daily levels and daily tidal oscillations measured about mean water levels for Chandpur (April to November 1991) are shown in Annex B Figure B.3.11.

Simulations with the Noakhali Sub-regional model require boundary conditions on the Meghna at Chandpur and Rahmatkhali regulator, and in the Bay of Bengal downstream of Kazirhat regulator. Flows through the regulators as well as the Dakatia river are affected by mean water levels and tidal ranges at their downstream end. It was therefore important to establish accurate mean water levels and tidal shape (amplitude and timing) at the three major outfall links of the Noakhali drainage system. The Noakhali khal also drains into the Bay of Bengal however, due to siltation which occurred in the late 60s, after the construction of the cross dams, its capacity is greatly reduced and tidal influence is negligible. Simulations also showed that flows through the khal are of the order of 20 m^3/sec in the monsoon season and its effect on water levels in the Begumganj depression is minimal.

Figure 10.3

Justification of Daulatkhan Datum Correction

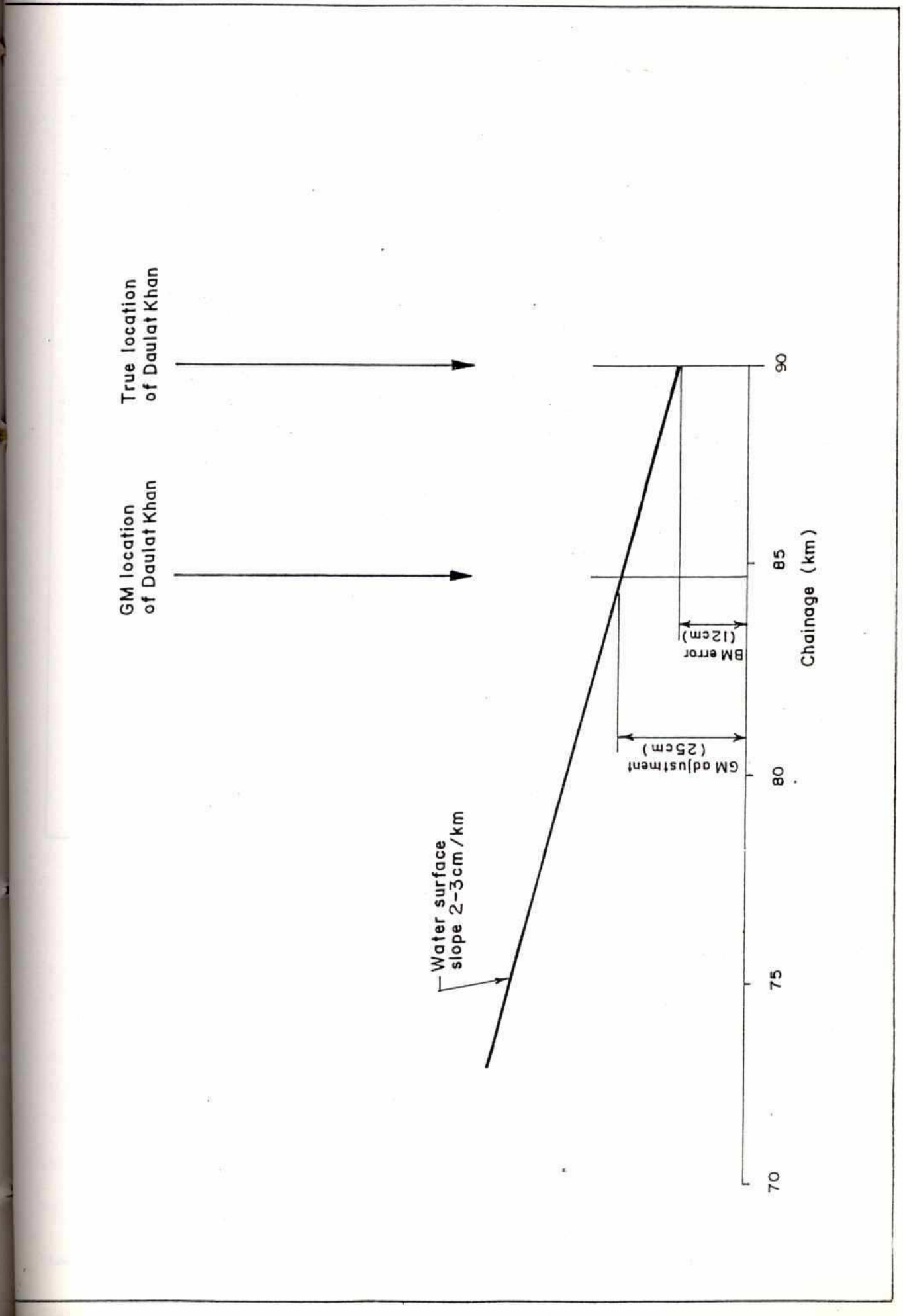
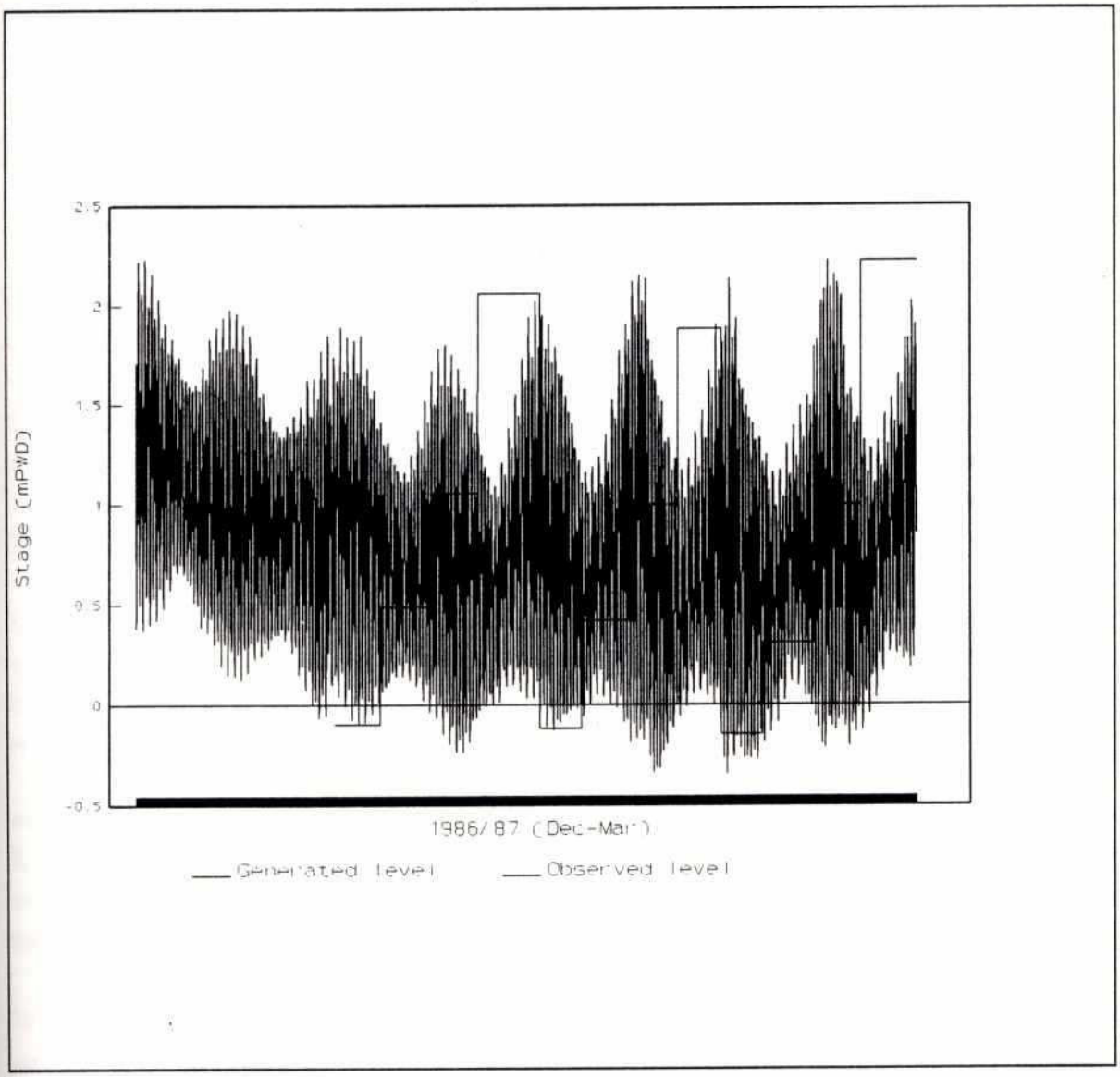


Figure 10.5

Dry Season Tidal Boundary at Rahmatkhali



C:\habib\nrp\Fig10_5

To correctly simulate flows through the Rahmatkhali regulator it is necessary to provide water levels at half hourly intervals at the regulator on the Meghna side. The time step being dictated by stability conditions in the Noakhali model. At present the General Model (GM) provides only mean daily water levels for the 25 year simulation period along the Meghna river. Recorded water levels at these are not available and, in addition, changes in the Meghna system, resulting from any of the other FAP projects, would be difficult to incorporate. The Noakhali model in fact needs to take into account these effects which are supposedly built into the GM model.

To generate half hourly water levels there were two possible alternative methods:

i) run GM in tidal mode for 25 year period;
ii) add daily tidal fluctuation on simulated mean daily water levels;

With method i) the distortion and delay affecting tide travelling along the Meghna river is taken into account by the hydrodynamic model. The drawback of this method is that it requires calibration of the GM model in "tidal mode" and run time will be very high because of the small time step required. For this task more detailed information of the geometry and hydraulic roughness conditions of the Meghna would also be required.

Method ii) relies on a simpler method to estimate distortion and delay of tide along the Meghna. It uses the output from the GM model to calculate attenuation and lag factors A and K with which new tidal components are calculated. Tidal fluctuations are then added to the mean daily water level. The model therefore uses calibrated and verified simulated water levels.

After careful examination of the data available and the time constraints for the study, it was decided that method ii) would be the most appropriate. The method, which relies on the GM to provide mean daily water levels and the hydraulic factors and a reasonably long tidal record at Chital Khali, is considered sufficiently accurate for the scope of the study.

To this end a computer programme has been prepared to read Mike11 result files and cross sectional hydraulic parameters from the GM model and, calculate attenuation and lag terms according to the methodology previously presented. The tidal levels produced are then superimposed to the "non-tidal" results from the GM model. The output is prepared in a format compatible with Mike11 boundary files. The method is able to reproduce tidal range and seasonal variations. Calibration of simulated against recorded levels at Piarapur showed good agreement between recorded and simulated levels for the wet season (See Annex B Chapter B.3) Synthetic tidal oscillations against GM model mean daily water levels for year 1965 are presented in Figure 10.4.

The dry season comparison of simulated levels at Rahmatkhali with the maximum and minimum recorded levels for each spring and neap tide (Dec 86 to March 1987) is shown in figure 10.5. This clearly demonstrates that the simulated tidal range and levels are very similar to actual levels.

b) **Discharges**

The discharge through Rahmatkhali regulator is shown in Figure 10.6 for the 1991 monsoon season. The variation of discharge over the spring neap cycle is clearly seen. Peak discharges are about 275m^3/s. During height of the monsoon the tide flaps remain open throughout the tidal cycle whereas in the pre-monsoon they close fully.

The present regulator suffers damage to one or more tide flaps every year. The single links or hinges on the flap gates are prone to fracture and this prevents the flaps operating as designed. The broken flaps remain open and allow flow to enter from the Meghna.

In the model simulation 3 of the 14 tide flaps were assumed to cease working at the end of June. With the broken tide gates, the model indicates the magnitude of the negative flows enter the project area. These are relatively small, less than 40m^3/s, in comparison with the overall outflow and would not have a significant effect on the internal levels.

The results of the model verification suggested that no further recalibration of the model was necessary for the purposes of undertaking the feasibility study.

10.2.5 Without Project Simulation

The verified model described in the previous section was used in the 25 year simulation run for a future 'without' project condition. This simulation was of present conditions in the modelled area; it incorporates all existing developments.

It must be stressed that the objective of the Without Project simulation was not to simulate observed water level and discharge variations over the 25 year period from 1965 to 1989. It was to produce data on water level and discharge variations over a period of 25 hydrological years.

This simulation provides baseline data for investigating and comparing the impacts of developments proposed as part of the Noakhali North project.

Table 10.1 presents the model predicted flood phases, for Without Project conditions, for each of the post-processing sub-areas in the Noakhali project area. These flood phases are based on the 4-day maximum, 1:5 year decad level which gives the deepest flooding except in the areas where the tidal fluctuations are large. In these areas, the flood phases are based on a level 10cm below the maximum recorded in the decad. The sub-areas listed in Table 10.1 correspond to those given in Figure 10.2.

10.2.4 Model Verification

The modifications outlined in Section 10.2.2 were incorporated in to the Noakhali model and run for the 1991 monsoon season. This was effectively a verification run, to ensure that the changes incorporated in to the model gave a good match between observed and modelled water levels.

Comparisons between observations and model results for 1991 are shown in Figures B.5.4 to B.5.13 in Annex B.

a) Water Levels

Rahmatkhali and Begumganj depression : Modelled and observed levels upstream and downstream of the regulator site show a reasonable agreement. Unfortunately, there is only a short observed record at both sites and a full comparison throughout the monsoon season cannot be made. However, a good agreement is found at Piarapur and this suggests that the model representation of the structure and its operation approximate to that in the prototype. Further upstream, at Chandraganj and Begumganj, a good match is found between observed and modelled results. This is also true at Noakhali where the water levels are seen to be very similar to those at Begumganj and display no obvious tidal influence.

It is interesting to note that in many of the water level observations, under the influence of Rahmatkhali regulator, display an early peak at the beginning of the monsoon period; for example, Piarapur, Chandraganj and Begumganj. This response is not observed in the modelled results and it is known that this was during the period when the regulator was being mended following damage from a cyclone (April/May 1991). During this period some of the regulator gates would have remained inoperable and prevented drainage from the area thereby resulting in a ponding of water upstream. Following the repair works, drainage was once again possible and levels brought to their normal monsoon levels. The model has assumed the regulator functioned throughout the entire monsoon season and is not therefore expected to predict such events.

Dakatia : At Chandpur the tidal variations correlate well with the model boundary condition and give confidence in the tidal boundaries generated for the study. Further upstream, at Chitoshi, the tidal influence of the Meghna is only seen at very low stages and again a good match between modelled and observed levels is found.

Little Feni : The model results immediately downstream of Kazirhat show a good match with the observed levels. The troughs tend to be over-estimated but the peaks agree much more closely. The influence of the siltation on the downstream side during the early monsoon period is clearly seen in the observations. The model has also been able to reproduce this effect. Upstream of the regulator, peak levels are predicted reasonably but the timing of the peaks is very different between the model and observations. The troughs predicted by the model are also too high. This may be accounted for by morphological changes in the bed profiles during the monsoon season whereas the model assumes a fixed channel geometry, which is generally the silted dry season bed profile.

Model predicted flood phases for the areas adjacent to the Noakhali project area are given in Table 10.2.

TABLE 10.2

Without Project Simulation Flood Phases
Adjacent to Noakhali Project Area

Area	Flood Phase (%)			
	F0	F1	F2	F3+F4
KZ	95	4	1	0
LF1	22	69	9	0
LF2	54	21	23	2
NAN	35	25	39	1
DKW	1	53	43	3
DKE1	0	7	85	8
DKE2	1	36	62	1
DKE3	0	2	94	4

In the area immediately north of the Dakatia flood depths fall primarily in to the F1 and F2 categories with little or no F0 land. In the Little Feni, the area immediately upstream of Kazirhat regulator does not suffer heavily from flooding but further upstream drainage congestion results in inundation with up to 30% F2 land. Bed levels in the Little Feni indicate that there may be a constriction to flow in the middle reaches of the Little Feni and this is supported by the flood phase results.

Flood phase figures were also produced for each minute square within the project area. These give an indication of the areal distribution of the flood phases and are shown in Figure 10.7.

10.3 Design Option Simulations

10.3.1 Introduction

The Noakhali model area is a complex network of khals with three major drainage routes; Rahmatkhali, Dakatia and Little Feni. Each of these three routes are interlinked and the division of the area in to isolated catchments is not possible. The model was used to assess the influence each of these major drainage routes has on the Noakhali project area and to assess the effectiveness of different development scenarios.

TABLE 10.1

Without Project Simulation Flood Phases for Noakhali Project Area

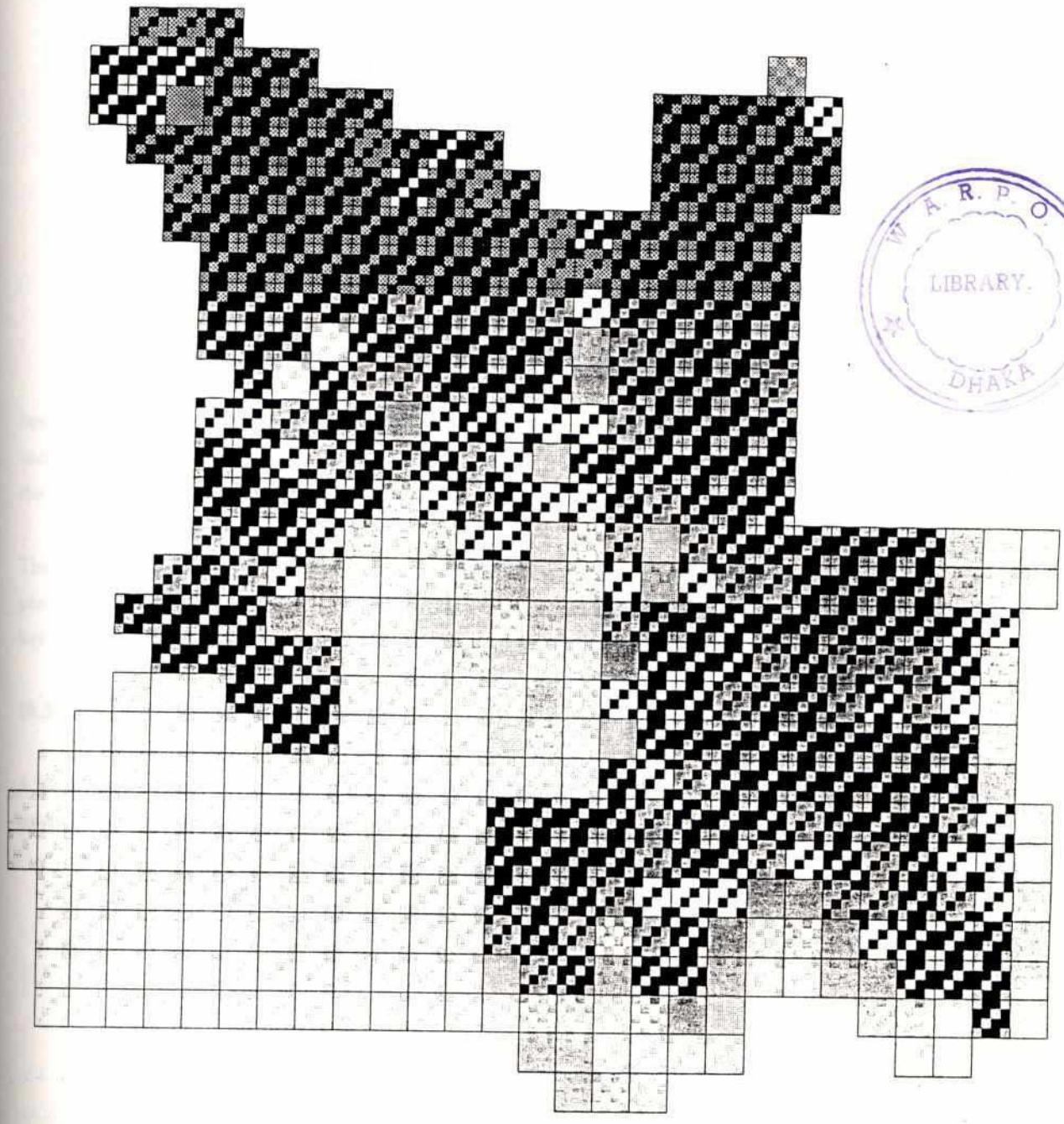
Area	Flood Phase (%)			
	F0	F1	F2	F3+F4
A1	92	8	0	0
A2	78	21	1	0
A3	100	0	0	0
B1	0	15	80	5
B2	9	46	44	1
B3	1	43	56	0
B4	0	7	92	1
B5	9	70	21	0
C1	24	65	11	0
C2	2	73	25	0
C3	2	22	76	0
C4	7	21	71	1
C5	6	26	67	1
C6	61	37	2	0
C7	7	74	19	0
C8	1	29	70	0
D1	0	12	84	4
D2	5	12	81	2
D3	1	31	68	0
D4	0	4	95	1
D5	0	17	77	6
D6	0	3	83	14
D7	0	8	90	2
D8	0	3	92	5

In Zone A, Piarapur to Rahmatkhali, there is little inundation at present. The channel conveyance in this reach is relatively large and the area is drained rapidly due to its close proximity to the regulator site. The severity of the flooding increases further up the WAPDA/Rahmatkhali system with the deepest flooding occurring in and around the Begumganj depression. This area is effectively a lake during the height of the monsoon season.

Immediately south of the Dakatia, the area suffers from relatively deep inundation, high percentage of F2 land, as do the central and western parts of the region.

Figure 10.7

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



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% of NCA with Flood Phase F2 or F3/F4
(1 in 5 year Peak Flood Depth > 0.9m)

0–10 10–20 20–30 30–40 40–50 50–60 60–70 70–80 80–90 90–100

% of NCA with Flood Phase F0 or F1
(1 in 5 year Peak Flood Depth < 0.9m)

90–100 80–90 70–80 60–70 50–60 40–50 30–40 20–30 10–20 0–10

The model was used to assess not only changes in the hydraulic regime within the project boundaries but also in the adjacent areas, to ensure there were no significant disbenefits in these areas as a result of benefits within the project area.

Four main elements were considered in the design option simulations:

- capacity and operation of Rahmatkhali regulator and its constriction to effective drainage of the area
- khal excavation and regrading and the constriction to drainage due to insufficient channel conveyance
- a new regulator at the mouth of the Dakatia to prevent tidal inflows from the Meghna
- a new regulator at the outfall of the Little Feni, south of the existing Kazirhat regulator

Investigations of the different developments were undertaken for the 1983 monsoon period, May to November inclusive. 1983 was selected as the design year as this was approximately a 1:5 year event throughout most of the model area.

The options were assessed primarily through changes in water levels between the development scenarios and present conditions and between the development scenarios themselves. Changes in discharge and velocity in key channels and through the regulating structures were also considered.

10.3.2 Rahmatkhali Options

A summary of the trial runs undertaken is shown in Table 10.3 and the conclusions drawn during the analyses are summarised below.

TABLE 10.3

Summary of Option Runs for Rahmatkhali

Run No.	Regulator No.	Sill (MPWD)	Channel Sections	Other Changes	
PP	14	-1.5	Present		
R0	20	-1.5	Present		
R1	14	0.0	Present		
R2	14	-1.5	Excavated		
R3	14	-0.5	Excavated		
R4	20	-0.5	Excavated		
R5	28	-0.5	Excavated		
R6	28	-0.5	Excavated		Dakatia regulator
R7	28	-0.5	Excavated	10m	Widening in WAPDA khal
R8	28	-0.5	Excavated	20m	Widening in WAPDA khal
R9	24	-0.5	Excavated	10m	Widening in WAPDA khal, Musapur regulator
R9P	24	-0.5	Excavated	10m	Widening in WAPDA khal, Musapur regulator, pump station

Run PP : Baseline simulation for present conditions.

Run R0 : Increasing the number of gates at Rahmatkhali to 20 gave no reduction in the peak levels in the Begumganj depression. This indicated that the major constriction to drainage in the area at present is due to insufficient conveyance capacity in the Rahmatkhali and WAPDA khals rather than the capacity of the regulator.

Run R1 : The initial option run investigated the impact of raising the sill level at Rahmatkhali regulator by 1.5m to 0.0mPWD, with all other conditions remaining the same, that is, the present channel geometry. Peak water levels in the system were unaffected, same as at present, but minimum levels were raised upstream of the regulator.

Run R2 : Excavation of the channels increases their conveyance capacity thereby increasing drainage from the Begumganj depression. Peak levels at Begumganj reduced by some 0.5m. However, this led to drainage congestion at the existing regulator site where peak levels were increased.

Run R3 : Raising the sill level by 1.0m, compared with R2, to -0.5mPWD did not lead to any change in peak levels and suggested that the peak levels were relatively insensitive to variations in the sill level. It was clear that the regulator capacity itself, however, was now the main constriction to the drainage.

Run R4 : Increasing the number of gates at the regulator, to 20 in total, improved outflows from the area and removes the drainage congestion at the regulator site by reducing peak levels immediately upstream by 0.1 to 0.2m. The water surface profile was flattened upstream of the regulator but there was no significant improvement in the Begumganj depression itself compared to R2 and R3.

Run R5 : Increasing the number of gates further, to 28 in total, gave a slight lowering of peak levels, by 0.05m, in the reach between Chandraganj and Piarapur. The results indicated that further increasing the number of gates at the structure would not have any significant impacts.

Run R6 : As R5 but with a regulator on the Dakatia to investigate the impact of reducing inflows from the Meghna at Chandpur. The Dakatia regulator was found to have no impact on peak levels in the Rahmatkhali/WAPDA khal drainage system.

Run R7 : Widening of the excavated khals, by 10m, in the middle reaches of the WAPDA khal reduced peak levels, compared with R5, by 0.15m at Begumganj, but levels remained the same at Piarapur.

Run R8 : Widening the channels by a further 10m had only a minor impact with peak levels falling by a mere 0.05m at Begumganj compared with R7. This further widening could not therefore be justified.

Run R9 : Runs R4 and R5 suggested that there was an optimum number of gates at the regulator site beyond which no further significant improvement in peak levels could be achieved. With the number of gates reduced to 24, in total, peak levels remained similar to those in R7 (28 gates).

Musapur regulator, located on the Little Feni downstream of the existing Kazirhat regulator, was included in this run. The results indicated peak levels in the Begumganj depression were not influenced by this development when this run was redone without the regulator.

Run R9P : In comparison with R9, the run showed that pumped drainage at Rahmatkhali caused minor reduction in peak levels (0.05m) at the regulator but that no impacts were produced upstream of Piarapur. As this area does not suffer from any severe flooding the pumped drainage is of little benefit.

Improving the drainage conditions in the Begumganj depression not only gave reduced peak levels in this area but also as far north as the Dakatia. For example, Runs R7 and R9 reduced peak levels in the Dakatia by 0.1-0.2m in the reach between Hajiganj and Chitoshi. Upstream of Chitoshi the impact diminishes rapidly.

10.3.3 Chandpur Options

The option of a regulator on the Dakatia was dropped after the results of R6 were analysed. The regulator provides only a small reduction in levels along the lower reaches of the Dakatia and these diminished rapidly further upstream. The regulator has no significant benefits in the Begumganj depression or at Rahmatkhali regulator. The only time the regulator would provide a benefit would be during extreme events when the levels in the Meghna were exceptionally high.

10.3.4 Little Feni Options

Kazirhat regulator suffers from sediment deposition on its downstream side which severely inhibits drainage flows during the early monsoon period. This causes levels upstream of Kazirhat to be high during this period. The introduction of a new regulator, approximately 15km downstream of Kazirhat, will prevent this deposition and help to reduce the high early monsoon levels. Furthermore it provides protection from high tidal levels to the area between the two regulators.

A summary of the runs undertaken for a new regulator on the Little Feni, at Musapur, are given in Table 10.4 and the conclusions drawn during the analyses summarised below.

TABLE 10.4

Summary of Option Runs for Little Feni

Run No.	Regulator No.	Sill (mPWD)	Other
PP	-	-	
K1	20	0.0	Gates 3.0m x 3.5m
K2	20	0.8	Gates 3.0m x 3.5m
K3	22	1.0	Gates 3.0m x 3.0m

The incorporation of a regulator downstream of Kazirhat significantly improved the flow conditions through Kazirhat itself. Peak water levels immediately upstream were reduced substantially and the regulator was able to discharge fully during the early monsoon period as no siltation occurs on the downstream side. However, further upstream, outside the influence of Kazirhat regulator, levels still remained high. This suggested that there is a constriction to the flow in this area. This was not investigated further as the model requires updating and improving along the Little Feni reach before it can be used with confidence in further studies.

10.3.5 Conclusions

The conclusions drawn from the option runs can be summarised as follows:

- Rahmatkhali regulator would not restrict drainage from the area if the existing regulator was supplemented by an additional regulator of 10 gates. A common sill level of -0.5mPWD gives improved flow conditions in the channels upstream (Reduced velocities at peak discharges).

- Channel excavation/regrading improves drainage from the Begumganj depression; discharges from the depression are increased and there are significant reductions in water levels throughout the monsoon season.

- The addition of pumped drainage does not give any significant benefits to peak levels in the Begumganj depression

- A new regulator on the Dakatia would have little impact on levels in the project area and does not have a large impact on levels in the Dakatia as tidal variations are small during the monsoon season.

- The proposed developments in the Noakhali project area are not influenced significantly by the introduction of a new regulator site on the Little Feni at Musapur. There is little cross flow between the two drainage systems and they function almost entirely as separate drainage basins.

Based on the findings of the option simulations the preferred option was selected and a 25 year simulation undertaken as the With Project condition (See Section 10.5.

10.4 Irrigation Development

10.4.1 Introduction

Hydrodynamic models to look at dry season flow conditions and developments for irrigation within the project area were developed.

Two areas were considered for irrigation development. These would also improve the drainage characteristics in these areas. The two models covered the WAPDA/Rahmatkhali drainage system and the Dakatia drainage system.

10.4.2 Rahmatkhali Irrigation Model

a) Model Set-up

At present, Rahmatkhali regulator is a one way flow structure allowing outflow to the Lower Meghna only. The structure can be used, with appropriate modification, to operate in a reversed manner during the dry season with the aim of retaining water for irrigation purposes. In this case, the structure would also allow only one-way flow but this being from the Lower Meghna in to the project area.

The regulator was modelled as for the 'With Project' conditions (see Section 10.5). In comparison with present conditions, the increase in the number of gates and the revised gate arrangements are able to substantially increase the volume of water that can be taken in to the system over a tidal cycle.

A five month irrigation period from December to April, inclusive, was modelled. Irrigation offtakes were lumped together at selected offtake locations with a total command area of some 30,000ha.

The command area for the Rahmatkhali irrigation model included the WAPDA and Rahmatkhali khals together with its tributaries and distributaries. The model extends to the Panchgur khal to the north and to Noakhali khal in the east. Additional minor khals, not included in the flood season flow model, were also incorporated, Figure 10.8.

Storage of irrigation water in the river/khal system was increased by re-grading and re-sectioning the existing khals. This included both the main drainage system and other associated minor khals.

In the minor khals, revised sections included a minimum bed level of -0.5mPWD, 2:1 side slopes and a minimum bed width of 1-2m. Only those khals which could accommodate such a section, in general sections with top widths greater than 20m, were considered. This avoids land acquisition and the problems which this introduces.

Along WAPDA khal top widths varied from 40m at Begumganj to over 150m upstream of the regulator. Re-grading was also included with bed levels varying from -0.5mPWD to less than -3.0mPWD. Similarly, Rahmatkhali khal was re-graded and re-sectioned. Maximum top widths varied between 24-50m.

b) Tidal Boundaries

The FAP 25 General Model simulations are calibrated for monsoon season flows with little emphasis put on the dry season flows and levels. Checks were therefore undertaken to ensure that the tidal boundary at Rahmatkhali, based on the GM results, was representative of that in the dry season.

Comparisons with observed data, Figure 10.5 and section 10.2.3 indicated that the General Model results superimposed with a tidal variation gave a good match with observed HWL and LWL for the 1986/87 dry season. This gave confidence that the GM results could be used during the dry season modelling in the irrigation model.

Irrigation demand for a total area of 30,000ha was considered. Low lift pump (LLP) operation was considered over a 12 hourly period each day. Peak decad abstraction rates, over the entire area, were about $90m^3/s$ during the first and second decads of March. The total abstraction was distributed along the khal network as point outflows at approximately 5km intervals.

c) Results

Tidal variations at Rahmatkhali regulator allow peak discharges of about $300m^3/s$ to enter the project area on spring tidal cycles in late February/early March. The general operation of the regulator during a 48 hour period is demonstrated in Figure 10.9.

Figure 10.8

Khals in Rahmatkhali Irrigation Model

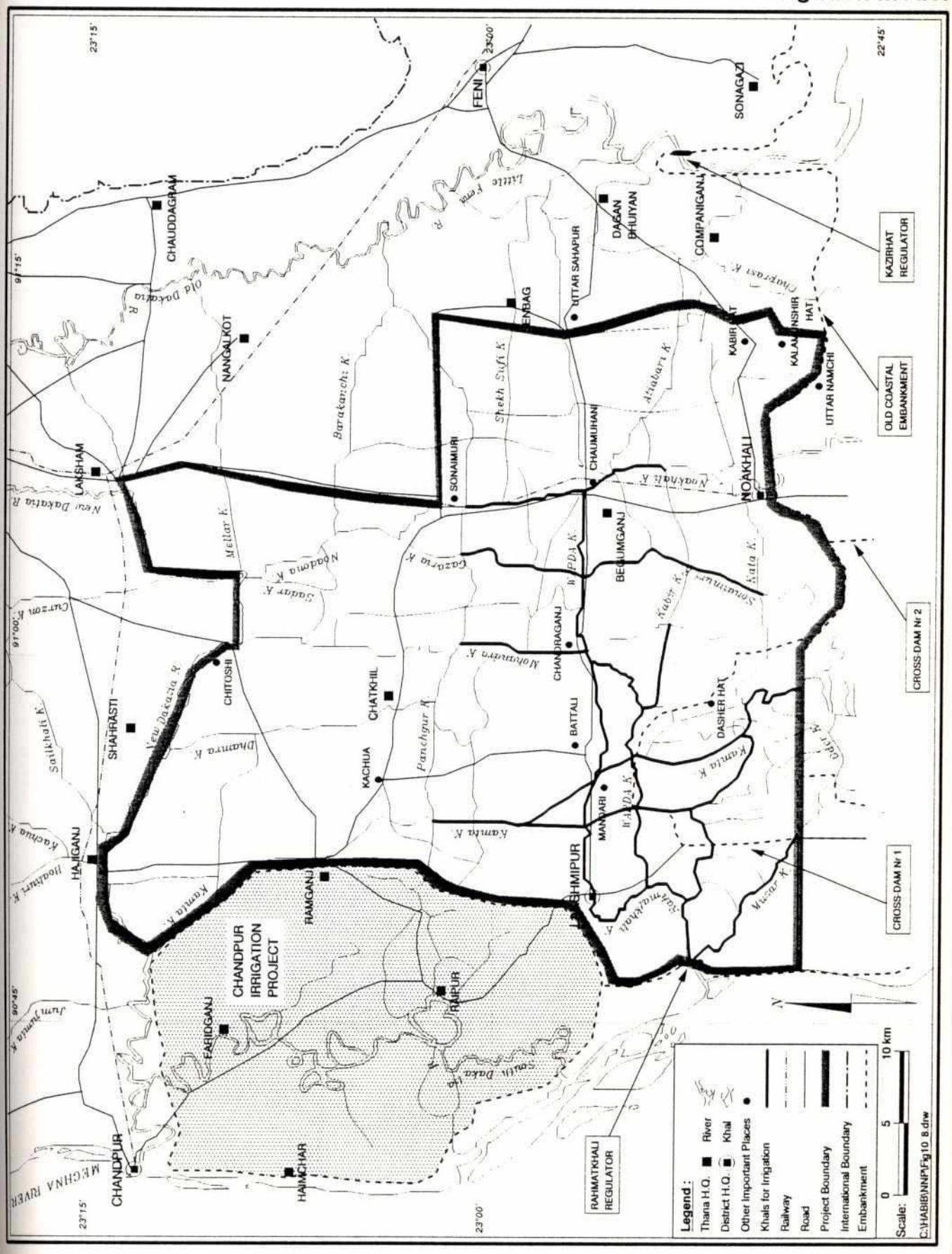
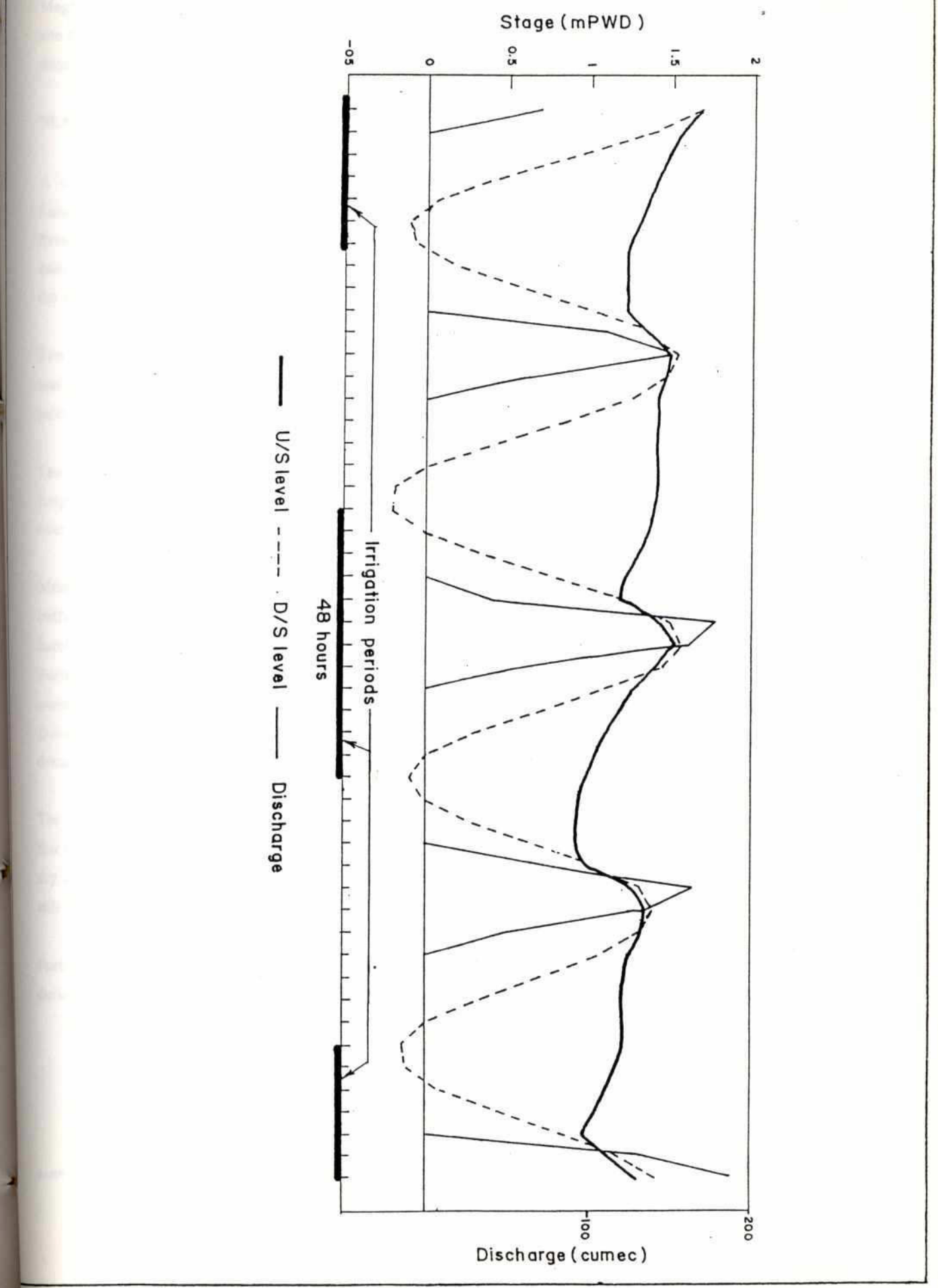


Figure 10.9

Rahmatkhali Regulator Irrigation Inflow



The water level hydrographs throughout the 5 month period (December to April) are shown in Figures 10.10 for Piarapur and Begumganj. Water levels reach a minimum during the months of February and March when Meghna levels are low and the irrigation demand is highest. As expected, at locations furthest from the regulator site the drawdown in level is greatest (ie Begumganj) but remains sufficiently high to provide the irrigation demand without drying out the channels, even for an hour.

10.4.3 Dakatia/Chandpur Irrigation

A model was also developed to investigate the potential of irrigation water supply, similar to that at Rahmatkhali, for the area between the Dakatia and Panchgur rivers. Channel excavation was considered along those khals which had an existing top width capable of taking a trapezoidal channel (1:2 side slope) with a minimum bed level of -0.5mPWD and a minimum bed width of 1-2m. Effectively, this requires a top width in the region of 20m, as ground levels are around 4.0mPWD.

The channel excavations were possible along the northern reaches of Noakhali khal, Mohananda, Naogaon khal and parts of the Frider khal. In addition, some further khals linking to the Dakatia were introduced in to the model, which were not included in the flood flow model.

The irrigated area was about 30,000ha, requiring a peak decad abstraction rate in the region of 90m^3/s. Irrigation offtakes were located as point outflows at a 2.5km spacing along the channel network. Operation was over a 12 hourly period per day.

Modelling options undertaken for the monsoon season had already indicated that a regulator structure at the outfall of the Dakatia was not viable. The differential head generated throughout the tidal cycle is small and is barely sufficient to operate the tide flaps. It would only provide benefits during extreme high tides. Furthermore, the structure cannot be justified purely for local gravity irrigation. The irrigation model simply considered an open outfall, as at present, and was used to test whether the volume of water entering the Dakatia, and its associated tributaries/distributaries, during the dry season were sufficient to supply the irrigation demand.

The model was run over a 5 month period (Dec-Apr) for the 1986/87 dry season. The results indicated firmly that this level of irrigation could not be satisfied and that the network of irrigation channels would begin to run dry in early January. Sensitivity tests also indicated that even a 50% reduction in the irrigation demand would still lead to a drying of the system in late January.

Further investigations of the potential for lift irrigation development in this area were therefore not considered during this study but will be considered in the regional plan as part of the Dakatia/Little Feni proposals.

10.5 With Project Simulation

10.5.1 Description

Following the design option simulations and the irrigation analysis a development plan for the Noakhali project area was formulated. A With Project simulation was carried out for this development plan.

The With Project simulation was based on a 25 year simulation for the period 1965-89 and considered the monsoon season only, from May to November inclusive. The impact of the proposed developments was investigated by comparing the results of the With Project simulation with those from the Without Project simulation.

The key components of the development plan simulated in the With Project conditions were as follows:

Rahmatkhali Regulator

- existing regulator upgraded to ensure tide flaps functioned throughout the whole season without failure, and additional flap gates for dry season irrigation
- sill level at the existing Rahmatkhali regulator raised to -0.5mPWD
- additional regulator added in parallel with the existing regulator; 10 vents, 3m wide gates (including dual tide flaps) and sill level at -0.5mPWD

Channel Excavation

- re-grading and re-sizing (to trapezoidal section) of WAPDA and Rahmatkhali khals, minimum bed levels varying from -0.5mPWD in the Begumganj depression to less than -3.0mPWD near the regulator site
- excavation of tributaries and distributaries of the WAPDA and Rahmatkhali khals to a bed level of -0.5mPWD with trapezoidal section and minimum bed width of 1-2m
- all tributary and distributary khal excavations carried out within the existing top width (plus banks) dimensions to minimise loss of agricultural land and land acquisition requirements.

Musapur Regulator

- new regulator, downstream of the existing Kazirhat regulator, with 22 no. 3mx3m gates, tide flapped, and sill level set at +1.0m

This last item has no measurable effect on the results but was included to obtain information for design of the regulator for Regional Plan studies.

10.5.2 Results of the With Project Simulation

a) Water Levels

The operation of Rahmatkhali regulator is demonstrated in Figure 10.11 As tide levels fall the tide gates open and water is drained from within the project area, with levels dropping rapidly immediately upstream. Peak discharges occur at or around low water. As the tide rises the discharge reduces as the head differential across the gates is reduced, until the tide flaps finally close. During closure, internal levels rise until they exceed the tide level and the tide flaps open once more.

Figure 10.12 shows a long-profile of 1:5 year levels (based on mean daily values) along the WAPDA khal with and without the interventions. In the vicinity of the Begumganj depression levels are reduced by almost 0.8m. At Chandraganj the level is reduced by over 0.7m and at Piarapur by almost 0.2m. Immediately upstream of the regulator there is only a small change in peak levels but this is an area which does not suffer from inundation even under present conditions.

Comparison of the hydrographs (1983) with and without the project at Chandraganj is shown in Figure 10.13. It indicates that the tidal influence extends further upstream under the proposed developments although this becomes insignificant at higher levels, when the flows are out of bank. This is due to the re-sectioning and re-grading of the bed profile.

An important feature of the hydrographs is the recession rate at which excess monsoon water can be evacuated from the area. The recession to inbank conditions is much earlier in the With Project situation and would lead to an improved situation for agriculture.

b) Discharges

During the monsoon season, under present conditions, the Begumganj depression becomes a lake and agricultural benefits can only be gained by draining this area more rapidly. Figure 10.14 shows the discharge hydrographs at Chandraganj for With and Without project conditions.

Under With Project conditions discharges are increased significantly, more than 50% at the peak, which leads to improved drainage of the area upstream. Again, Figure 10.14 demonstrates how the tidal influence has extended further upstream in the With Project conditions.

The 1:5 year discharge through Rahmatkhali regulator is almost 500m^3/s whereas under present conditions the 1:5 year discharge is 310m^3/s. The maximum discharge through the regulator is about 540m^3/s.

Figure 10.10

Model Results

Water Levels at Piarapur

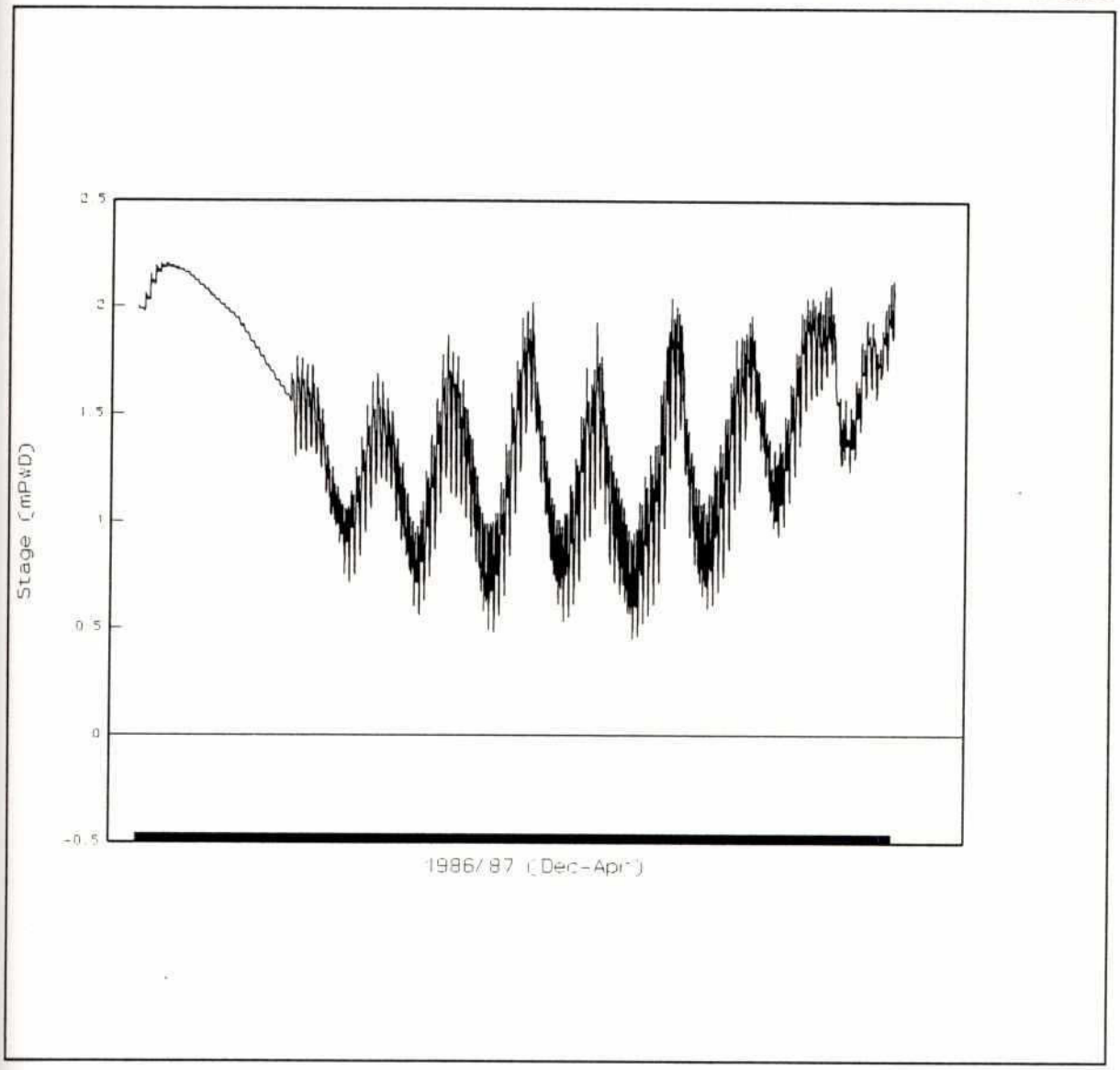


Figure 10.11

Rahmatkhali Regulator Monsoon Season Operation

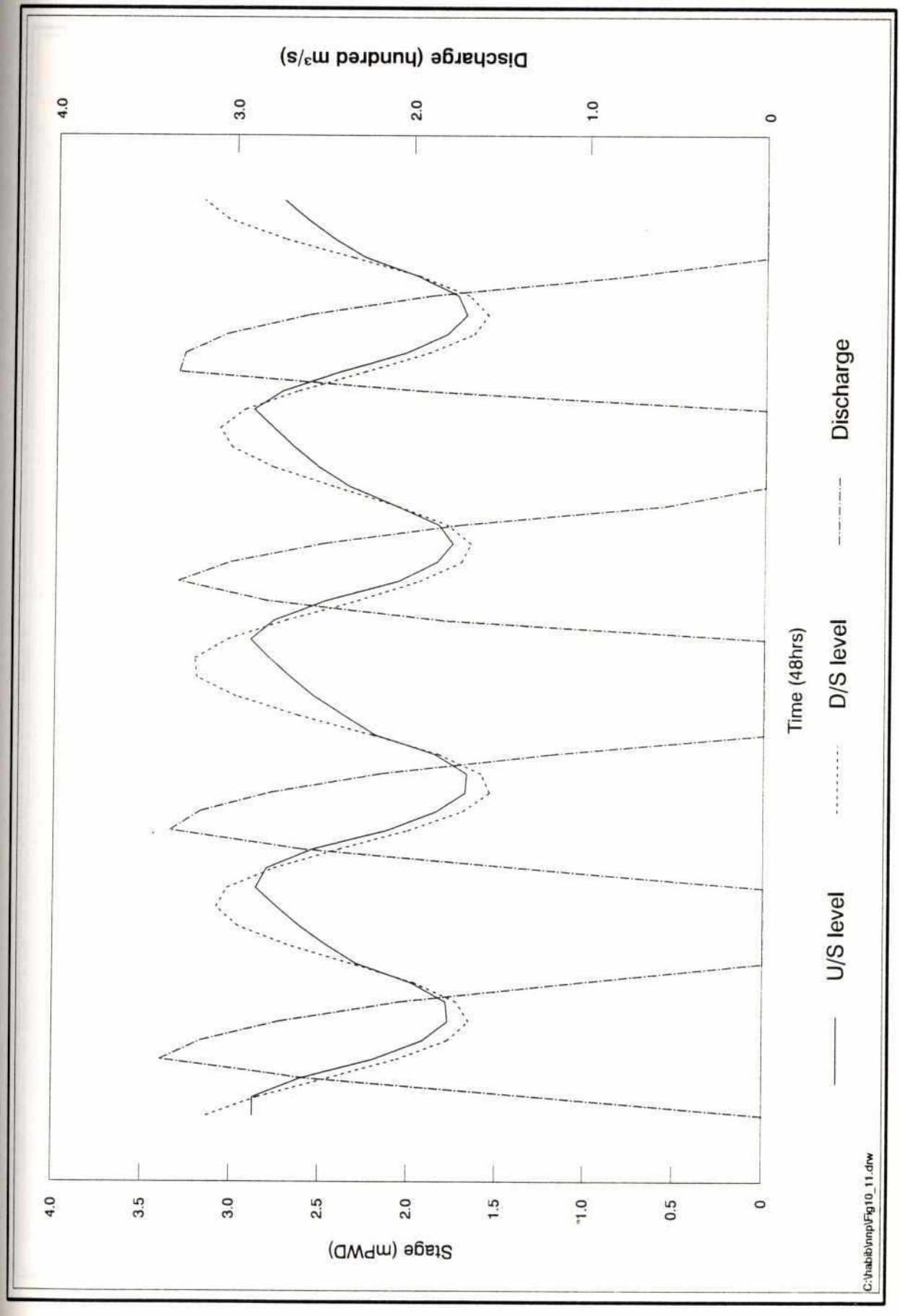


Figure 10.12

Water Level Profiles along WAPDA Khal
1:5 Year Levels

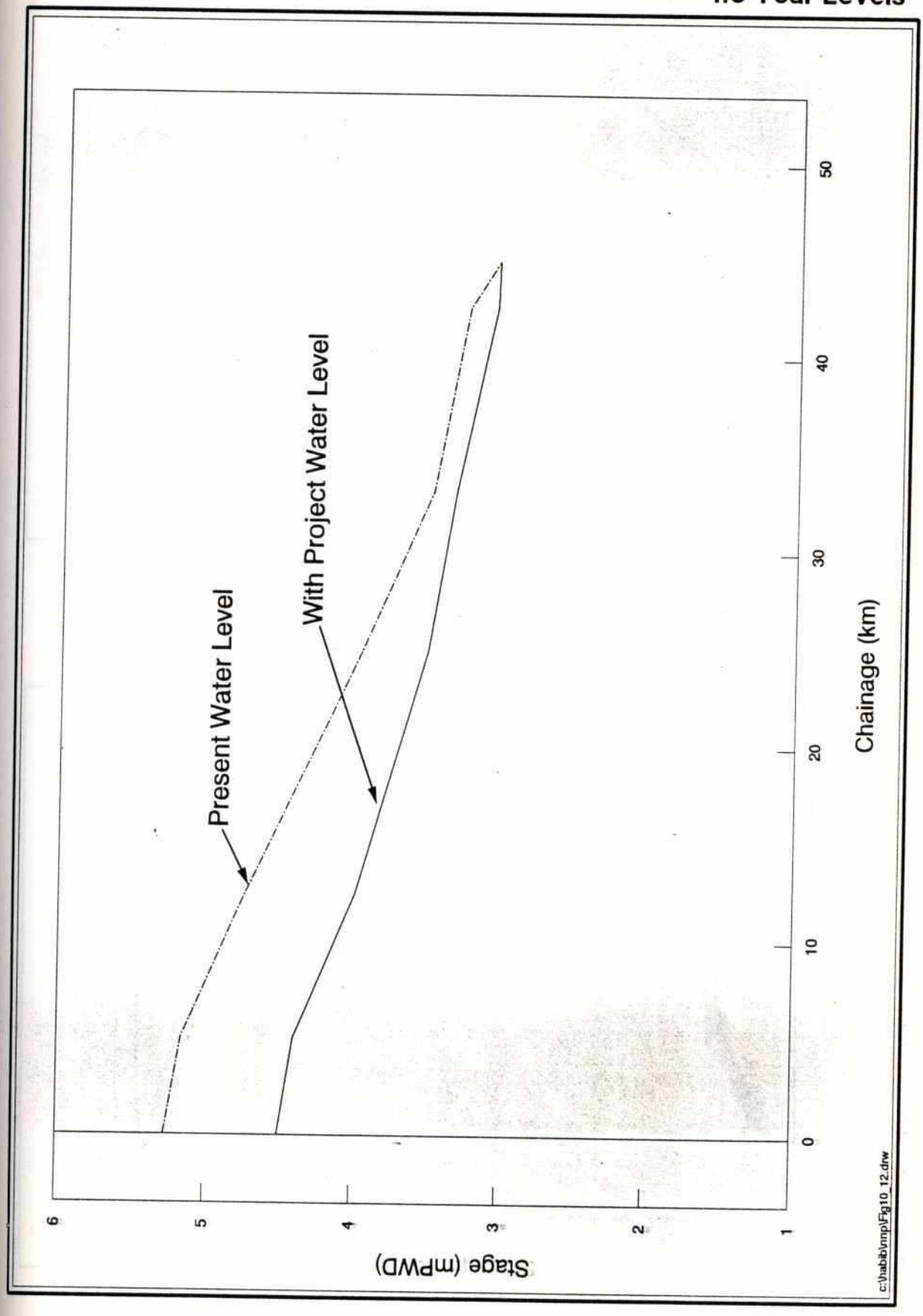


Figure 10.13

Monsoon Season Water Level at Chandraganj

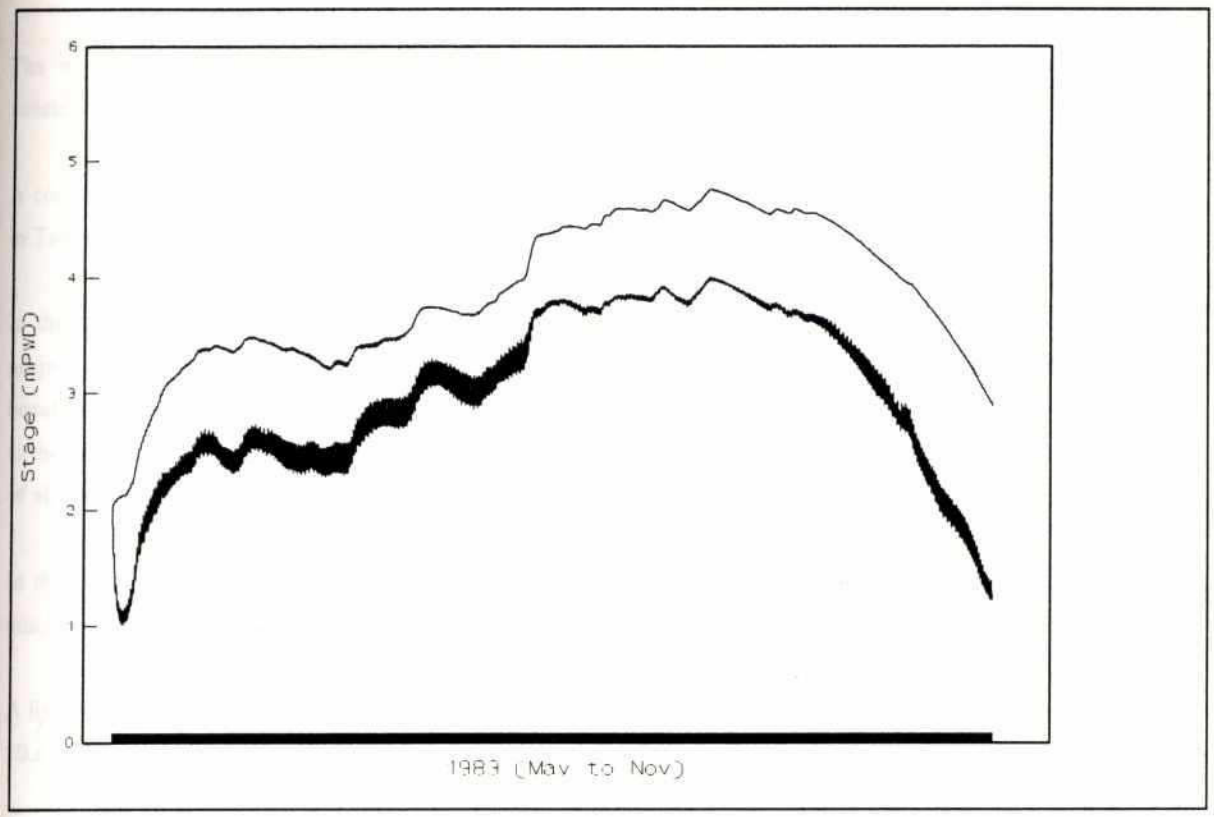
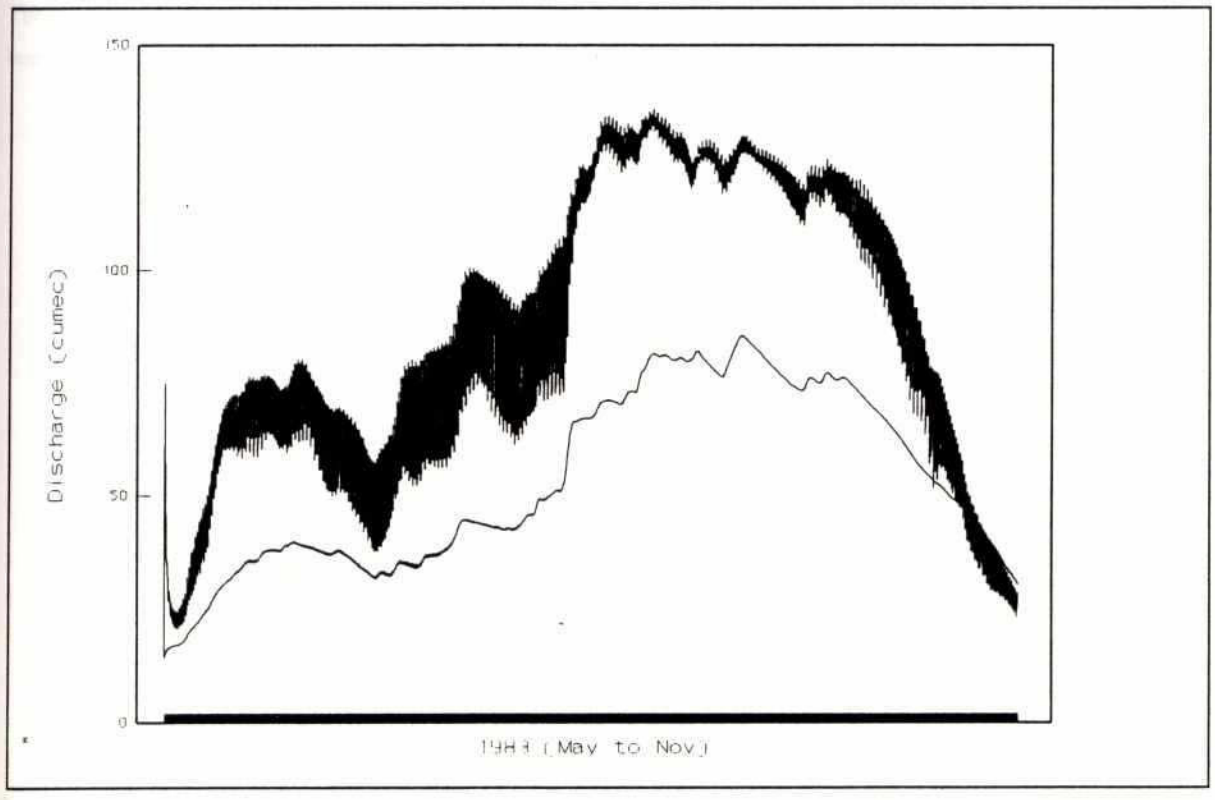


Figure 10.14

Monsoon Season Discharges Upstream of Chandraganj



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c) **Flood Phases**

The most effective means of assessing the benefits and disbenefits of the proposed interventions is by considering the impact these have on flood phases throughout the project area.

A comparison between the flood phases for With and Without conditions within the project area is presented in Table 10.5; figures in brackets refer to Without Project conditions.

In the With Project situation there is a reduction in the depth of inundation throughout the entire Noakhali project area. The greatest shifts in flood phases occur in the Begumganj depression although this in turn has beneficial effects along the tributaries and distributaries which drain through this area. The area immediately to the east of the Begumganj depression shows a less marked improvement in flood phases as it lies on the ridge of slightly higher ground which divides the Begumganj depression from the Little Feni.

In the northern areas of the project area there has been some improvement in the flooding regime but this is much less than that in the central and southern areas.

A listing of model predicted flood phases for the areas adjacent to the Noakhali project area are given in Table 10.6.

Along the north bank of the Dakatia there is a slight increase in the area of F0 and F1 land due to the lowering of water levels in the Dakatia. Along the little Feni, again there is an improvement but this is not as significant as within the project area itself.

The flood phase figures for the adjacent areas indicate that the flooding regime outside the project area has not been made worse at the expense of improvements within the project area itself.

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TABLE 10.5

With Project Simulation Flood Phases for Noakhali Project Area

Area	Flood Phase (%)			
	F0	F1	F2	F3+F4
A1	94(92)	6(8)	0(1)	0(0)
A2	90(78)	10(21)	0(1)	0(0)
A3	100(100)	0(0)	0(0)	0(0)
B1	31(0)	57(15)	12(80)	0(5)
B2	59(9)	40(46)	1(44)	0(1)
B3	2(1)	54(43)	44(56)	0(0)
B4	17(0)	79(7)	4(92)	0(1)
B5	94(9)	6(70)	0(21)	0(0)
C1	69(24)	31(65)	0(11)	0(0)
C2	23(2)	74(73)	3(25)	0(0)
C3	14(2)	56(22)	30(76)	0(0)
C4	15(7)	36(21)	48(71)	1(1)
C5	11(6)	37(26)	52(67)	0(1)
C6	93(61)	7(37)	0(2)	0(0)
C7	93(7)	7(74)	0(19)	0(0)
C8	59(1)	40(29)	1(70)	0(0)
D1	4(0)	48(12)	48(84)	0(4)
D2	7(5)	48(12)	45(81)	0(2)
D3	10(1)	82(31)	8(68)	0(0)
D4	2(0)	20(4)	78(95)	0(1)
D5	0(0)	24(17)	71(77)	5(6)
D6	0(0)	8(3)	88(83)	4(14)
D7	0(0)	24(8)	76(90)	0(2)
D8	0(0)	9(3)	90(92)	1(5)

Note : Figures in brackets are for Without Project situation

TABLE 10.6

With Project Simulation Flood Phases
Adjacent to Noakhali Project Area

Area	Flood Phase (%)			
	F0	F1	F2	F3+F4
KZ	100(95)	0(4)	0(1)	0(0)
LF1	39(22)	58(69)	2(9)	0(0)
LF2	61(54)	19(21)	20(23)	1(2)
NAN	42(35)	27(25)	30(39)	0(1)
DKW	3(1)	58(53)	37(43)	2(3)
DKE1	0(0)	11(7)	84(85)	5(8)
DKE2	7(1)	50(36)	43(62)	0(1)
DKE3	0(0)	10(2)	90(94)	0(4)

Note : Figures in brackets are for Without Project situation

10.5.3 Sensitivity Analyses

a) Rise in Level at Chandpur

FAP-25 have carried out General Model simulations to investigate the impact of a range of scenarios which are combinations of various external developments (eg along the major rivers) which may result from the recommendations of individual FAP regional studies.

Most of the simulated developments produce changes in mean daily water level in the reach of the Meghna adjacent to the northern part of the Noakhali project area of less than +/-10cm. The maximum predicted change is 17cm, at Chandpur. These changes in level diminish downstream of Chandpur with little or no change indicated at Rahmatkhali.

A model simulation was carried out to investigate the impact of changes in Meghna level and considered a rise in water level of 15cm at Chandpur, Molakandi and Matlab. Levels at the outfall of Rahmatkhali regulator were assumed to remain the same. This gives an increase of 15cm in the differential head between the upper and lower reaches of the project area. This has little impact on levels in the Rahmatkhali/WAPDA khal system, peak levels increase slightly (0.03m at Begumganj) but these do not threaten the viability of the proposed intervention. Indeed they demonstrate its robust and stable nature.

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Along the Dakatia, peak levels increase by 10-15cm for some 80km from the outfall. Upstream of Hajiganj, the rise in Meghna levels would largely negate the benefits along the Dakatia which were introduced by carrying out the Rahmatkhali drainage improvements, but this was not a major benefit in economic terms.

b) Effect of Musapur Regulator

The Musapur regulator, located downstream of the existing Kazirhat regulator, on the little Feni has an impact on levels upstream of Kazirhat regulator. A simulation run was undertaken to assess whether this had any significant impact on water levels in the project area, in the vicinity of the Begumganj depression.

Long profiles of peak water levels (1983) along the WAPDA khal, with and without Musapur in place, indicate that there is no significant change. Maximum changes are in the order of 1-2cm at Begumganj and no change at Chandraganj or further west. Analysis of discharges in the link channels between the Little Feni and the Begumganj depression were found to be small with or without the regulator which further substantiates these results.

The developments associated with the Rahmatkhali drainage system are therefore not dependent on those in the Little Feni and can be carried out independently.

CHAPTER 11

THE PROJECT

11.1 Introduction

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 which are described in Chapter 13. 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.

11.2 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.

11.2.1 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 concurrent improvements are required:

- 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 balanced improvements of the main structure and the main channels by increasing their capacity.

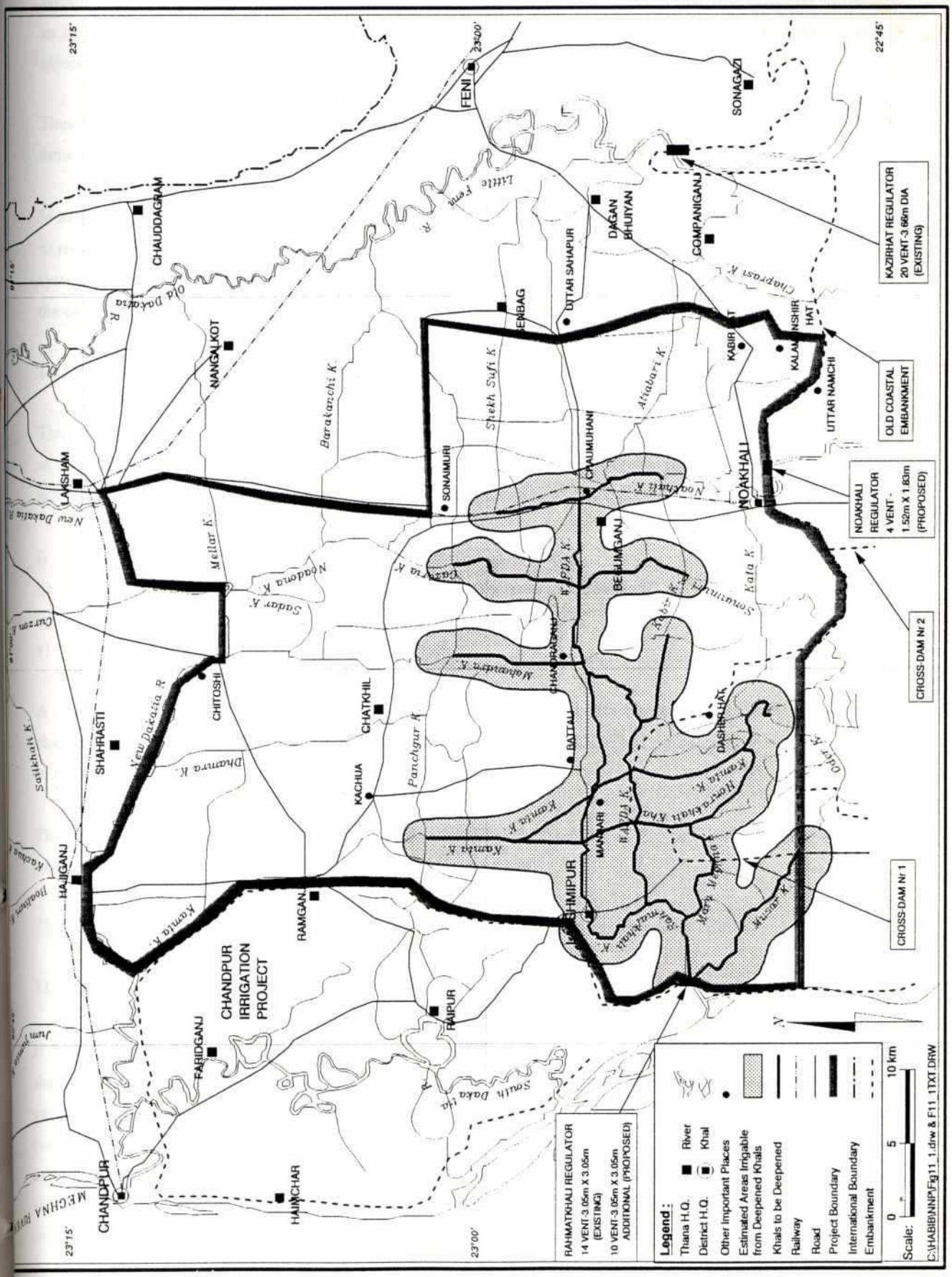
Local people have expressed a preference for deepening rather than widening the channels and this has been done to the maximum extent possible since this also keeps land acquisition to a minimum. However it is important that the channels are kept to a minimum stable width to prevent erosion and meandering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

11.2.2 Irrigation

As explained in Chapter 2 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.

Figure 11.1

Proposed Intervention



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.

11.3 Selection of Recommended Option

The selection of the recommended option was based on a series of tests carried out on the hydrodynamic model as described in Chapter 10. After preliminary runs aimed at identifying 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 (ref FAP 25)
v) the effect of a pump station at Rahmatkhali

A described in Chapter 10 none of these possibilities has a significant effect on the expected benefits since the changes in water levels at the 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 11.1 and its principal features are described below.

11.3.1 Rahmatkhali Regulator

It had been widely supposed that the existing regulator was the currently limiting constraint to improved drainage. However, as explained in Chapter 10, 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. A refinement which could be tested at design stage would be to enlarge the gates on the new structure by deepening them by say 0.5 m and at the same time lowering the sill level below that of the existing structure. This could have the effect of reducing the maximum discharge through the existing structure whilst maintaining the total discharge capacity. This could further improve the hydraulics of the existing structure.

Details of the proposed improvements to the existing structure are described in Annex I but the essential elements 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.

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.

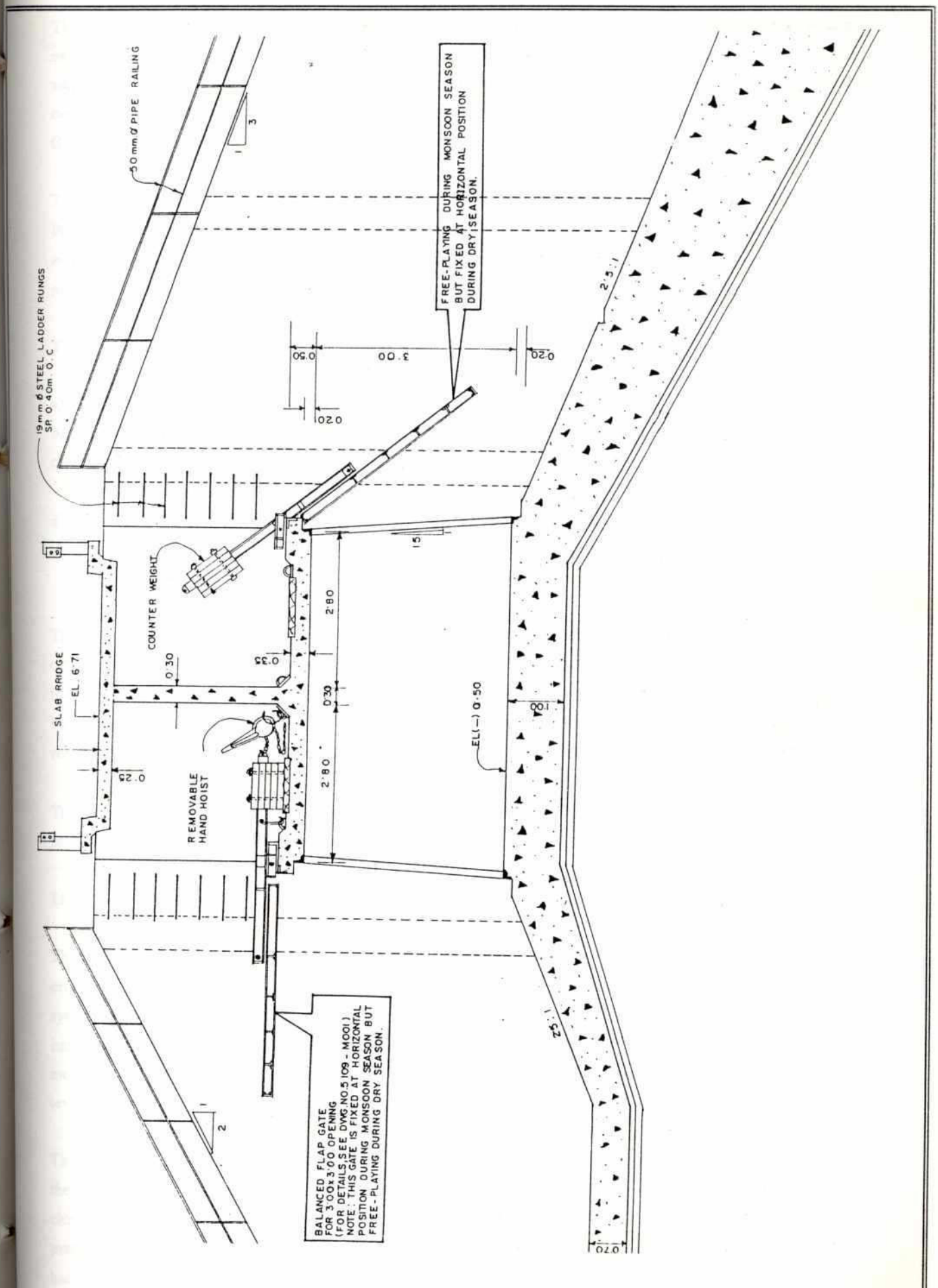
An outline of the proposed gate arrangements is shown in figure 11.2.

11.3.2 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.

Figure 11.2

Rahmatkhali Regulator Gate Arrangements



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 (see Chapter 10 and Annex B).

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 end of WAPDA and Rahmatkhali Khals. It is also a reflection of the more accurate analysis possible with a calibrated tidal model. Details of the remodelled and enlarged khals are given in Annex I.

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.

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. Various methods have been considered and these are discussed in Chapter 13.

11.3.3. 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.

11.3.4 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.

11.4 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 changes in flood phases for the various sub-catchments within the project area are shown in Chapter 10 Table 10.5. The without project, with project and changes in FO and F1 areas by minute square are shown in figures 11.3,11.4 and 11.5.

The evaluation of these improvements, in terms of agricultural and other benefits is described in Chapters 3 and 15.

Figure 11.3

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

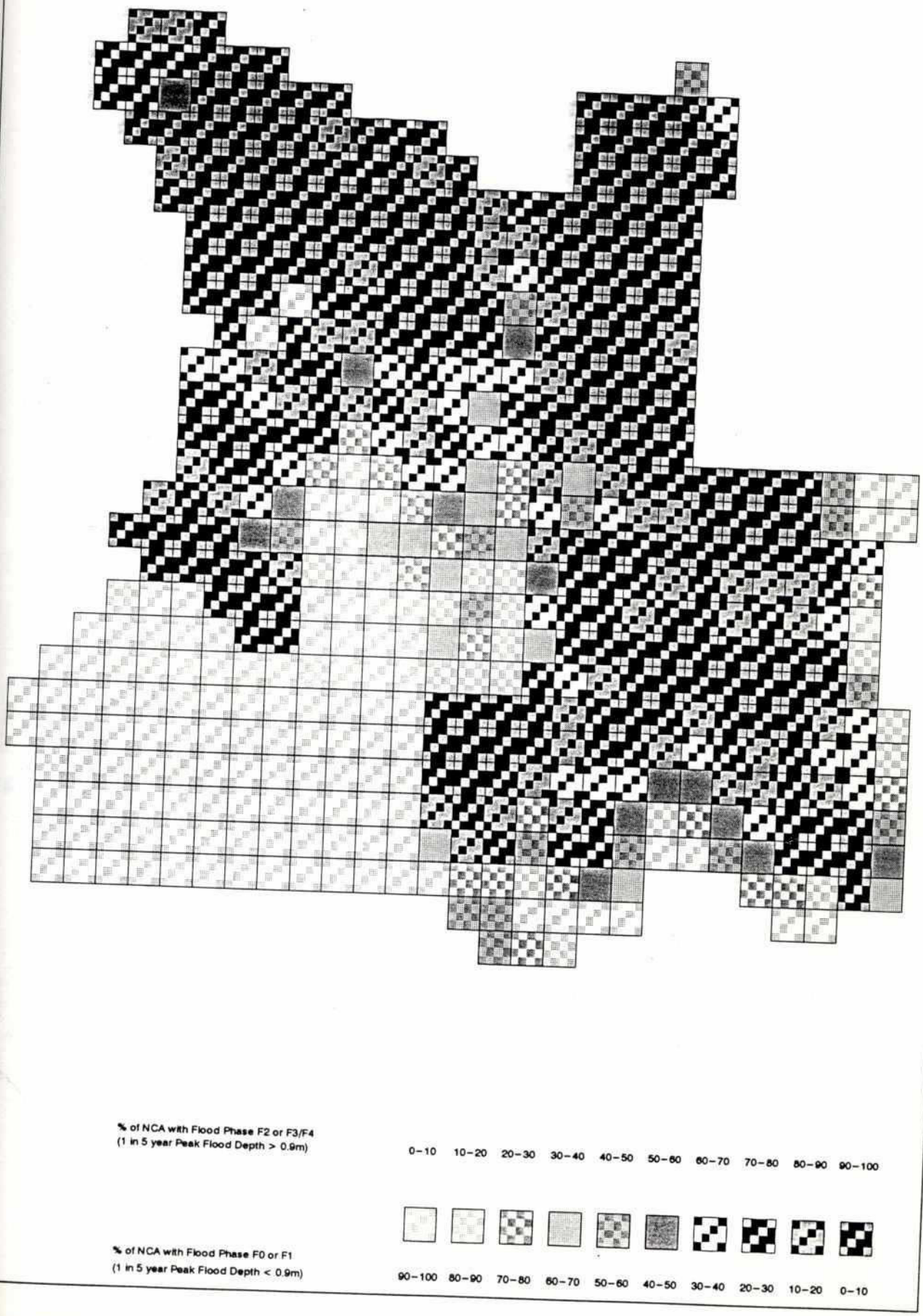
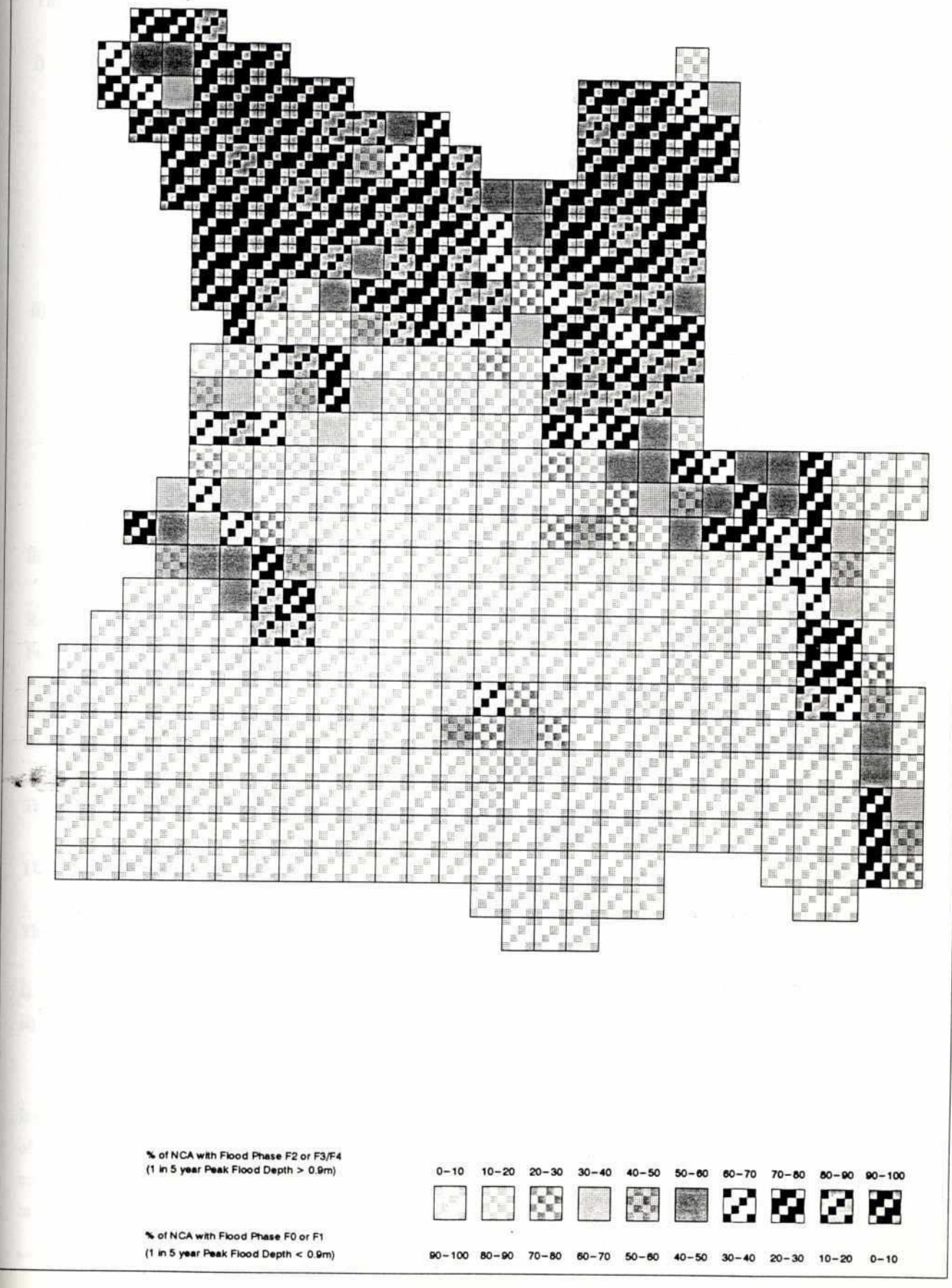


Figure 11.4

With Project 1 in 5 Year Peak Flood Phasing



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 and this is further discussed in Chapter 15.

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 I.

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.

11.5 Dis-benefits and Mitigation

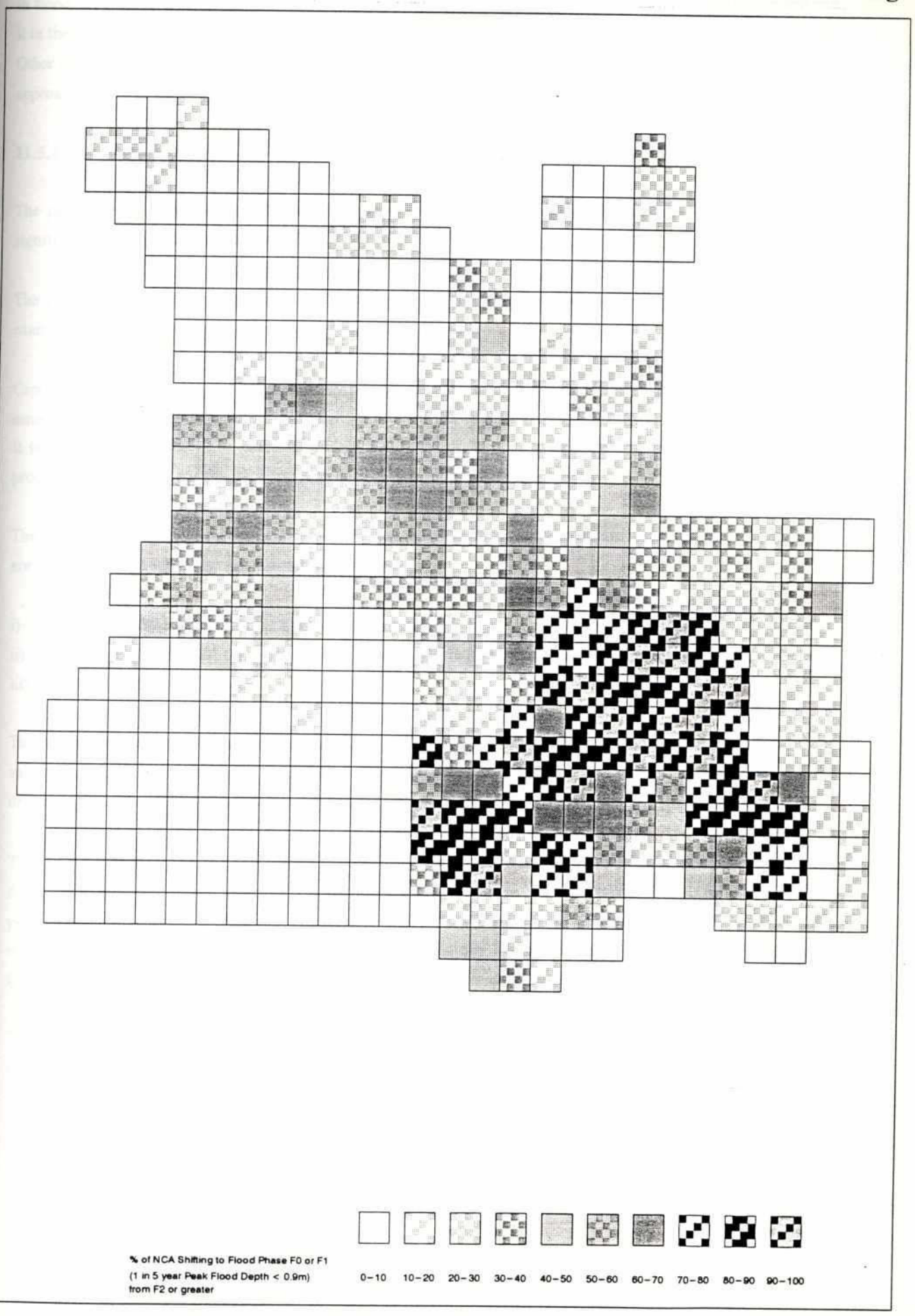
The principal dis-benefits of the proposed development are twofold

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

Figure 11.5

With vs Without Changes in 1 in 5 Year Peak Flood Phasing



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 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.

11.5.1 Capture Fisheries

The presently estimated potential losses to capture fisheries are presented in Chapter 4 and their economic significance is discussed in Chapter 15.

The possible mitigation options for the affected communities are discussed here and these aspects are also examined in the environmental impact analysis (Chapter 12).

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 the fisheries Annex F and are reproduced below:

Zone	No. of Full-time Fishing Household
A	3,294
B	927
C	2,070
D	10,061
Total	16,352

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 les 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 inplementing 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.

11.5.2 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:

i) Land required to achieve the proposed sections of the Khals.
ii) Land for depositing spoil excavated from Khals.

The different aspects of these two elements are discussed below:

a) 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 limits 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.

b) 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:

i) 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.

ii) 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 top soil stripping and replacement (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 acceptablity 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. (see chapter 13).

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 costs by up to 25 % (see Chapter 15 for sensitivity).

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.

This aspect is discussed further in Chapters 12 and 13. It is one of the main reasons for recommending the activities of the NGO (See Chapters 5 and 13) since the possibilities of agreeing suitable methods of implementation and working out methods acceptable to each local community are crucial both to the design and implementation process. The involvement of a locally respected NGO throughout the design and implementation process could greatly help in gaining the people's confidence, allay the currently widely held expectations of poor implementation and allow a genuine and meaningful dialogue to ensure adoption of acceptable methods for each locality.

CHAPTER 12

ENVIRONMENTAL IMPACT ASSESSMENT

12.1 Aims and Objectives

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.

12.1.1 Scope of the Environmental Studies

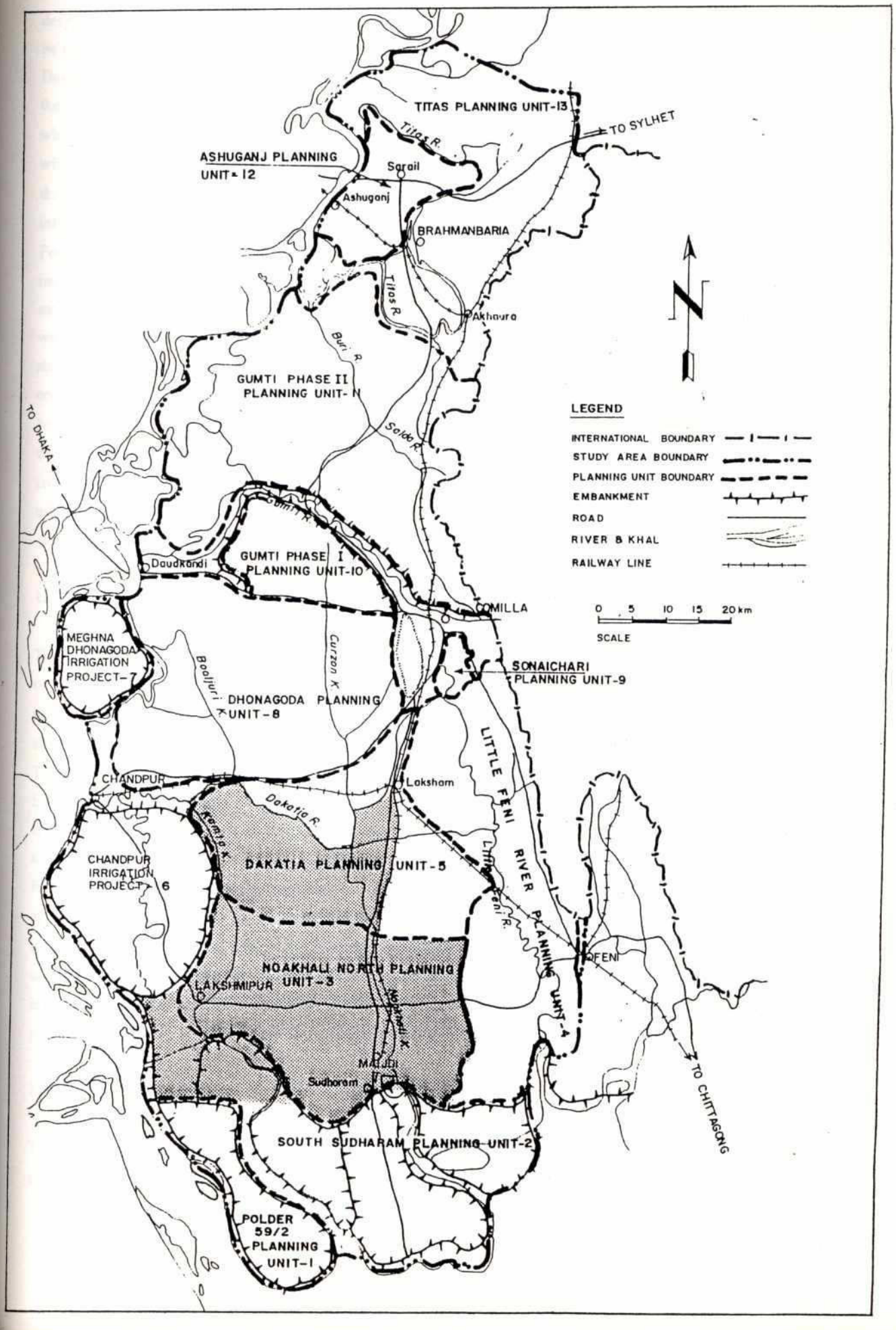
Environmental assessment considers both the natural environment and the human environment, their interaction and how this is likely to change as a result of proposed interventions. The range of issues considered important was drawn up as a result of initial baseline assessment work carried out in the study area. The predicted outcomes of the main drainage improvement and irrigation intervention include a 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 already exists or can be collected, quantified and if appropriate valued, either in relative or economic terms. However some of the impacts may be difficult to quantify 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.

12.1.2 Definition of the Study Area

The study area lies within the South East Region of Bangladesh which is being studied under the FAP 5 component of the Flood Action Plan (FAP). This is shown within the national context on the Frontispiece. The study area is Planning Unit 3 and parts of numbers 2 and 5 in the South East Region and this regional context is given in Figure 12.1. The study area was defined by the nature of the proposed intervention which was formulated as part of a water and land development plan for the region drawn up as part of the work of FAP 5. The proposed intervention was for a drainage programme centred around deepening and widening of the existing Khal system associated with a proposal to enlarge and modify the operational regime of the outfall regulator to the Meghna river at Rahmatkhali. The revised regulator operation would include allowing water inflow from the Meghna river during high tides so that this could be made available for irrigated farming. The environmental situation in the Regional Study area was outlined in Annex IV of the FAP 5 Regional Plan Report and was considered when drawing up the proposed intervention.

Figure 12.1

Regional Planning Context Map



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 study boundaries are shown on the Study Area map in Figure 1.3. 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. The study area was split into four planning zones and these are shown in Figure 12.2 based upon the FAO agro-ecological and MPO flood mapping. However the output of the hydraulic modelling indicated that the boundary between Zones A, B and C has been misaligned using seasonal flood plain extent as a criteria. It was by this time too late to adjust this as all the agro-socio-economic survey data and fisheries catch assessment had been collected in the field. This has thus made the comparative assessment of spatial differentiation of impacts less useful than it could have been as B and C are two mixed zones rather than one having primarily flood plain reductions and the other primarily irrigation benefits.

12.1.3 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 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.

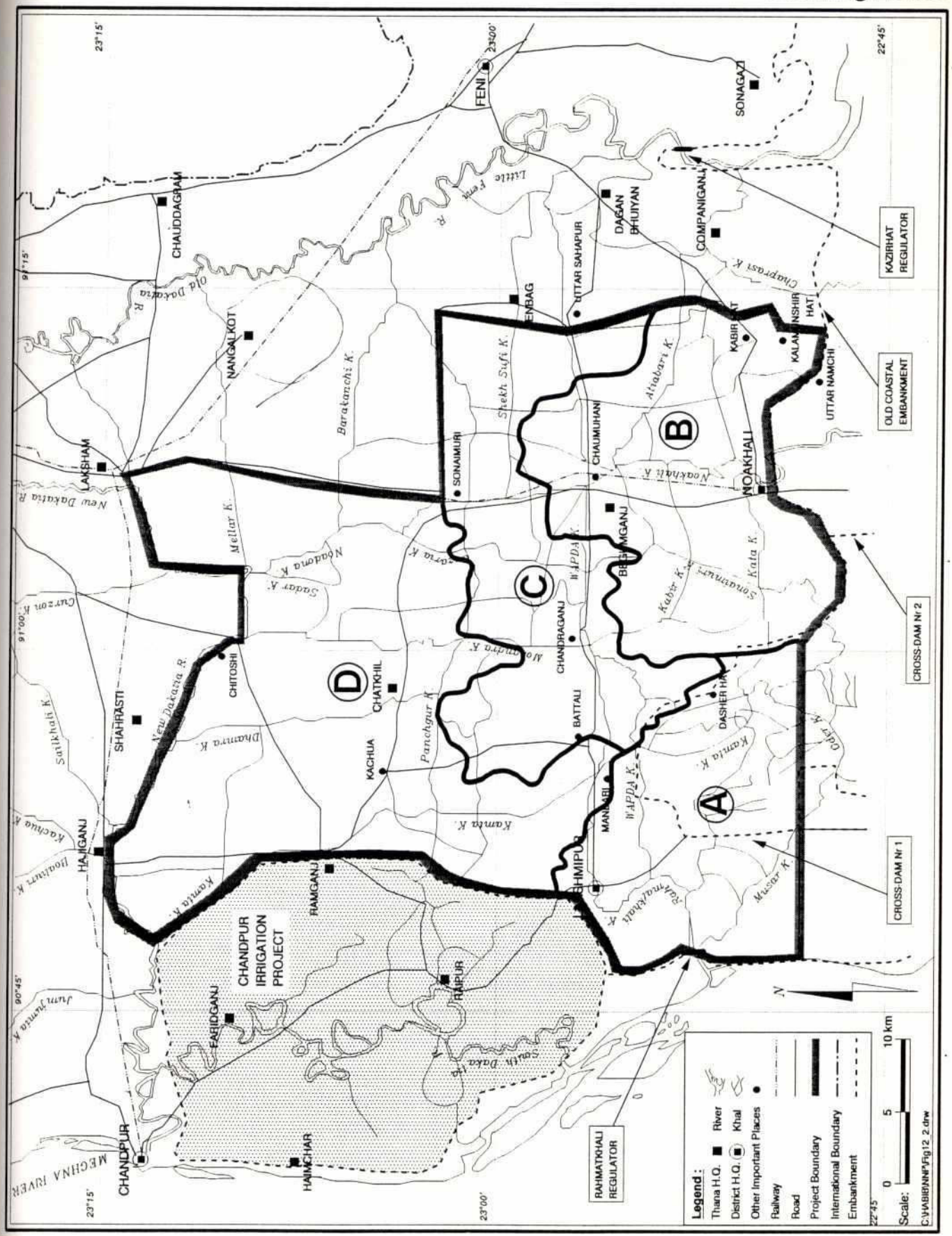
12.1.4 Interface with Other Disciplines

The environmental component to the study was co-ordinated by a broad environmental planner with specialist staff made available to cover the following issues and disciplines:

- Water Quality

Figure 12.2

Planning Zones



- Aquatic and Terrestrial Ecology
- Fisheries
- Health and Nutrition

In addition there were separate specialists outside the environmental component who addressed the environmental considerations of their own disciplines:

- Groundwater
- Socio-economics
- Agro-economics

The findings of each of these study components are given in the respective Sections of this main report and also in the appropriate Annexes. A sample agro-socio-economic survey was carried out in the study area which was principally aimed at obtaining data on agricultural economics. It was of limited use for social impact assessment (SIA) as it was done before the outputs of the hydraulic modelling of the intervention were known and a clearer idea of the spatial variation in likely impacts could be seen. This data shortfall could have been addressed to some degree if all the 1991 BBS data for the area had been made available, but unfortunately the important northern and western areas were not. For any future work it is essential that this data is made available.

12.1.5 Public Participation

There was a significant public participation component in the study which carried out a three stage set of visits to four villages from each of the four planning zones. This allowed a needs assessment for water and land planning priorities to be carried out and the results of these are summarised in Table 9.2. A major outcome of this work was that it demonstrated the varying importance of the same issues in different parts of the study area. Overall the participation work indicated that flooding due to external water in-flow to the area is not a problem, and what flooding that does occour in Zones B and D develops from locallised depressions filling with rainfall. These gradualy join until a large part of the study area (but none of Zone A) is under water in the peak of a normal flood. This process is quickened by poor drainage and early rainfall events which cause congestion resulting in local rainfall run-off back-up. This is made worse by the overall governing drainage constraint being the level of water in the Meghna River. There was considered to be a "flash flooding" problem (better described as early flooding so as not to confuse it with run off from the Indian Hills which is normally considered to be the definition of flash flooding in this part of Bangladesh) in the Dakatia river in parts of Zone D. There appeared to be no major problem of drownings or even homestead destruction due to flooding and it would seem that most homesteads are flood proofed on raised grounds above even high normal flood level. There was a widespread call for the supply of surface irrigation water in the dry season as groundwater use for irrigation was discounted in most places due to the dry seasonal depth to the non saline aquifer being so great as to rendering its extraction uneconomic for irrigated agriculture. There were calls to excavate the drainage system to allow for this supply of dry season surface irrigation water and also to improve rainfall run-off.

It also transpired that drinking water supply problems were regarded as the most serious constraint in Zone A and even in Zone D it was highly significant. The other broad issue to emerge was the lack of wage paid labouring opportunities, particularly for women. This was thought to have become more difficult as traditional household income earning opportunities, particularly rice husking, have become mechanised and done outside the household economy.

12.2 Environmental Profile of the Study Area

The environmental profile of the study area, covering both the natural and human environment is given in Section 2 of Annex H of this Report. The basis for differentiation of these aspects are the four planning zones shown in Figure 12.2 delineated using a range of criteria including ago-ecological zone, MPO flooding zone and topography. The most important environmental issues are summarised below:

12.2.1 The Natural Environment

From the point of view of trying to draw up an integrated water and land management programme for the area, the key issues are all underpinned by the surface water hydrology, specifically the nature of flood patterns. These have been studied by mapping the output of the MIKE 11 hydraulic model for each 10 day period, using a water level at that time for each of the 32 modelling cells which cover the study area. This then used the best topographic data (0.5m contours) that could be sensibly handled quickly to give A3 sized map outputs on clear polyester sheets. This was carried out for both a 1 in 2 "normal" year and a 1 in 5 high "normal" year, firstly for the present without intervention situation and latterly for each of the post construction situations for the strategies under consideration. The modelled outputs for the 1 in 2 year flood of the present situation are shown in Figure 4.2 for a rising flood and Figure 4.3 for a falling flood. The equivalent maps for the 1 in 5 year situation are shown in Figures 12.3 and 12.4.

The mapped outputs of the present flooding situation in the study area were some what surprising as they indicated that most of the study area goes under seasonal flood water even in a 1 in 2 "normal" year. This was surprising as the field study period, although starting at the end of the monsoon (September) was exceptionally dry with very few floodplain areas. This has significant implications for the ability of the fish catch survey work to accurately reflect floodplain fisheries for a normal year. The overall picture that emerges is that there is no flooding into the study area from outside and the flood pattern is almost entirely dependent upon local rainfall and topography. The climatic norms at Noakhali, including the mean seasonal rainfall distribution, are shown in Figure 12.5.

As stated above, the mapped outputs from the model were rather surprising due to the untypical situation under which site visits were carried out. However the model outputs did seem to be credible from some inhabitants localised observation and reporting. The model outputs resolved many of the difficulties that were being experienced in attempting to interpret a flooding pattern picture built up from episodic discussion data. This had not been helped by the fact that there were insufficient study resources to acquire time series flood season remote sensing imagery that could have been available to the study much earlier than the model outputs.

The mapped outputs, which are the extents of >0.30m flooding, show that in a 1 in 2 "normal" year the area commences flooding in early July. This is in scattered depressions, presumably as a result of localised rainfall run-off. These flooded areas are situated in Zones B and D, particularly in the middle Dakatia floodplain and also against the Chandpur eastern embankment. There are also flooded areas at the eastern extents of Zones B and D, presumably as a result of these locations being the most upstream points of the drainage system. It is interesting to note that the two locally reported drainage areas (the Begumganj and Laksham Depressions) do not fill during this early flood time. By the third decad of July the scattered flooded depressions have

Figure 12.3
Extent of Rising Flood, 1 in 5 Year

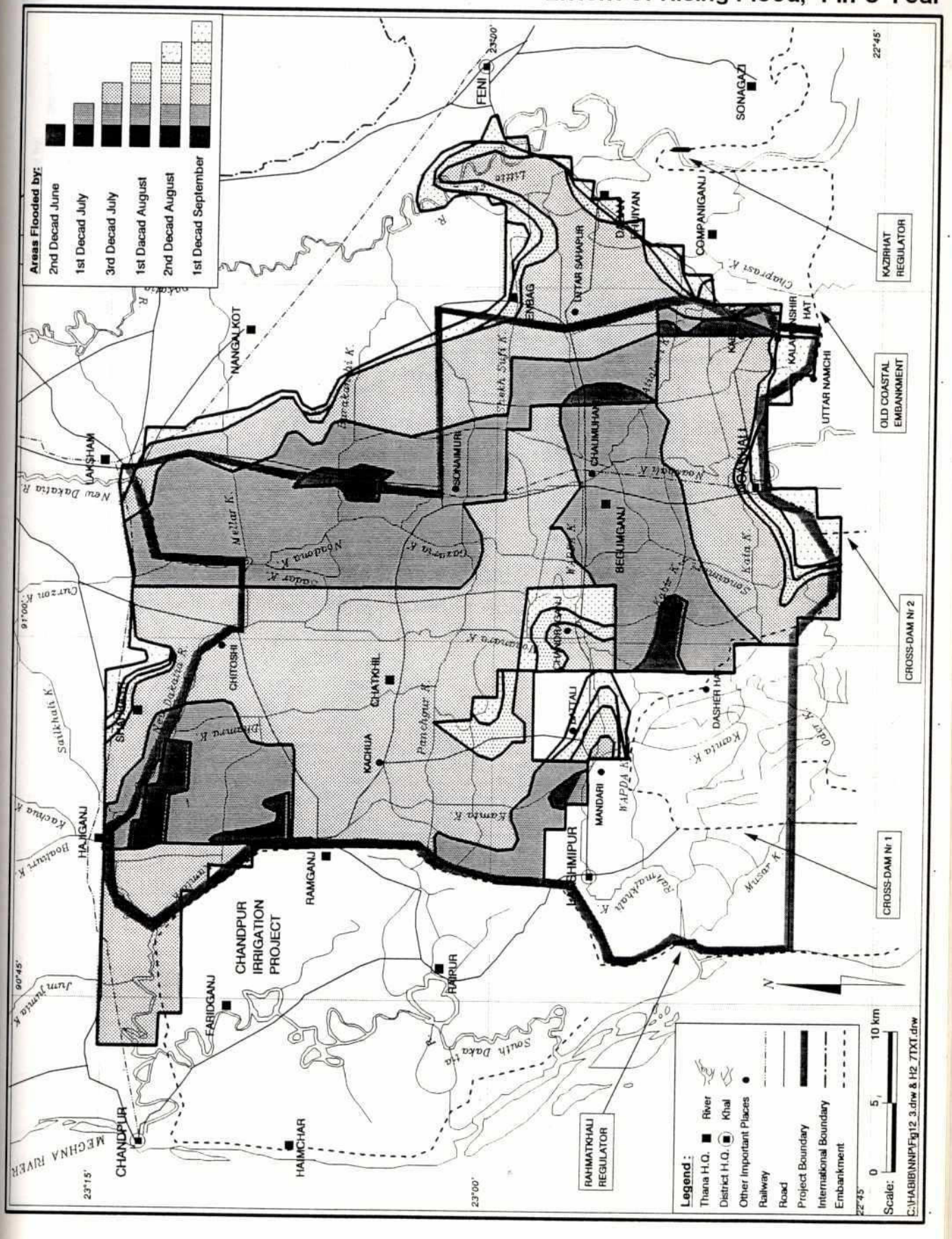
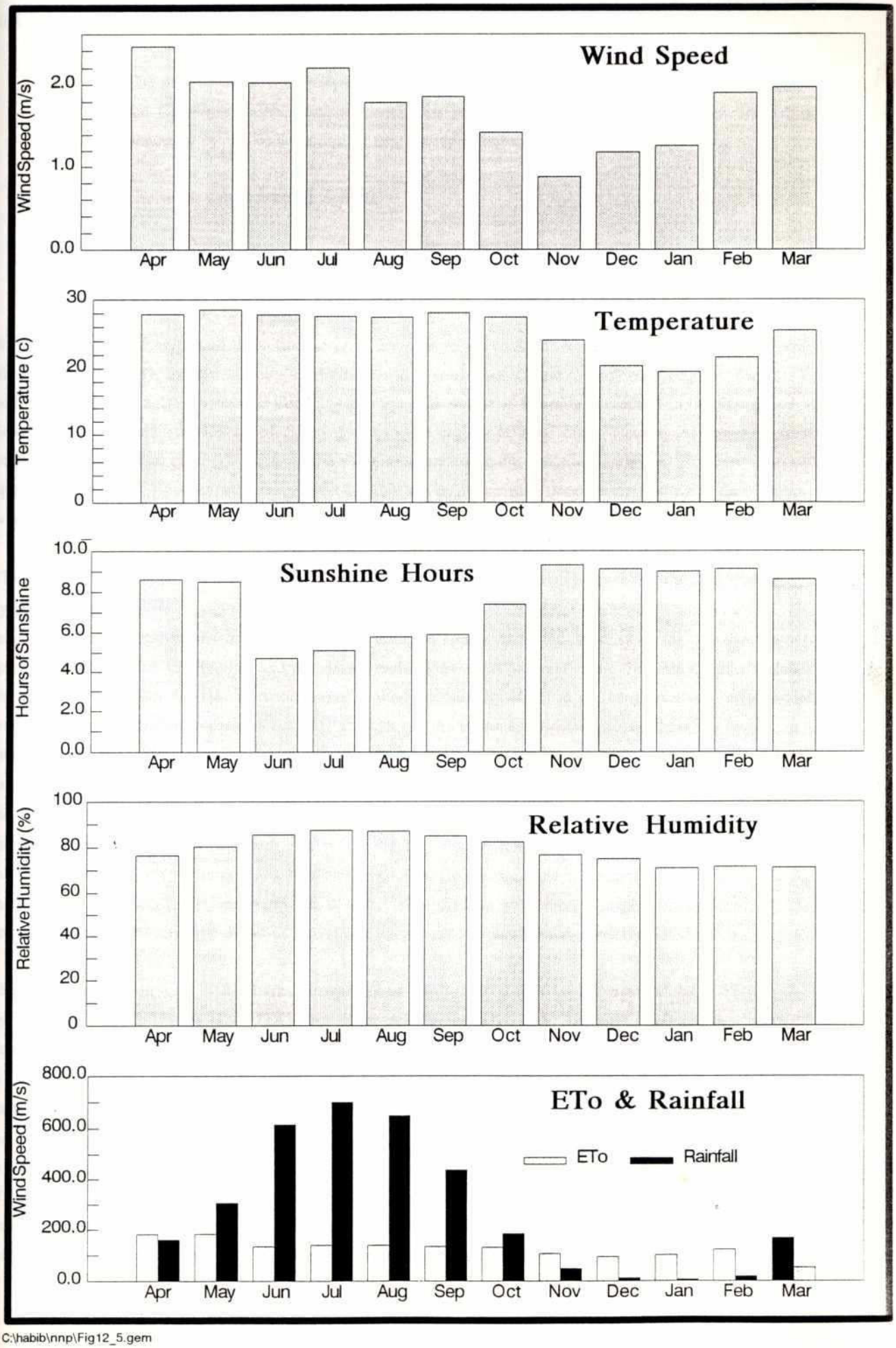


Figure 12.4
Extent of Falling Flood, 1 in 5 Year

Figure 12.5

Climatic Norms at Noakhali



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amalgamated into four major flooded areas, again still concentrated in Zones B and D, but two of the four areas linked by a corridor which passes through Zone C. These four areas are:

- The middle and lower Dakatia combined with the north western part of Zone D adjacent to the Chandpur eastern embankment. This would possibly seem to have been created or worsened by the construction of the Chandpur embankment restricting outflow.
- The south west corner of Zone D
- The eastern part of part of Zone D which is combined by the corridor through Zone C to the flooded area covering all of the northern half of Zone B.

By the first decad of August all these flooded areas have combined to form one large flood plain area covering all of Zones B and D, except the very southern central part of Zone D and the southern edge of Zone B. In addition the eastern half of zone C is also flooded. The peak extent of flooding is reached in the first decad of September and covers virtually all of Zones B and D, the eastern 60% of Zone C and quite extensive areas outside the eastern and northern limits of the study area including the Dakatia floodplain. However it would appear that this peak flood extent is very short-lived in a 1 in 2 "normal" flood, lasting no more than 20 days when compared to 50 days for a 1 in 5 high "normal" flood.

The falling flood pattern for a 1 in 2 "normal" year is mapped in Figure 4.3 and shows that the present drainage system is more effective in reducing flood extents in the southern part of the study area than the north. The main constraints to reductions in flood extent and duration appear to be the capacity of the drainage system (presently reduced due to siltation) and the water levels in the main Meghna river. The latter factor includes issues of daily and lunar cycle fluctuations due to the tidal back up effect in the Meghna river and seasonal water level variations due to monsoon run-off through out the Brahmaputra, Ganges and Meghna basins. In a "normal" year the falling flood appears to take slightly longer to clear from the peak than the rising flood takes to go from dry to its peak extent (50 days as opposed to 60 days). The spatial extents of the falling flood pattern indicate that the flooded area remains as one waterbody up until the second decad of October when it breaks into two major areas, one in the west of zone D and the other in the east of zone D extending southwards through Zone C to include the northern half of Zone B. This is a similar spatial pattern as the rising flood. By the third decad of October it breaks up into at least seven discrete water bodies inter connected only by the drainage channels. By the first decad of November only small localised depressions remain flooded.

The flooding situation for a 1 in 5 high "normal" flood situation is shown for the rising flood in Figure 12.3 and a falling flood in Figure 12.4. The major differences between the high "normal" flood and the "normal" flood are that the high "normal" flooding starts 20 days earlier (second decad of June) and the peak flood extent is reached by the third decad of July rather than the first decad of September. The high "normal" flood thus starts 20 days earlier, rises quicker and hence reaches its peak extent 40 days before a "normal" flood. However the spatial extent of the high "normal" peak flood is no different than a "normal" flood but it remains at this extent for much longer (50 days instead of a maximum of 20 days), only starting to fall after the third decad of September. However it falls much more quickly than a "normal" flood, (40 days instead of 60) and this would seem to confirm that the major drainage constraint to the area is the water level in the Meghna river. It must however be remembered that although the inundation of the flood plains is considered a constraint to

agriculture, there are benefits to fisheries production. The spatial variation and timing of the flooding is crucial both to crop planting dates and fish migration, spawning and growth. The balance between these two production systems and an understanding of how this varies according to the flood return period is crucial in considering and assessing any proposed intervention which changes this, both in terms of flood extent, duration and timing.

Other natural environmental issues considered include water quality (mentioned in Section 6.3 of this main report) with sample results being shown in and locations given in Annex H. A conclusion of this work is that the main Meghna river water at Rahmatkhali regulator has low salinity, lower than that found in the study area during the wet and dry seasons, both of which are in any case low for all use parameters. Main river erosion and accretion patterns derived from time series Landsat imagery over the last 20 years are shown in Figure H.2.9 of Annex H, and show the only major problem to be main bank erosion on the Meghna in Zone A estimated to have been 13m per year since 1989. The longer term trend can be seen by study of the 1931 map overlain with the present situation in Figure 6.6. For land resources, the situation with regard to soils has already been outlined in Chapter 3 of the report, with the FAO 1988 agro-ecological zone mapping being given in Figure 3.2 soils in Figure 3.3 and land capability in Figure 3.4. Attempts to obtain the existing surface soil chemistry data for the area were unsuccessful, but the national soil chemistry standards for agricultural use are given in Table H.2.3 of Annex H. The broad conclusion is that soils are not a major constraint to agricultural development but careful management may be required under drained and irrigated conditions. The situation with regard to ecology has been given in Section 6.2 of this Report and habitat mapping along with vegetation zones are shown in Annex H (Figure H.2.14). The situation with regard to fish distribution is given in Figure H.2.30.

12.2.2 The Human Environment

The most notable feature of the human environment is the very high population density and the long length of time that the area has been settled (from 350 BC at least with stable administration from before the 9th Century AD). The history of settlement in the area has been given in Section 6.6.1 of this report, along with an indication of known archaeological sites and landscape considerations. Formal political adminstration has been well established in the area and the boundaries of the units have been fixed for a considerable time. These are shown in Figure 12.6 and are based upon the BBS Small Area Atlas data and Police Station Maps which in turn are based upon the 1913-16 survey maps of the area, amended in 1931 and reproduced in the Government Gazetteers.

There is significant differentiation in population density across the area, although the only presently available complete data is for 1981. In 1981 the density varied from below 750/km2 in the south western newly accreted and settled lands to over 1750 per km2 in the peri-urban areas round Noakhali, Begumganj and the old administration town area around Lakshmipur. The mean density in 1981 would appear to be around 1000-1250 people per Km2. The situation in 1991 for the south east portion of the study area is given in Annex H together with the trends for this area between 1981 and 1991. This indicates some decline in localised peri-urban areas, possibly due to local in-migration to the larger towns. Otherwise there appears to be a general increase although this is highest in the urban centres and lowest in central parts of Zone D. However the full data set is required to sensibly interpret the picture, particularly for the south west part of the study area which is very different than the rest.

Figure 12.6

Administrative Boundaries

The 1981 distribution of landless households (defined as having less than 0.02ha of land) is given in Annex H. In general the rural figure is about 30-40% which is lower than many parts of the country, perhaps an indicator that dispossession due to river bank erosion is not a major problem in the study area. The highest levels are found in the urban areas and are between 50-70%. Similar data for 1991 is available for the south east part of the study area and the difference between 1981 and 1991 for these areas is described in Annex H and G. This shows a very fragmented pattern with some 20% of the Unions (mainly the more peripheral rural and smaller urban ones) having decreased landlessness. This may well be the result of out-migration from these areas to the larger urban towns. Overall there would seem to be an increase in landless households of some 5% over the 10 year period, a normal situation for Bangladesh.

The proportion of households in 1981 with agriculture as their main activity is highest in the south western area. This is newly accreted and settled land with poorly developed urban employment sectors. apart from this the pattern is again very fragmented with general levels of around 50-60%. The lowest levels are along the north south spinal road and rail system routes. The 1991 data for the southeast area is shown in Annex H with the difference 1981-1991 for the same area. The 1991 map shows a very different situation than the one in 1981, with a nucleated pattern from a centre of low agricultural employment at Begumganj unevenly spreading outwards. The 1981-1991 change map shows highly variable patterns and without the full 1991 data set it is unwise to read much into this.

Literacy rates for 1981 are given in Annex H and G and are very low in the south western part of the study area being less than 20%. This is possibly due to the fact that the area is relatively newly settled land with fewer facilities than elsewhere. In addition it is likely to have encouraged in-migration of dispossessed people who are probably poorer than the average and less well educated. The highest literacy rates (50-60%) are recorded in the immediate urban area of Noakhali town followed by the north central part of the study area with levels of 40-50%. Similar data for 1991 are available for the south eastern part of the study area and they show that there has been a considerable improvement in literacy rates in some areas although the high levels in Noakhali town have declined, presumably as a result of in-migration. However a complete set is required to sensibly interpret this data.

This again illustrates that in order to carry out any sound socio-economic assessment of the area it is imperative to have the 1991 BBS data. This can then be mapped and then trend mapping produced to see the complete picture of the change over 10 years. From this detailed household surveys can then be carried out sampled from a known population using relevant spatial and social criteria for the intervention being considered.

It is impossible to map land use in a formalised way in much of Bangladesh due to its complexity in both seasonal and spatial terms. Even attempts to do this using detailed SPOT multi-spectral satellite imagery down to 1:25 000 have failed to produce useable information (see the work of FAP 3) and if anything have confused the situation still further. Instead a conceptual model is required which combines the agro-ecological zones (Figure 3.2) with flood timing (Figures 4.2, 4.3, 12.3 and 12.4) and depth to the seasonal cropping calendar and also how this varies across the different flood zones. This demonstrates the importance of flood timing, extent and depth on the cropping pattern and agricultural production system in the area.

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The level of fishing activity in the study is very varied indeed, but approximately 15% of households (60 700 households) depend on fishing to some degree. The degree of household dependence upon fishing for both economic livelihood (full time and part-time fishing households) and for directly consumed animal protein (occasional fishing households) shows that some 4% of households are primarily dependent upon full time fishing, with the figure in zones A and D being nearly 7%. The number of part time fishing households (i.e. doing it as their second economic activity for cash sale) is overall very low at 1% again with the highest figures in Zones A and D. The proportion of occasional fishing households is around 10% and looks to be concentrated in the flood plain areas in Zones C, followed by A and B with the lowest figure in Zone D. It is not known how many of the fishing dependent households are involved in culture fisheries as opposed to capture fisheries. In all the area presently produces an estimated 23 600tonnes of fish, 65% of which are from ponds, the rest being capture fisheries, by far the majority of which come from seasonal flood plain fisheries. Overall the most production is estimated to come from Zone D followed by Zones B, C and A. The relative importance of capture fisheries by zone is also the same, concluding that the pond production diffusion spatial pattern maybe similar to that of floodplain fisheries production. There is insufficient data to ascertain the degree to which fishing dependent households rely upon capture and culture fisheries.

The picture with regard to health and nutrition has been briefly outlined in Section 6.5 and is given in detail in Appendix 4 of Annex H of this report. In Annex H Figures H.2.34-H.2.37 show the prevalence of Diarrhoea, Malaria, Skin Disease and Night Blindness respectively. The conclusions are that, whilst overall the levels of disease are lower than the national average, they are still significant and in some specific areas there are pockets of high incidence. There is a problem with diarrhoea in Zone D (6% of the population are effected) and malaria in Zones A and B with a serious outbreak reported there in April/May 1992. The level of skin diseases was generally high throughout the year in all zones effecting 17% of the total study area population. Night blindness was very variable, with a serious and escalating problem at Ramganj in Zone D and a one-off high recorded incidence in March 1992 at Laksmipur in Zone A.

The nutritional level of people in the study area, whilst above the national average, is still cause for serious concern. There are general problems of malnutrition, with a particularly serious problem in children under the age of five in Zone A. There was a general lack of vitamins in diet, despite the reasonable level of vegetable consumption, with the most serious problems in Zone D. Fresh fish were by far the most important source of all protein, with meat and Dal consumption being very low indeed and virtually all Dal being purchased rather than grown. The main source of fresh fish was markets, but consumption from own ponds was significant in Zone B. However the nutrition field studies were carried out in the dry season and consumption was only recorded from Khals and not floodplain sources. This is probably a serious omission from the overall picture of nutritional sources.

The situation for domestic water supply has been given in Section 6.3 and whilst the levels of deep tubewell use were found to be quite high when compared to the national average this reflects the fact that this is the only way of obtaining safe drinking water in the area. Ponds were still being used as drinking water in some parts of the study area and this, along with poor sanitation and health education is probably the reason for the levels of diarrhoeal disease.

Transport access through the centre of the area is good with a tarmac road system and the railway line. However it would have been improved considerably for the peripheral areas (particularly the western edges of zone A and D) if the major embankments had been constructed for dual purpose use as flood protection and all year flood proofed roads. The road network is on embankments and these have implications for effects on flood patterns. The waterborne navigation system is now very limited, especially since the area was embanked and is no longer on the coast. The water control structure at Rahmatkhali prevents boats entering the southern part of the study area. There is also insufficient water in most of the Khals during the dry season and many of them are chocked by water hyacinth. There would appear to be extensive small boat transport in flood times in cases where homesteads are left on raised areas surrounded by water.

12.3 Development Proposals and Impact Assessment Methodology

12.3.1 Development Options and Strategies

The drawing up of intervention strategies for the study area was carried out as part of the FAP 5 Regional Study and outlined in the Draft Regional Plan put forward in April 1992. These water and land development options were then rated by priority and this resulted in the Feasibility Study for Noakhali North area being commissioned. This was to be carried out simultaneously with the Gumti Phase II study using the same staff.

As stated in Section 12.1.1, the aim of the environmental component of the study is to review the previously selected Noakhali North Drainage intervention proposal to see if, overall, it is considered to be sound from an integrated environmental perspective. This process should allow the principal negative impacts to be identified and their differing social and spatial variation to be studied. Provided it is considered sound overall, then recommendations are to be made as to how any negative impacts could be avoided or mitigated for, within the framework of an integrated Environmental Management Plan.

12.3.2 The Proposed Intervention

The intervention proposed for the Noakhali North area is to widen, deepen and grade the bed of 200km of the main drains and Khals upstream of the Rahmatkhali Regulator. In addition the regulator itself is to be enlarged from 14 to 24 gates, increasing its peak capacity from 300cumecs to 540cumecs, and its operation improved. The overall aim is to remove the constraints to drainage within the present system to allow faster out-flow in the monsoon season and also inflow of water in the dry season (using tidal back-up flow and two way flap gates) for surface irrigation supply. The intervention is illustrated in Figure 11.1. The locations and quantities for Khal excavation have been optimised using the hydraulic modelling so that the drainage outflow has no bottlenecks and also allows the maximum possible dry season inflow based upon tidally induced back-up flow.

The proposed intervention construction programme is phased over a five year period with a significant demand for construction labour in years 3,4 and 5. Due to the optimisation of the hydraulic flow of the Khal deepening programme, it does not easily lend itself to a long term incremental approach with an option of only partial implementation. It is essentially an "all or nothing" intervention, although it is proposed to spread construction over a five year period, which is likely to provide more sustainable social and local socio-economic benefits than a shorter construction period. It could be possible to delay or stop construction during the five year period if for any reason there were constraints to full implementation. However this would require that construction

was systematically implemented from the downstream to upstream so that a partly implemented programme would be operational, if over-designed.

The basis for data collection and analysis of the impacts are the Planning Zones shown in Figure 12.2. These zonal boundaries were drawn up early in the study using the MPO Flood Zones (Figure H.2.4) and the 1988 FAO Agro-ecological Zones (Figure 3.2), before the results of the MIKE 11 hydraulic modelling for the area were available. Once the model results for the present situation were plotted in map form, it became apparent that the boundaries between Zones A, B and C did not fit the flooding pattern as had been intended. This has resulted in the spatial impact analysis being of less use than it could have been, as Zones B and C are very mixed and do not show the benefits and dis-benefits to flood plain reduction nor the benefits of dry season surface irrigation as clearly as they could.

The identified impact zones are shown in Figure 12.7 and comprise the deepened and widen Khals, the predicted dry season surface water irrigation area, the area of peak "normal" floodplain which will remain unflooded due to the intervention and the peak area of floodplain which will remain after the intervention. However the floodplain which remains will be inundated for a shorter time. It can also be seen that there are adjacent areas to the study which presently flood but will not do so after the intervention or will flood for a shorter period. The with intervention results of the hydraulic modelling for both a rising and falling flood in a 1 in 2 "normal" and 1 in 5 high "normal" flood are shown in Figures 12.8-12.11. The differences in floodplain extent in the with and without intervention for a 1 in 2 "normal" flood are shown by decad in Annex H and interpreted in Section 12.3.4 below.

12.3.3 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 12.12 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 4.3million person days per annum. These estimations are calculated using the FAP Guidelines methodology with the stipulated crop prices.

Figure 12.7

Impact Zoning Map

Figure 12.8

Extent of Rising Flood with Intervention, 1 in 2 Year

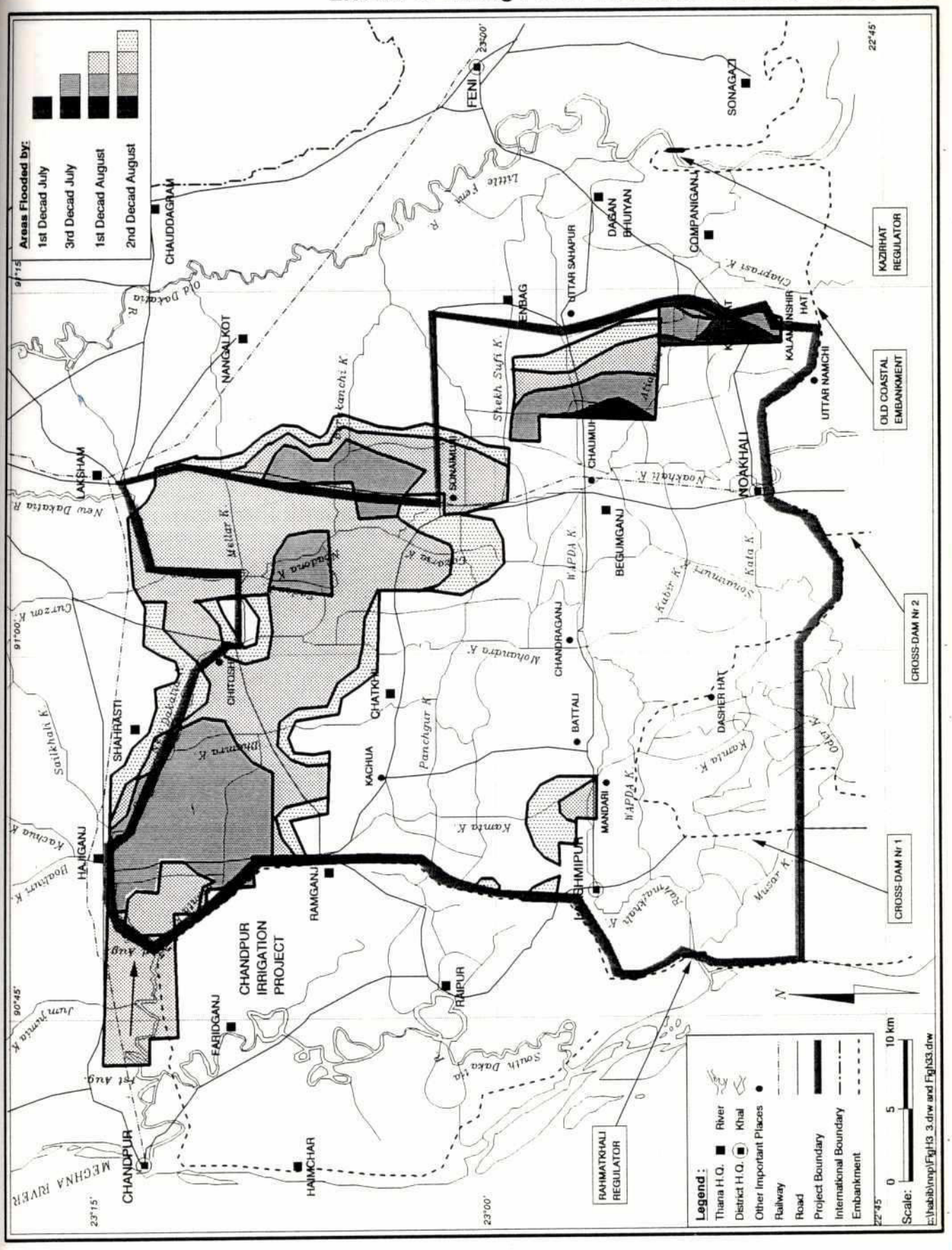


Figure 12.9

Extent of Falling Flood with Intervention, 1 in 2 Year

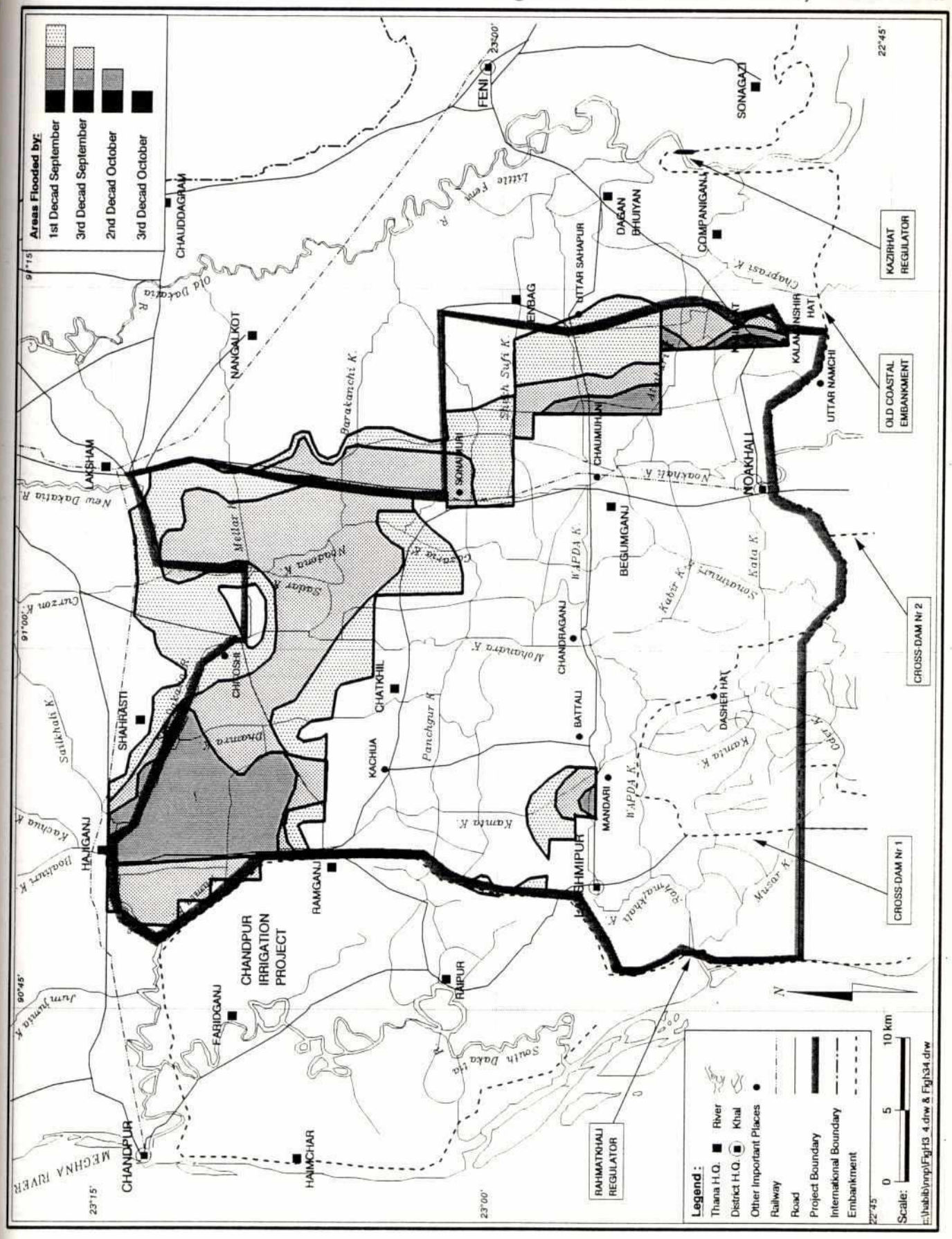


Figure 12.10

Extent of Rising Flood with Intervention, 1 in 5 Year

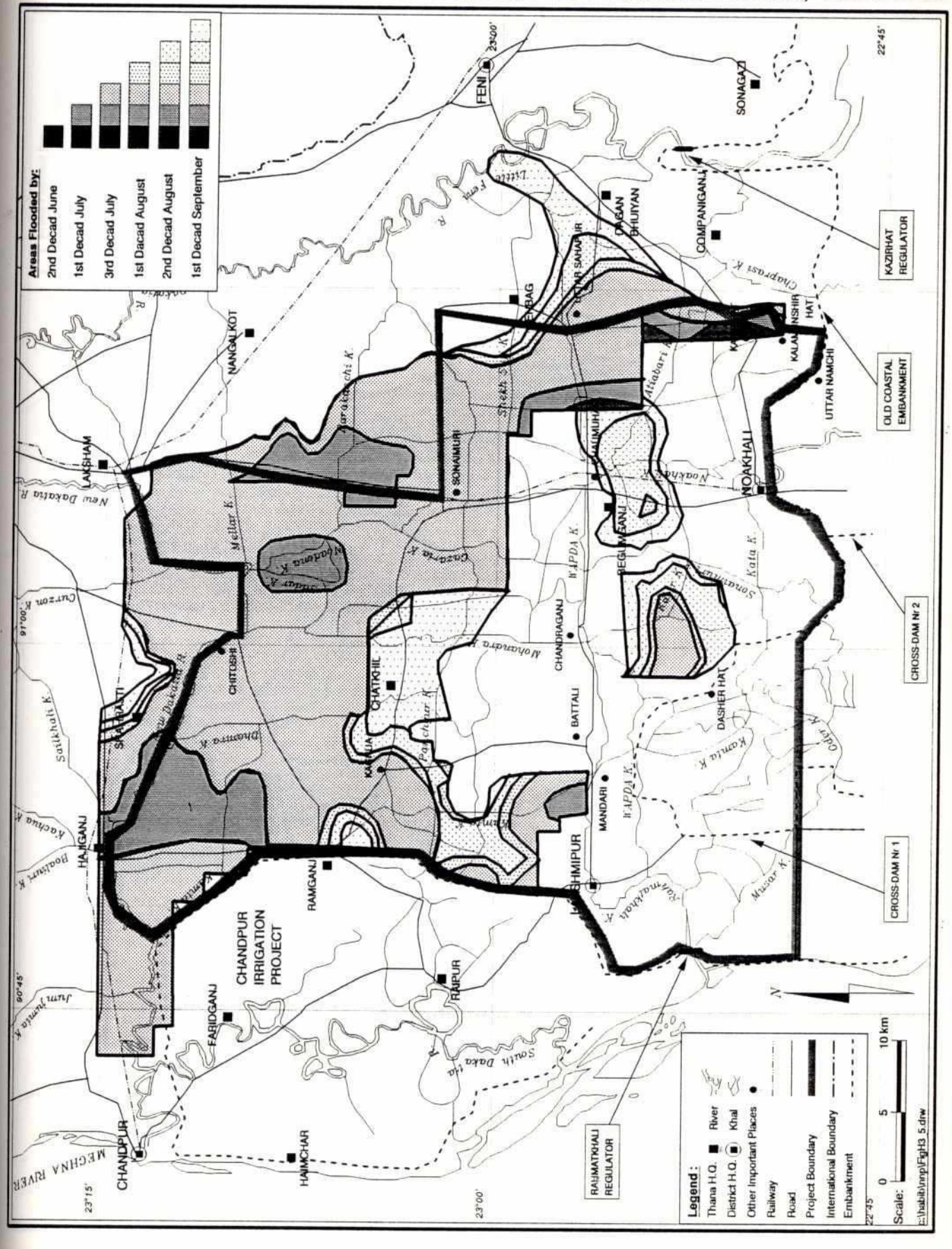


Figure 12.11

Extent of Falling Flood with Intervention, 1 in 5 Year

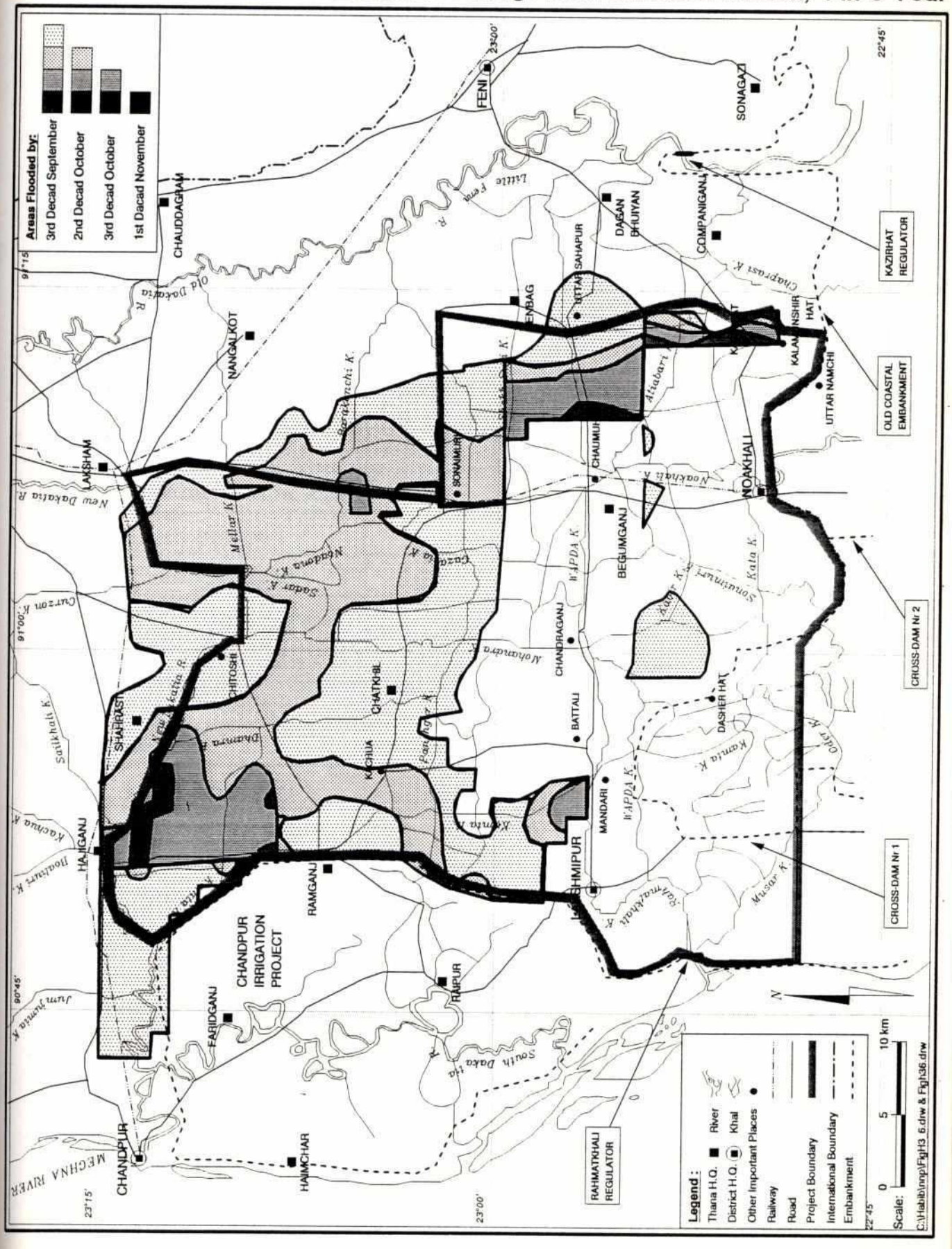


Figure 12.12
Environmental Rating Matrix of Proposed Intervention by Zone

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 (#)											

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		

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.

12.3.4 Hydraulic Modelling of the Intervention

As stated above the intervention has been subject to hydraulic modelling, both for a 1 in 2 "normal" year and a 1 in 5 high "normal" year. The outputs from this work are shown for rising and falling floods in Figures 12.8-12.11 In addition these have been compared to the without intervention situation and the differences mapped by decad are shown in Annex H. In addition the areas of flood plain for each decad were tabulated for each zone for the with and without intervention situation. This work indicated that overall the mean reduction of flood plain area in a 1 in 2 "normal" flood year was 81% in Zone B, 62% in Zone C, 34% in Zone D and 40% in the external areas with Zone A remaining unflooded in the with intervention situation. This gives a mean loss of 48% of floodplain area in the with intervention situation.

The peak extent times of flooding were slightly changed, but this varied according to zone. The peak was brought forward by 10 days in Zone B, stayed the same in Zone C and the external area but was delayed by 10 days in Zone D. The present project "normal" peak floodplain area was given as 73 111ha (from a total study area of 110 212ha) with a further 23 516ha in the external areas. With the intervention this is reduced to 46 653ha and 15 608ha respectively at peak times. However this reduction in peak flood extent was significantly less (10% of the total flood plain area) than the mean seasonal change in overall floodplain area. This would seem to indicate that the intervention is efficient in reducing early and late flood extents but is less so during peaks of a "normal" flood year.

The decad mapping confirms this to be the case overall, however there are very great spatial variations with this. The intervention appears to be very effective in delaying the onset of very early (first decad of July) "normal" flooding in all areas except the very east of Zone B. However by the end of July it is ineffective in the north west part of Zone D, the Laksham Depression in Zone D and the external area east of Zone D as well as continuing to be so in the east of Zone B. From this time the "normal" rising flood would appear to be almost as rapid as without the intervention. However the overall peak extent occurs about 10 days earlier, being in the early part of the third decad of August, and the extent reduced by at least some 40% (see Figure H.3.17). The intervention is very effective for "normal" floods in all but the eastern parts of Zones B and C and the northern half of Zone D. It is also as effective overall in the external floodplain areas. It also allows the falling flood to be some 20 days quicker with only the very eastern part of Zone B and the north western part of Zone D flooded by the second decad of October. Even these two areas are virtually dry by the third decad of October.

In a 1 in 5 high "normal" flood the intervention is slightly (about 5%) less effective overall at reducing the peak flood extent than in the 1 in 2 year situation. However it is effective in keeping the peak flooding extent reduced for a considerable length of time (about 40 days). The rising flood is delayed by about 10 days in the north of Zone D and by 20 days in the east of Zone D and prevents flooding in much of the rest of the study until the third decad of July, when the peak extent (about 70% of the high "normal" without intervention extent) is nearly reached. This is some 25 days earlier than without the intervention. The exception to this pattern is the eastern part of Zone B, where the intervention appears to be far less effective than anywhere else in preventing the speed of rising flooding but very effective in reducing the peak flood extent. The duration of the peak extent is, if anything, made slightly longer but at a lower level over a smaller area. It allows the flooding to start receding some 20 days earlier and whilst the flooding falls significantly faster than in the 1 in 2 year with and without project situations it is not as quickly as the 1 in 5 year without intervention situation. In all the area is completely free of flooding some 10 to 15 days earlier than without the intervention. This again would seem

to confirm that the major constraint to drainage of the area is water levels in the Meghna river. It appears that the intervention is effective at greatly reducing this constraint but not fully overcoming it.

The outputs of the hydraulic model were also used to study the effects on Khal and drain water depths, bearing in mind before and after intervention bed levels and water levels. Sample points in the drainage system were taken (the locations are shown in Annex H) and the mean yearly water depths calculated for a with and without intervention situation for a "normal" year. This indicated that, as planned, the deepened Khals have significantly more water in them (up to +2.6m in one case, but the average was +1.25m). However outside this there are non-deepened Khals which are drained quicker and earlier as a result of the intervention, leaving them for longer periods with less or no water. Whilst the mean annual figure was not great at -0.25m, there are localised places where this could be of concern, especially in the southern part of Zone B where the figure was -0.45m. However it may be that in the longer term the channels may regrade themselves and the effects will be less marked.

12.3.5 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 impact matrix should be considered in relation to the Impact Zoning Map, Figure 12.7.

The comparative impact assessment matrix for the proposed intervention is given in Figure 12.12. 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 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 12.4 and those lesser issues with a rating of -2 are dealt with in broad terms.

12.4 Principal Negative Impacts of the Proposed Intervention

12.4.1 Introduction

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 12.5.2 and 12.6.3. 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.

12.4.2 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 the differential flood mapping in Section 12.3.4 above. 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.

12.4.3 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 this report and the estimated production changes for the intervention by fishing system and zone are given in Table 4.3. 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 3645tonnes (13% of the total) in the study area and 737tonnes 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 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 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.

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12.4.4 Socio-Economic and Livelihood Impacts

A Social Impact Assessment (SIA) has been carried out as part of the socio-economic studies and is written up in Section 4 of Annex G and summarised in Chapter 5 of this Main Report. 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 76ha of land to be acquired for permanent works although this could in theory be offset to some extent by 19ha 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 457ha of permanent land acquisition. However if the spoil were to be thinly spread this would effect 3633ha 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 (see Tables J.5.1 and J.5.2) 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. However 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 4.3million 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. Suggestions for this are made in the SIA section in Annex G and included in the implementation programme (Chapter 13).

12.4.5 Fuelwood and Grazing

The complex linkages and interaction within the rural energy system based around crop residual availability and nutritional status as feed, linked to livestock numbers, draft animal requirements and the availability of power tillers, are likely to change as there is an inevitable reduction in common grazing land availability reduction as agriculture intensifies. This is the case with or without an intervention, but is likely to be made worse under intervention conditions unless there is a targeted programme to address this. A crucial factor is the change in availability and quality of straw for stall fed cattle feed and the competition for its use as domestic fuel and building material. Fuel wood now appears to be in short supply and reserved for commercial users such as brick making and pottery as it is so scarce and expensive. Animal dung is also now being used as fuel, particularly in the peri-urban areas and hence not being used as fertilizer. This tends to result in greater use of artificial fertilizers with a risk of wrong or over application leading to increased risks of algal blooms causing water quality problems in both surface and groundwater.

It would seem likely that the situation in the study area is likely to get more difficult irrespective of any intervention, but the intensification of agriculture could make this more significant. It is likely that demand for draft animals will increase and the lack of grazing land will prove to be a major constraint. However it has been predicted that the overall availability of rice straw will increase, the increase in production of short stalk, lower nutritional rice residues being sufficient to produce a greater useable volume. Whilst this may be able to sustain the same or larger animal numbers, it will require many of the grazed animals to be stall fed in future.

The promotion of social forestry at homesteads and on embankments can go some way to providing domestic fuel sources. In addition the use of power tillers, which whilst having sustainability issues of their own, would seem to relive pressure on a stressed system.

12.4.6 Change in Patterns of Specific Waterborne Diseases

The impact rating matrix has indicated that there is likely to be a problem with water borne diseases in the area. This is complex and difficult to predict, but on recent trends it would seem that these are likely to increase irrespective of any intervention but a drainage intervention could increase the risk of these to the point where it becomes a significant issue. At present there are serious diarrhoeal disease problems in Zone D and it is predicted that these are likely to get worse unless there is a targeted programme of sanitation, water supply and health education to tackle these issues. There appears to be evidence that the annual flushing effect of flooding is useful in diluting and removing the sources of diarrhoeal disease. There is a fear that if annual flooding of the land is curtailed then there is likely to be an increased risk of diarrhoeal disease. Surveys carried out for the Gumti Phase II study would seem to indicate that flood protected areas have higher diarrhoeal disease rates.

There has recently (April/May 1992) been a serious outbreak of malaria in Zones A and B, although this is assumed to be the non- fatal Benign Tertiary vivax strain carried by culex mosquitos. There is a strong possibility that conditions in the post construction situation next to Khals with all year standing water and the prevalence of irrigation will increase the habitats for malaria carrying mosquitos (see WHO/Tiffen). This requires a detailed baseline data collection programme and subsequent monitoring to gain sufficient knowledge to tackle this issue.

12.4.7 Human Nutritional Consequences

As mentioned above, the loss of fisheries resources to occasional fishermen is likely to have serious localised problems in the reduced flood plain sections of Zones B, C and D. The total number of households likely to be affected is estimated to be 20 000 which while locally significant is only 5% of the overall population. When compared to the predicted agricultural benefits to the area (a 23% increase in rice production) the loss is less significant, particularly if the predicted increases in agricultural labour (4.3million person days per year which is equal to 4.8 times the predicted losses to fisheries labour) are realised to occasional fishing households and this allows them to earn sufficient income to buy fish in the market. This is especially the case if a targeted pond aquaculture programme were set up to provide alternative livelihoods for the 3500 full and part-time fishermen that are estimated to be dis-benefitted. It also appears that this process is already happening in Zone B where 40% of fisheries consumption in the sample site was from households own ponds.

12.4.8 Soil Fertility Issues

These issues have been outlined in Chapter 3 and apply to any area which is proposed to be drained or come under irrigation. They are not thought to be of immediate concern in the study area, but there are implications for the drained and irrigated areas in the medium to long term (i.e.5-10 years). This is particularly the case if continuous mono-cropping of rice is to be carried out in any areas. An appropriate baseline data collection programme will be required, along with access to the existing SRDI surface soil chemistry data. This then needs to be followed by a monitoring programme and a feedback system that allows crop, soil and water management policies to be modified if these are thought necessary.

12.4.9 Potable Water Issues

The present situation with regard to domestic water supply has been outlined in Section 6.3 and was also addressed in the health and nutrition field work. In addition the public participation studies indicated that in 10 of the 13 responding villages local people considered that the water supply was inadequate. This was reinforced by the health study which showed that ponds were being used as dry season domestic water sources in some places. The analysis of the likely future waterborne disease situation in a with and without project situation has been discussed in Section 12.4.6 above. The conclusion would seem to be that irrespective of any intervention there would appear to be a need for increased provision, which is made more important still due to the intervention. However study of the part data from the 1991 census indicates that provision levels in the south eastern part of the study area has improved markedly since 1981, although this is uneven. It would seem necessary to review the position as soon as the full 1991 data becomes available and assess the position. The central issue is that in some areas the provision of safe drinking water is seen by some households to be of a higher priority than flood plain reduction, drainage and the provision of irrigation water.

12.4.10 Change in Flora and Fauna

The assessment of the effects of the detailed interventions on the ecological system are given in detail in the Ecological Annex D. The natural fisheries system is likely to suffer the most serious problems, especially in the floodplain areas of Zones B, C and D. In addition, the clearing of 200km of drainage channels is likely to cause significant changes in the flora and aquatic flora in the Khals. This has implications for future Khal ecology and suitable habitats for improved and managed fisheries.

These resulting changes in habitat and are extremely difficult to predict, especially in the case of an area where the present situation would seem to be in decline irrespective of any intervention. A baseline monitoring system will be required in those Khal areas and also on the impacted and non-impacted flood plain areas.

Construction impacts on the ecology could be severe in the Khal excavation areas if this is not appropriately managed. However many of these issues can be avoided by careful planning and allowing regeneration to occur more quickly in places where there may be some longer term benefits. Development of social forestry on embankments and homesteads may help provide added habitats, but alternative replacement for the two main flooded depressions at Begumganj and Laksham would seem impossible to provide and a decline in water birds seems inevitable. In terms of human use, it would be worth doing a check on important medicinal plants in the Khals to be deepened and also in the impacted flood plain areas, to see if these are important enough to consider the availability of replacement sources.

In terms of pests, the water hyacinth is a serious problem in the water courses and will need to be continuously cleared if drainage and irrigation supply is to remain unimpeded. Enquiries with the paper making operation at Feni indicate that they can take cut and bundled stalks. Alternatively it may be worth considering setting up a similar operation within the western part of the study area. This would need careful consideration in co-operation with the relevant NGO technical specialist at the Mennonite Central Committee. The incidence of rats and ways of natural control of these need to be investigated as this has proved a serious problem in some drained areas in other parts of the country.

12.4.11 Disruption to Waterborne Navigation

The present use of larger country boats is presently restricted to the Dakatia river as the construction of previous interventions has prevented the movement of such craft into the study area. There is in any case insufficient draught to allow dry season navigation even if access were possible. Of more importance are small passenger and goods boats which are commonly used on the flood plain areas in the monsoon season. These will be restricted to the reduced flood plain areas and reliance will need to be switched to road transport as is the case in the dry season. There is therefore likely to be little problem in provision of a replacement monsoon service, although unsurfaced roads may need improvement to make them suitable for all weather use. It would also help if the existing flood control embankments were adapted for dual purpose use as roads. The unknown factor is the degree of livelihood loss that is likely to be suffered by boat owners, operators and builders along with secondary links to freight transport, if any exist. Study of this requires a highly specific targeted data collection programme and set of analysis. however the issue is not considered to be significant.

12.4.12 External Impacts and Constraints

An indication of the likely upstream and downstream external constraints and impacts to and from the intervention are shown in the matrix. However there is insufficient data to adequately address some of these and overall there are too many unknown factors, especially the likely nature of FAP 6 upstream proposals and the possibility of embanking the right bank of the Padma river. However most of the issues would appear unaffected and the main downstream constraint of Meghna main channel water levels, which is the most crucial aspect of the hydrology of the study area, is the very issue that the intervention addresses. Also the modelling has tested a 15 cm rise in Meghna levels at Chandpur and the proposed intervention seems insensitive to changes of this magnitude.

12.4.13 Direct Construction Impacts

The most serious direct construction impacts are likely to be the requirements for land acquisition which has implications for compensation and resettlement needs. These have been outlined in Section 12.4.4 above and the Social Impact Assessment section of the Sociology Annex. The detailed location and design of the deepened khal will need to bear these issues in mind so that they are minimised and if possible avoided. Under World Bank Operational Directive 4.30 it is likely that a resettlement and compensation plan will need to be drawn up. However detailed enumeration and asset inventory work is required before this can be done. This is best done using low level enlarged air photography to update cadastral mapping. A detailed asset inventory will need to be done at some stage, but it may be worth doing this in the following study stage, provided a freeze is enforced on all land transfers and new development in the area to be acquired. In addition a socio-economic assessment survey of directly effected households will need to be carried out to formulate a suitable resettlement and compensation strategy. It would also be worth reviewing the land acquisition experiences of the Coastal Embankment Rehabilitation Project (CERP) to see where problems are likely to arise and how they can be adequately dealt with. The whole question of environmental considerations to contractors operations will need to be reviewed once there is a clear idea as to the likely organisation and prioritorisation of the construction programme and the detailed nature of construction technology that is to be used. The present review being carried out of the CERP Phase 1 construction issues will be valuable in doing this.

There are likely to be significant socio-economic benefits offered by the construction works, especially when this is designed as an intrinsic consideration in the planning of the construction programme. If appropriately phased and using labour intensive construction techniques this is likely to provide some 10 000 dry season wage paid jobs over a three year period. The use of Labour Contracting Societies (LCS) has been mentioned above and in the SIA. This could be particularly valuable for disadvantaged groups and when combined with a responsive public participation institutional structure and supervision, could ensure that the work is carried out to a high standard.

12.4.14 Hazard Risk and Sustainability

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 drainage system has been full and resulted in localised changes in ground levels and gradients. Whilst this is nothing like as severe a constraint as for a flood protection embankment, it is still a consideration for sustainability of the intervention, even if it is an infrequent occurrence. The issue of relative sea level change has been reviewed and the latest work predicts a possible rise of some 0.1m over the next 30 years due to global warming. This level of increase is insignificant in terms of project viability. Seismic activity may have far more serious consequences to relative land and sea levels than global warming.

The other factor that would seem important is sedimentation of the drainage system. It seems that the system has suffered from siltation in the past, although the source of the material would seem to have to come from within the study area. The main cause of this could possibly be field run-off and drainage bank collapse. It is thus imperative that the Khal deepening work is carried out according to the design so that this can be avoided and prevent the need for recurrent desilting of the drainage network. Even so it is planned that an on-going de-silting operation will be needed, and using the FAP Guidelines operation and maintenance procedures it has been

estimated that 1 000 people will be needed to achieve this. Whilst this is likely to provide the benefit of regular employment for these people, a workable system of raising this revenue from beneficiaries is required. The record for achieving this in Bangladesh is presently very poor and the institutional arrangement for doing this need to be carefully established. Recommendations are included in Chapter 14.

There are a whole group of social impacts, particularly those at individual household level which have implications for risk levels to socio-economic livelihoods. The major issues have been discussed in Section 12.4.4 and are dealt with in more detail in the Social Impact Assessment in Appendix G of this report. Other household livelihood risks, including those to boat owners, operators and builders, have been mentioned above. The real difficulty is that it is impossible to assess these realistically in detail as there is insufficient data made worse by the fact that much of the 1991 BBS census work is still unavailable. A detailed social impact assessment component with a baseline monitoring survey will be required in any follow-up work to the study.

In overall environmental terms the engineering design of the intervention is relatively robust, and from an energy use point of view it is very sound indeed, effectively harnessing the tidal power of the sea to use it as a ram pump. Its operation has been deliberately designed to be as simple as possible, with the minimum of human intervention so that a predicable water regime results and potential beneficiaries can then have faith in it to invest their resources to use what it has to offer in the most advantageous way for them.

A major issue in terms of economic sustainability is how any intervention programme is to be funded, be it a grant or a loan, how this is to be paid back and whether there is a better alternative use for this money.

12.4.15 Summary of Principal Impacts by Zone

The impact assessment matrix indicates the differentiation of impacts by planning zone. However the boundaries between the zones delineated prior to the results of the mapped outputs of the hydraulic modelling being available. It now appears that the boundaries do not correspond with the likely limits of the flooding areas and intervention areas. The intervention and impact zones are shown in Figure 12.13 and a brief summary by zone is given below:

Zone A

Zone A presently experiences no major flooding of agricultural land and the intervention does not change this situation. The deepening of Khals ensures that nearly all the area can be irrigated in the dry season from surface sources. There are no flood plain fisheries, and if anything the fisheries should improve slightly as a result of there being water in the drainage system all year. The area has the greatest possible benefits overall, both in terms of agricultural production (67%), the demand for agricultural labour and construction work opportunities. However the zone is likely to require the largest land acquisition area. There has recently been a serious outbreak of malaria in the area which could be exacerbated by increased all year standing water as a result of the intervention. There remains a serious problem of lack of safe domestic water supply provision to much of the zone and this would seem to be a higher development priority for many households rather than irrigation water. The levels of malnutrition amongst young children are high and there has been a recent occurrence of night blindness. These two factors are possibly the result of unbalanced diets which would probably best be overcome by production of a more diverse cropping system and less emphasis being placed on rice production.

Zone B

Zone B is a very mixed area, a considerable part of it being subject to seasonal flooding, most of which, except the very eastern end, will be stopped as a result of the intervention. However this is likely to result in the most serious fish habitat losses to both the natural ecological system, with implications for bio-diversity, and "common good" fisheries resources which also has nutritional implications for poorer households. It is estimated that the floodplain fisheries will be reduced by 81% and up to 9 800 occasional and 700 full and part-time fishing households could be effected. It requires more detailed studies to find out the proportion of registered fishermen who are engaged in pond aquaculture as opposed to capture fisheries and the ease with which the transition from capture to culture fishermen can be made. Despite the fact that the irrigated area is relatively small, the predicted agricultural benefits are 26% most of this is from increased monsoon season cropping. The wage paid labour that this generates could result in increased incomes and the replacement of "common good" capture fisheries by purchased fish produced from pond aquaculture, a situation which already exists in the zone. There is a large part of the zone which, as a result of the intervention, will be dry all year where as it was previously seasonally flooded. However a considerable part of this piece will not have irrigation water supply and will have to rely upon residual moisture and dryland farming systems. In the south of the zone there are some areas where water availability in Khals could be less than in the pre-intervention situation. There has been a serious malaria outbreak in the area and this could be exacerbated further by the year round occurrence of standing water.

Zone C

Zone C is, like Zone B, a very mixed area with the eastern 70% of it that is presently floodplain being reduced to some 30% located in the extreme east part. This remaining flood plain area will start to drain earlier than in the pre-intervention situation. When combined with the provision of dry season irrigation water to most of the post-intervention flooded land, agricultural production is predicted to increase by some 25%. This is likely to produce significant demand for agricultural labour as well as a short term demand for construction workers. However the flood plain fisheries losses are estimated to be 62% and it is estimated that up to 7 650 occasional and 2 070 full and part time fishing households will be effected to some degree. Again this depends upon the proportion already involved in culture fisheries. There is one significant part in the north west of the zone which is exceptional, as it is not flooded at present and will not receive irrigation water. It appears there will be few direct benefits to this area and this could be the cause of social friction. The level of water supply provision would seem to be less of a problem here than in other zones and fewer health problems have been recorded.

Zone D

Zone D will experience a 34% reduction in peak flood plain extent as a result of the intervention but only a very small part will be provided with surface irrigation water. The khals in the rest of the area will drain faster and have slightly less mean annual depth of water in them. The losses to the floodplain fisheries system are predicted to be 34% and 32% for the Khal fisheries system. It has been estimated that up to 3 500 occasional and 3 400 full and part time fishing households could be effected to some degree. This again this depends on the degree to which fishing households have already switched into culture fisheries, although the ratio of pond production to floodplain is lowest in Zone D due to the high levels of floodplain production. The fisheries loss could be offset to some degree by the additional labour requirement that the predicted 7% increase in

agricultural production is thought to give. There will be little direct construction work in the zone, but it is likely that the demand for construction labour will be high enough that people from Zone D will find it possible to work temporarily in the construction areas in other zones. There are presently poor levels of nutrition in the zone, including night blindness, and the incidence of diarrhoeal diseases is high and could be made slightly worse as a result of the intervention. There would seem to be justification in targeting what benefits that can be gained from mitigation measures to this zone, as it would appear to have the fewest opportunities to take advantage of the intervention.

Adjacent External Areas

The situation in the adjacent external areas is difficult to assess as there is a lack of data and some of the areas are different than others. The intervention results in the lower Dakatia in the north west edge of the study area being made flood free, whereas the peak flood extent is reduced by 30% for the other areas and the mean flooded annual area is reduced by 40% due to shorter duration flooding. The flood plain fisheries are estimated to fall by 14% in the lower Dakatia and 40% in the other external area, a total loss of 737tonnes. No data is available for fishing dependent households nor the significance of other fishing systems.

12.5 Impact Mitigation and Environmental Management Plan

12.5.1 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 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 12.1, 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. Many of the mitigation measures have already been discussed in the previous main Section of this Chapter of this report, when dealing with the main negative impacts. They are dealt with below in order of priority.

TABLE 12.1

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 Construciton Impacts:					
- Permanent Land Loss	Estimate 76 ha	Tk 43.6 million	Possible	None	0
- Temporary land Loss	3633 ha	Estimate Tk 58 million	Possble	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

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.

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.

12.5.2 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 indicated in Section 12.6.3. It would also not normally be considered justifiable to prepare such an Environmental Management Plan until a firm commitment has been given to taking the intervention to further detailed study. The detailed study work will need to be more adequately resourced than the present study if it is to achieve these aims.

12.5.3 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.

12.5.4 Residual Impacts

Table 12.1 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.

12.6 Conclusions, Recommendations and Future Work Programme

12.6.1 Conclusions

The environmental component to the study has attempted to assess the proposed drainage and irrigation intervention to gauge its overall effect on both the natural and human environment. The broad conclusions are that overall the predicted agricultural benefits are high with a 25% increase in rice production. this is valued at TK 351 m/annum and this is estimated to provide an extra 4.3million person days of agricultural labour. The main dis-benefits are the nearly 50% loss to the floodplain fisheries system which are estimated to be 3645tonnes within the study area and a further 737 tonnes outside it when compared to a without project situation six years after completion of construction. The value of this lost fisheries production is estimated to be Tk 47.5 m/annum and the loss in fisheries labour is 0.9million person days per annum, (some 21% of the agricultural labour gains due to the intervention). Although the floodplain losses are high in percentage terms, they are predicted to constitute only 34% of the total fisheries production at present and 27% in the comparative without project situation. The major implication of this is the loss of "common good" directly consumed fish to, at the most some 20 850 occasional fishing households. A maximum of some 4 660 full and part-time fishing households are expected to have their livelihoods jeopardised to some degree as a result of the intervention and this represents some 1% of the total study area population. The resulting nutritional losses could be mitigated by targeting the increased wage paid labour to non-farming occasional fishermen, allowing them to earn sufficient cash to buy fish produced by expanded aquaculture programmes that could be targeted to the effected full time fishing households. There is some evidence that this is already happening in one part of the study area, but further, more detailed studies are required on this. Concern must be expressed that the fisheries dis-benefits in Zone D and the immediate adjacent areas may not be fully matched by agricultural benefits in these areas and this could be socially divisive unless mitigation measures are implemented in this zone.

There are likely to be localised issues of land acquisition for permanent construction works, and in all some 76 ha are required for this purpose. In addition land will be required for disposal of excavated spoil, either 457ha permanently or 3633ha temporarily. The latter is slightly more expensive but is on principle to be preferred on socio-economic grounds. The need for land acquisition raises issues of compensation and possible resettlement. Under the World Bank Operational Directive 4.30 a resettlement and compensation plan needs to be drawn up. This requires detailed cadastral, fixed asset and household livelihood surveys so that a resettlement strategy that maximises effected peoples choices, can be drawn up. However the numbers of people that are likely to be effected are very small when compared to the total population of the study area and the likely beneficiaries. It is however vital that this work is carried out in close co-operation with the effected households and that compensation is seen to be fair, equitable and timely.

There are other less serious negative impacts but these do not detract from the major issues which concerns the justification for increasing agricultural production (specifically rice) by some 25% and valued at Tk 351 m at the expense of the Tk 47.5m value of lost fish production. In the process a maximum of 25 500 fish dependent households (some 6% of the population) are likely to be dis-benefitted to some degree although targeted mitigation programmes could address this to a great degree. This also raises the issue of likely changes in future rice prices and if these will remain at the levels used in the economic analysis for the study, especially bearing in mind the recent falls in these due to increased output.

12.6.2 Recommendations

From the impact assessment work carried out so far it can be seen that the intervention has significant predicted increases in agricultural production, and the losses due to dis-benefits, whilst significant to 6% of the households in the study area, appear to be heavily outweighed by the cash value of the increased agricultural production. With targeted mitigation programmes it is considered that the major dis-benefits can be overcome. However detailed and highly specific follow-up studies are required over a minimum 12 month data collection period to obtain suitable information to address the design of mitigation interventions and provide baseline monitoring data.

The decision to proceed with the following Detailed Design phase of the study therefore is a matter of policy priorities. Should the floodplain fishing system of Noakhali north, which has already been negatively impacted by past FCD/I interventions, be reduced still further to provide increased agricultural production, specifically rice? Based upon the economic analysis it would appear that due to the relatively simple nature of the intervention, along with significant social benefits that could result during its construction, the Noakhali North area seems to present a better place than many in Bangladesh to promote the development of agriculture.

12.6.3 Future Work Programme

Data collection programme

Assuming that the proposed intervention is found to be justifiable, then a highly specific programme of detailed data collection is required that addresses the issues raised in this impact assessment. Data needs to be collected and tabulated using newly delineated impact zone boundaries. It is imperative that the 1991 BBS data and SRDI soil chemistry data is made available to the study before it commences. The detailed studies need to cover a full 12 month period and include the following components:

- A detailed fisheries study, including a catch assessment concentrating on the flood plain area inside and outside the designated study area. A study of fish migration and species mix in the floodplain area and how this is likely to change as a result of floodplain reduction and changing inundation patterns. A detailed Socio-economic survey of fishing households aimed at trying to ascertain income levels, the degree of dependency on fishing and the split in this between capture and culture fisheries and the trend in this.

- Nutrition surveys particularly concentrated on the occasional fishing households dependent on the floodplain and also targeted households in Zones A and D.

- A detailed field cadastral survey of the areas for permanent land acquisition, plus a full inventory of immovable assets and a household livelihood assessment. A reconnaissance level assessment of temporary land acquisition requirements. This work should provide sufficient data to produce a resettlement planning and compensation strategy.

- Studies of land acquisition requirements, and formulation of an appropriate compensation and resettlement strategy, with significant public participation, to produce a Resettlement Plan under World Bank Operational Directive 4.30.

- A fuel-wood, grazing, fodder and rural energy balance survey.

- A baseline socio-economic survey to ascertain the future income generation capability of irrigated agriculture and construction operations and aquaculture in the area. The 1991 BBS data is required before this can be designed.

- Waterborne disease vector study, especially for diarrhoeal diseases in Zone D and malaria in Zone A and Zone B.

- Soil structure and chemistry monitoring in areas of likely irrigation and drainage areas. This will need access to the existing SRDI chemistry data.

- Detailed flora and fauna surveys of all impacted areas.

- A review of likely direct detailed construction impacts bearing in mind the engineering design, nature of construction contract and the experience with the BWDB implemented Coastal Embankment Rehabilitation Project.

Environmental Management Plan

The above data will need to be collected so that the following issues can be addressed in the next stage of the study and form the basis for an Environmental Management Plan:

- Land acquisition, compensation and resettlement plan under OD 4.30.

- Management of stocked Khals in the irrigation area

- Professional Fishermen re-training, probably capture fishermen into pond aquaculture

- Targeted income generation for occasional fishing households aimed at providing sufficient income to purchase replacement protein, probably pond aquaculture fish.

- Targeted income generation programmes for maximising opportunities for wage paid labour from irrigated agriculture and construction employment

- Social forestry programme
- Health programme including water supply, sanitation and health education
- Soil management guidelines
- Flora and fauna management guidelines

CHAPTER 13

IMPLEMENTATION AND PROJECT COSTS

13.1 Introduction

This chapter describes the preparation, design and construction proposals which the study team considers offer a sound method of achieving a well developed project. The principal theme has been to incorporate recent policy initiatives and guidelines and to describe how these can be used to ensure the finally constructed project meets the needs of the local people and adequately compensates those who may be adversely affected.

13.2 Institutional Arrangements

It is vitally important that the institutional arrangements are established as soon as a decision is made to proceed with the project and that the core elements of these arrangements provide good continuity throughout all development stages.

The public participation guidelines issued by FPCO indicate that at the design stage a Project Coordination Committee (PCC) should be established by the implementing agency. This agency will be the Bangladesh Water Development Board (BWDB).

It is recommended that this committee be established initially to monitor the preliminary studies which are needed before the design starts and that this is then continued through all stages through to Operation and Maintenance (O&M).

In the past many projects have been monitored by Project Implementation Committees (PICs) but from the public participation programme it would seem that these committees are not held in high esteem owing to their having been dominated by local elites and vested interests. Thus the PCC must be clearly seen to operate in a different manner.

The PCC should allow representation from the concerned central government and local government agencies and their officials, and also from elected public representatives (eg MPs and/or Union council chairman) and also most importantly from representatives of potentially disadvantaged groups. (eg fishermen, landless people and those who will lose land through acquisition).

As a result of the participation programme undertaken at the feasibility study stage it is proposed that consultants be appointed for the predesign and design stages to ensure that the identified vulnerable groups are properly represented through the efforts of selected NGO's who would be sub-contracted to the consultants and could directly assist the design team and represent the vulnerable groups at the PCC meetings as described in the following sections.

13.3 Pre-Design Phase

Chapters 11 and 12 have recommended additional studies which are needed to allow finalisation of the design and to ensure that adversely affected groups are adequately compensated. These studies include:-

a) Detailed topographic/cadastral mapping to provide:

   i) Cross-section data on all Khals for detailed design/quantities

   ii) Accurate cadastral maps for identification of land-holdings, their ownership and occupation. This will lead to the final resettlement plan (see c) below).

b) Geotechnical Surveys to identify:

   i) Foundation conditions at the site of the new Rahmatkhali regulator

   ii) More detailed information on the distribution of sandy soils in the khals to identify areas requiring special attention for spoil disposal.

   iii) Foundation Survey of existing bridges.

c) Using the results of a) above prepare detailed recommendations and schedules for a land compensation/resettlement plan.

d) Detailed Fisheries Assessment, to confirm and complete the fish resource baseline assessment and to quantify the requirements for full-time fisheries redeployment. This study should aim to produce a self sustaining project component based on alternative production strategies utilising the available water body resources.

e) Additional environmental surveys as described in chapter 12 section 12.6.3. These surveys are required to fulfil the requirements of the FPCO guidelines. Although these studies may produce valuable data which can be used to prepare the detailed environmental management plan it is considered unlikely that these aspects are of sufficient significance to affect a decision on implementation.

The costs of these programmes need to be carefully considered and at this stage the project cost provided in section 13 include allocations which would fully meet the costs of a) and b) above and also include full costs for land acquisition compensation. The costs for the fisheries study are estimated at us $ 450,000 and this cost would be additional to those shown in the project costs. It is assumed that these costs would be justified by the resulting project and its net benefits.

The costs of the Environmental studies are estimated at $ 600,000. These studies could be carried out independently from the fisheries studies but it would seem more appropriate for them to be combined which would produce some limited cost savings for office/administration etc.

13.4 Design Phase

13.4.1 Requirements

The contract for scheme design would be tendered by BWDB. The TOR would include provisions for the consultant to employ an NGO (see section 13.2) to assist in ensuring proper public participation.

The consultants should be ready to start work as soon as the results of the topographic and geotechnical surveys are available. It is suggested that tendering for both surveys and consultants could start at the same time.

As stated in chapter 10 additional computer modelling will be required at the design stage and it is suggested that the following information should be available to the design team:-

- 1:10,000 photomosaics of the area based on 1990 air photographs. This data set was not available to the feasibility study.

- 1:10,000 mapping (FINNMAP-FAP BIWTA) with updated land level database. These maps were originally to be available for the feasibility study but are now much delayed.

- The new thana maps prepared by the LGED/ILO project.

This mapping would allow an improved model re-calibration and the compilation of a complete GIS based on the FAP 19 system which would allow spatial identification of benefitted areas.

13.4.2 People's Participation in the Design Phase

a) Issues to be Addressed

Until very recently, the development approach hardly recognized any role for local communities in project planning and design. This attitude is partly responsible for past failures of some water development projects to achieve their developmental objectives. This is particularly true for FCD and FCDI schemes which, in many cases, where not able to meet their agricultural production objectives. Among the reasons often quoted by the local people are:

- opposition of adversely affected people resulting in such actions as breach of embankments, which are ultimately aimed at restoring pre-project situation;

- poor implementation due to mis-management and corrupt practices resulting in the development of infrastructures which do not follow the required technical specifications and thus are not effective in meeting their objectives;

- poor maintenance of the infrastructure resulting in low efficiency of the scheme;

- lack of technical and financial support to take advantage of the improved agricultural production opportunities allowed by the construction of the scheme.

The involvement of local people, in a structured and coordinated manner, right from the design and planning phase, could minimize such failures and improve the efficiency and effectiveness of development projects. People's participation is required so as to get opinions and ideas from various quarters of the local communities and to include them in the project design.

In particular, the participation process should enable the planners to address the following issues in a socially acceptable way:

- mitigation of negative impacts e.g. identification of dis-beneficiaries and design of socially acceptable compensation measures and procedures;

- implementation and maintenance procedures, e.g. how the project/scheme will be implemented and how the maintenance of the infrastructure will be ensured;

- technical and financial support required by the would be beneficiaries to allow them to maximize the benefits to be derived from the scheme.

If people's participation is ensured in the design phase, the project so designed is more likely to be socially viable and acceptable. To achieve this, it is essential that:

- the economic and social interests of various socioeconomic groups, e.g. including those of the poor and the destitute, are considered in the project design;

- the interests and opinions of the majority have superseded the vested interests of the few;

- those who are going to lose all or part their livelihood as a result of the project are precisely identified.

- the amount of compensation is fair and matching the real loss incurred by these people;

Based upon the above considerations, and considering the specific features (khal re-excavation) of the proposed Noakhali North project (NNP), the issues which will have to be addressed through people's participation are discussed below:-

b) Questions to be Discussed with People

- **Khal Alignment, Disposal of Spoil, Land Acquisition, Compensation and Displacement**

These issues are closely interrelated because each possible option in terms of alignment and disposal of spoil can be translated in terms of area of land to be acquired and/or compensated and in terms of number of people to be displaced. As a result, the choice of a particular option for alignment and soil

disposal cannot be entirely based on technical criteria but should also be socially acceptable, and, as such, should be assessed through the participation process. In particular, the following questions should be answered by all the local people concerned:

- should the existing alignment be followed or is it better to straighten it up so as to reduce the erosion and siltation process?

- should the spoil be spread over cultivable land? is it better to raise large embankments along the khal which could be used as roads? or it may be that local people need soil to raise their homestead ?

- if the spoil is spread over cultivable land, who is going to be affected (owners and/or share croppers), how (which crop will be lost, and how many) and by how much (crop valuation);

- if land acquisition is inevitable, which landowner/landholder is going to be affected, how (loss of homestead, loss of cultivable land) and by how much (area to be lost and estimated value)?;

- what are the socially acceptable mechanisms for compensation to be defined in terms of timing of the compensation (before the work, during or after), its amount (land/crop/house valuation) and its nature (in cash or in kind);

c) Implementation Procedures

Traditionally there are two different ways used by BWDB to implement earth work schemes in Bangladesh. In Food-For-Works schemes, BWDB is disbursing wheat to a Project Implementation Committee (PIC) formed at the Union Parishad level which is then responsible for the implementation and supervision of the work. This usually applies to minor works with low technical requirements. For other works, BWDB is executing the work via civil work contractors or, recently, via Labour Contracting Societies (LCS) which are registered as D-class contractors.

A LCS is a group of 50 labourers previously organized by either BRDB or a NGO.

- LCS are registered under BWDB as a D-class contractor.

- LCS will take up the schemes as per standard BWDB estimates.

- BRDB or the concerned NGO will sign a letter indicating that they stand as guarantor for a given LCS in order to fulfil the clause of solvency which is required to be a contractor.

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System Rehabilitation Project (SRP) personnel expressed their full satisfaction concerning works accomplished so far by LCS and indicated two aspects of the system which need to be developed and could be generalized:

- The labourers are trained before starting the work and they are paid upon measurement and on a regular basis. Thereafter, the labour force is found to be exceptionally good and productive.

- The other great benefit of the SRP system is that the labourers get full payment of the work done because they are paid directly without intermediaries.

For the proposed re-excavation works, local people should be consulted on the implementation system which seems to be the most appropriate. Also, the procedures for maintenance should be defined at the design stage and commitment from people obtained prior the beginning of the work. (see chapter 14)

From the experience of SRP, which is now working on FCDI projects which were designed and implemented without consultation with the beneficiaries, it seems that involving the beneficiaries in the operation and maintenance through direct contributions, is now very difficult because the project is considered as a gift, and everybody expects that the implementing agency will take care of the maintenance.

However, people's attitude could have been different if direct consultation of the beneficiaries had been done during the design phase of the project so as to assess what level of commitment they are prepared to give to the project.

d) Proposed Methodology

Involving local people in the detailed planning of the project requires a proper methodology so as to ensure that each and every stratum is consulted and taken into consideration. In rural Bangladesh, the social structure is highly dominated by local elites which are using local institutions, including the traditional "Shamaj", to reinforce and/or extend their power and resource bases. In such a context, where patron-client relationships are dominant, the poor, the destitute, especially the women, are barely in a position to express views and opinions which would be different from those of their "patrons".

The development of a participation process which will not be vested and biased in favour of upper classes and elites, requires the encouragement of institution building among the poor so as to raise their awareness and to give them a representation and a "voice" in the project. The development of rural poor institutions is not a new concept in Bangladesh and several development agencies have already developed a significant experience in this regard. For instance, BRDB supported RD programmes have tried to promote the development of rural poor institutions through the formation of landless groups known as BSS (male) and MBSS (female). NGOs have also developed a quite successful experience in developing rural poor institutions and the organized NGOs groups should be involved in the participation process.

Based on the above discussion it seems that, to ensure that each and every socioeconomic group is consulted throughout the affected project area, the participation process should not entirely rely on the dominant local institutions such as union parishad, shamaj, imams, farmers' societies (KSS) but should also be designed to reach the rural poor though existing institutions, if any, such as NGOs groups, MBSS and BSS groups, fishermen groups, labour unions and organizations. In areas where no such institutions are existing, they should be built and developed during the detailed design phase as part of the people's participation component.

This underlines that people's participation is a process which requires time and effort and cannot simply be understood as a series of punctual meetings at village level. Because most people will not open their mind if they have no confidence, one the critical aspect is to be able to develop relationships with local people to be able to establish a real and fruitful dialogue. Therefore, eliciting people's views is a "round-the-clock" job which requires a permanent presence in the villages. This is the prerequisite of the success of the participation component.

In the context of this project where khal enlargement and re-excavation is the major component, ensuring a genuine participation/consultation of people in the project design requires the following actions:

- establishment of "people's participation centres in villages situated along khals to be re-excavated. The number of centres and their location has to be defined so as to make sure all the project area is covered. Because people are usually very reluctant to travel long distances, there should be enough centres to make sure that all the concerned people will be reached. It is estimated, that one centre should be set up for every ten km of khal;

- each centre will be staffed with one supervisor and two field workers in charge of the development of rural poor institutions through group formation;

- each centre will develop and maintain relationships with local institutions including, union parishads, "shamaj", farmers' groups (KSS), landless groups (BSS & MBSS), fishermen groups, NGOs groups and any other existing societies. In places where the poor and the destitute are under-represented, the staff from the centres will encourage institutional development through group formation.

- from each centre, information from project planners will be conveyed to local people through several media, including posters, newsletters and meetings, and feedback will be obtained. Then the results of the consultation will be forwarded back to project planners who may then adjust their approach. This process of communication between planners and people will be repeated until a satisfactory solution can be reached.

Given that up to 200 km of khal are expected to be re-excavated, twenty people's participation centers should be setup in the project area and maintained throughout the detailed design phase and during the early stages of the project implementation. It seems that a duration of four years is a reasonable term for these centres, this includes one year during design and preparation and 3 years of the construction programme. The overall estimated cost of the people's participation process is around Tk 28 million for four years. The breakdown of the cost is given in Annex G. Table G.4.1

As far as the implementation of this programme is concerned, the support of NGOs, with extensive field experience in the project area, would be required because NGOs expertise in reaching the poorest strata of the societies is well known and, to date, there is no other organization with such a positive record in this regard.

13.3.3 Design Procedures

As described in the earlier sections of this chapter it is envisaged that design consultants would be appointed so that they would be in place by the time the required topographic and geotechnical surveys were completed. Indeed it may be appropriate if the same team were to be involved in the additional studies recommended in section 13.3. so that good understanding and continuity is maintained and consistent advice can be given to the BWDB and to the PCC. The PCC's role at this stage would largely be to coordinate the activities of the design team, the NGO (participatory activities), the other ministries and local government agencies. These latter will include:-

- BWDB (design section, consultants etc.)
- BARDC (DAE) (Minor irrigation - NMIDP),
- R&H (bridges-modifications),
- DOF (Fisheries mitigation measures),
- LGED (bridge-modifications and local drainage programmes),
- Forest Department (New homestead areas).

The continued involvement of the elected representatives of the affected areas will also be essential.

13.5 Implementation Phase

13.5.1 Management Structure

The implementing agency, BWDB, will be responsible for the tendering, award and supervision of the various contracts needed to complete the project works. To achieve effective and timely completion they will require the cooperation and assistance of many other organisations and groups.

The vehicle for this cooperation will, once again, be the PCC. The public participation guidelines, FAP 15, SRP and others have already made many recommendations as to how projects would proceed. There is a common theme to these proposals but all have differences which are appropriate to their own views and the needs of their types of project. For this particular project it is considered that it would be most appropriate for both the design consultants and their corresponding NGO(s) to assist the BWDB both in ensuring maximum involvement and cooperation of the people and in translating the agreed designs into a finished product according to a predetermined timetable. The following sections identify some for the important elements necessary to ensure effective implementation.

No new or separate project structure is recommended for the project and at all stages the existing structure should be used in a progressive manner to achieve the project objectives using the procedures currently under development. The Chief Engineer, Design and the Chief Engineer, South Eastern Zone will need to actively cooperate at all stages of the project and should involve the Muhuri O&M circle staff at executive and sub-

divisional level to ensure all information and recommendations are fully understood at all levels. This will facilitate smooth transfer through design and construction to O&M. Existing staff at Feni, Noakhali and Lakshmipur should be involved at all stages.

13.5.2 Local Participation in Construction

As stated in sections 13.4.2 (c) and (d) a procedure and methodology for involving people is to be developed at the design stage involving extensive information and discussion to obtain understanding, acceptance and agreement to the proposals. These recommendations demonstrate the need for continuity from design through implementation. The people's participation centres set up at the design stage would continue to operate through the construction phase. Their objectives would include:

- encouragement of formation of local groups to be directly involved in construction such as LCS groups of landless (men and women), fishermen and farmers whose activities are disturbed by the works,
- Preparation of groups of farmers for forming water users associations (WUAs) for irrigation units and potential pump operators,
- Communication of the proposals for O&M including relationships between BWDB, pump operators and WUAS and their registration with BWDB as having a right to water use. (see chapter 14),
- Development of Khal maintenance groups (see chapter 14).

13.5.3 Contract Implementation Procedures

a) Rahmatkhali Regulator

It is recommended that one contractor be appointed both for the modification of the existing regulator and the construction of the new regulator. These structures' close proximity and the need to complete the works within two dry seasons could lead to difficulties in site access arrangements if separate contractors were used.

Work on the remodelling of the existing regulator would be restricted to the dry season (November-April/May) to ensure that the existing drainage capacity is maintained in the wet seasons during construction.

The same contractor could also be responsible for the associated channel earthworks.

b) Main Khal Widening and Deepening

The feasibility designs have allowed for deepening the existing Khals to the maximum depth achieved by the existing channels but not significantly deeper and then achieving the required sections through widening as necessary. This reduces the requirement for modifications to bridge foundations and scour protection.

It has also been possible to substantially reduce the net land acquisition requirements compared with those fore seen at pre-feasibility stage.

The major earthworks are programmed to be done by a fleet of mini-dredgers. This is because where much of the excavation is to be done under water it is unsuitable for hand excavation. Additionally the volumes required would involve large scale import of labour and the programme can be substantially shortened because the dredgers can work throughout the year. It is envisaged that the dredging work would be let as one or two contracts of 3 years duration so that the cost of the dredgers can be largely recovered by the contractor over the period of the contract.

The dredgers to be used are substantially smaller than those currently in use in Bangladesh since the dredging depth and power required for this work is less than normal. Also these smaller units can be more easily mobilised and assembled in the khal system and moved from place to place. Also because of their lower power requirements they are cheaper to operate.

However, for substantial parts of the Rahmatkhali Khal, which currently has little or no water in the dry season, it has been assumed that hand excavation methods could be employed using LCS supervised by BRDB, LGED or an NGO in a similar system as that used for the SRP.

Both methods allow for stripping of topsoil and respreading as necessary (all to be done by hand labour). This work also provides the compartments for the dredged material.

c) Excavation of Secondary Khals

All this work is scheduled as hand labour to be executed in the dry seasons using LCS groups in exactly the same manner as is used in b) above. Again topsoil stripping and respreading may be required in some locations but most of this excavation is relatively shallow where better soils are encountered.

d) Land Acquisition/Compensation

As explained earlier the compensation must be agreed prior to execution of the works. The NGO(s) will be most important in ensuring that disputes (inevitable) are brought to the attention of BWDB and the PCC in a timely manner to prevent/minimise disturbance to the implementation programme.

e) Other Works

i) Khal bank Protection should immediately follow the completion of earthwork at the appropriate locations,

ii) Refurbishment/Equipment of BWDB facilities should be completed in year 1 of the programme so that supervision facilities are in place for the major works.

13.6 Project Costs and Implementation Schedule

13.6.1 Project Costs

Two summaries of the project costs for complete implementation including engineering surveys, design and construction are presented in Tables 13.1 and 13.2.

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 13.1 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 13.2 assumes that all excavated spoil will be spread over farm land and that appropriate compensation will be paid as described in chapter 11. Also as described in that chapter allowance has been made for stripping topsoil and replacing after spoil spreading where this is needed.

The difference in capital costs in financial terms is less than 6 % and the difference in economic terms is also small (see chapter 15). The consultants recommend the slightly cheaper 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 I and are based on 1992 prices.

13.6.2 Implementation Schedule

Figure 13.1 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.

TABLE 13.1

Bill of Quantities for Noakhali North Project
Land Acquisition for Disposal of Spoil

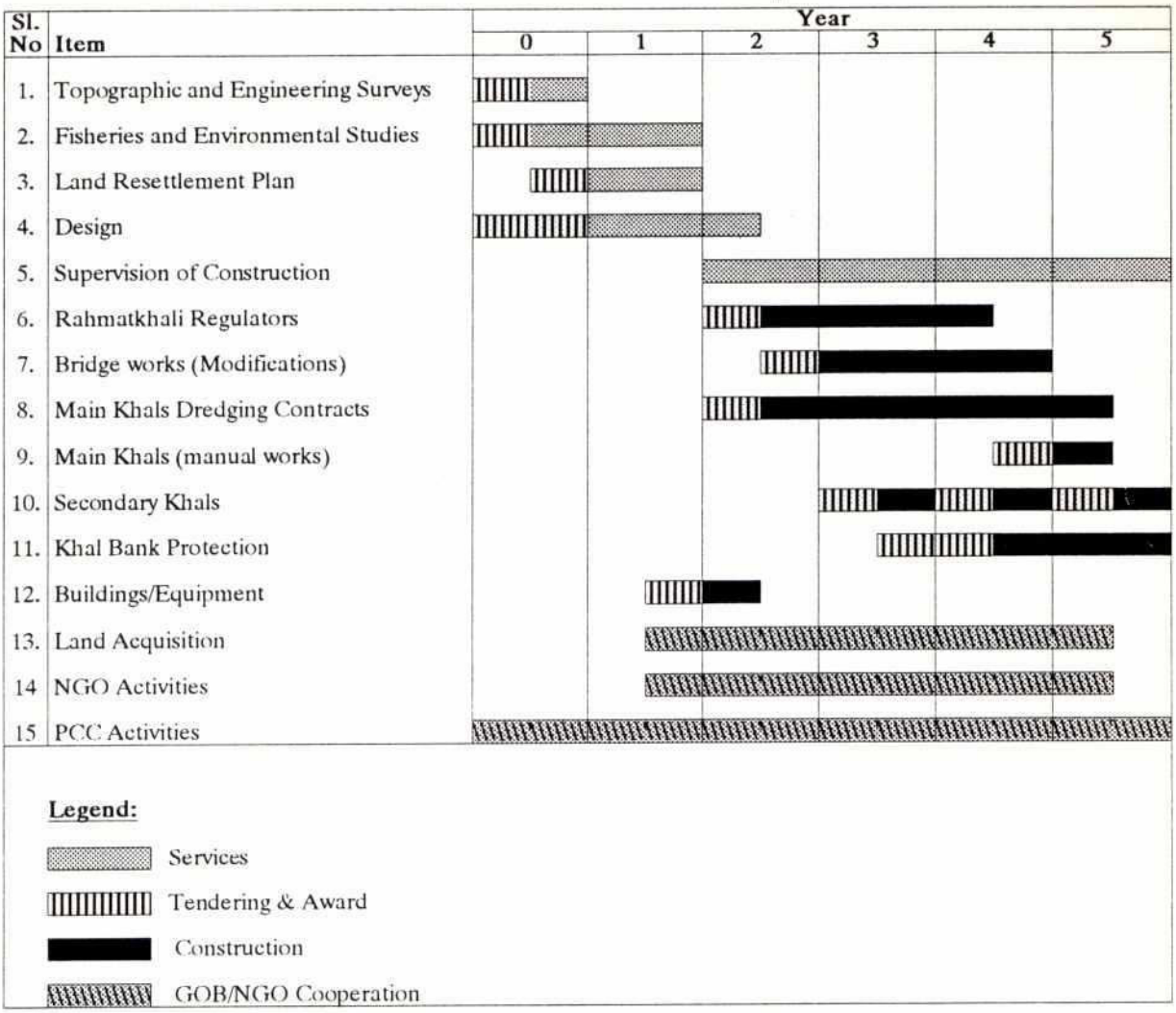
Sl No	Description	Unit	Rate	Quantity	Amount (Tk. Mil.)	Implementation Year				
						1	2	3	4	5
1	Modification of Existing	Nr	L.S.	1	20.50	–	5.00	10.00	5.50	–
	14 Vent Rahmatkhali Regulator									
2	New 10 Vent Rahmatkhali Regulator	Nr	L.S.	1	69.20	–	15.00	35.00	19.20	–
3	New 4 Vent Noakhali regulator	Nr	L.S.	1	5.92	–	–	5.92		–
4	Modification of Existing Bridges									
	a) Modification of Structures	Nr	L.S.	1	7.49	–	–	3.74	3.75	–
	on WAPDA/Rahmatkhali Khal									
	b) Scour Protection of Bridge Piers	Nr	L.S.	1	3.30	–	–	1.65	1.65	–
	c) Modification/Reconstruction									
	of Bridges on Minor Khals	Nr	L.S.	1	7.14	–	–	3.57	3.57	–
5	Dredging Rahmatkhali & WAPDA Khal	cu.m	50.0	7388393	369.42	–	36.82	138.80	138.80	55.00
6	Manual Excavation Rahmatkhali	cu.m	39.5	2340206	92.44	–	–	–	46.22	46.22
	& 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) Honrakhali 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	–	–	0.81	0.81	–
	and Respread (Loop Cutting)									
	b) Strip topsoil, Store,	ha	85000	456.80	38.83		4.45	12.94	12.94	8.50
	and Respread (Spoil Heaps)									
10	Buildings and Equipment									
	a) Refurbishment of BWDB offices at	Nr	L.S.	600000	0.60	–	0.60	–	–	–
	Lakshmipur, Noakhali and Feni									
	b) Computers, Generator									
	and Survey Equipment	Nr	L.S.	850000	0.85	–	0.85	–	–	–
11	Vehicles	Nr	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	Nr	L.S.	28250000.0	28.25	3.53	7.06	7.06	7.06	3.54
	Sub–Total of Direct Construction Cost = A				1034.04	3.53	214.24	377.74	289.30	149.24
	Physical Contingencies 15% of (A) = B				155.11	0.53	32.14	56.66	43.40	22.39
	Sub–Total (A) + (B) = C				**1189.15**	**4.06**	**246.38**	**434.40**	**332.70**	**156.80**
	Engineering Service Cost 12% of C				142.70	28.00	28.00	33.00	33.00	20.70
	Total Project Cost (Tk. mil.)(A)+(B)+(C)=				**1331.85**	**32.06**	**274.38**	**467.40**	**365.70**	**192.32**

TABLE 13.2

Bill of Quantities for Noakhali North Project
Land Renting for Disposal of Spoil

Sl No	Description	Unit	Rate	Quantity	Amount (Tk. Mil.)	Implementation Year				
						1	2	3	4	5
1	Modification of Existing	Nr	L.S.	1	20.50	–	5.00	10.00	5.50	–
	14 Vent Rahmatkhali Regulator									
2	New 10 Vent Rahmatkhali Regulator	Nr	L.S.	1	69.20	–	15.00	35.00	19.20	–
3	New 4 Vent Noakhali regulator	Nr	L.S.	1	5.92	–	–	5.92		–
4	Modification of Existing Bridges									
	a) Modification of Structures	Nr	L.S.	1	7.49	–	–	3.74	3.75	–
	on WAPDA/Rahmatkhali Khal									
	b) Scour Protection of Bridge Piers	Nr	L.S.	1	3.30	–	–	1.65	1.65	–
	c) Modification/Reconstruction									
	of Bridges on Minor Khals	Nr	L.S.	1	7.14	–	–	3.57	3.57	–
5	Dredging Rahmatkhali & WAPDA Khal	cu.m	50	7388393	369.42	–	36.82	138.80	138.80	55.00
6	Manual Excavation Rahmatkhali	cu.m	39.5	2340206	92.44	–	–	–	46.22	46.22
	& 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) Honrakhali 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									–
	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	Nr	L.S.	600000	0.60	–	0.60	–	–	–
	Lakshmipur, Noakhali and Feni									
	b) Computers, Generator									
	and Survey Equipment	Nr	L.S.	850000	0.85	–	0.85	–	–	–
11	Vehicles	Nr	L.S.	2100000	2.10	–	2.10	–	–	–
	(1 No Truck, 2 No pickup, 10 Motorcycle)									
12	Land Acquisition									
	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	Nr	L.S.	3E+07	28.25	3.53	7.06	7.06	7.06	3.54
	Sub–Total of Direct Construction Cost = A				**979.30**	**3.53**	**116.83**	**322.03**	**357.56**	**179.36**
	Physical Contingencies 15% of (A) = B				146.90	0.53	17.52	48.30	53.63	26.90
	Sub–Total (A) + (B) = C				1126.20	4.06	134.35	370.33	411.19	206.26
	Engineering Service Cost 12% of C				135.14	26.50	26.50	31.00	31.00	20.14
	Total Project Cost (Tk. mil.)(A)+(B)+(C)=				**1261.34**	**30.56**	**160.85**	**401.33**	**442.19**	**226.41**

Figure 13.1
Implementation Schedule



CHAPTER 14

OPERATION AND MAINTENANCE

14.1 General

There are a number of recently completed, ongoing and planned projects which have studied, are studying or will study various aspects of this important element of scheme development. These studies include FAP 13 (and the forthcoming FAP 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.

14.2 Operation and Maintenance Requirements and Costs

At the design stage detailed O&M manuals should be prepared but the principal elements are set out in the following sub-sections:

14.2.1 Operation

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 11.2). This is likely to occur during November but will vary from year to year.

Facilities and proceedures for dealing with water hyacinth are described in Annex I sections I.4.5 and I.5.52(i).

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 (see calibration records for 1991 in Appendix B). 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 (see section 14.3.1).

14.2.2 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 Khal 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.

- clogging through accummulation of water hyacinth and other floating debris.

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 section 14) do allow for this. The consultants would expect situation to occur at not more than a third of this rate in the main khals 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 agrement with the system beneficiaries.

It is anticipated that secondary khal desilting would be carried out in the secondary khals on a three year rotational basis with problem sections being done as needed. The main khals would be desilted by mini dredger according to need as a result of regular annual surveys. Clearance of water hyacinth should be done by WUAs at the start of the dry season and as required thereafter.

14.2.3 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. The consultants consider that these costs could be reduced by 35% (Tk 14m) if siltation in the main khals is as expected rather than as per FPCO provisions. 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 14.1

TABLE 14.1

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	17.93	3	0.538
5.	Dredged Channels	369.42	6	22.165
6.	Manual Excavations	173.53	6	10.412
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	-	-	39.958

14.3 Public 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 14.4. 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.

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.

14.3.1 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.

14.3.2 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.

14.4 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 contract will 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.

Although Tk 30m is less than the O&M costs given in Table 14.1 it is more than the reduced costs anticipated as discussed in section 14.2.3.

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.

It is recommended that O&M cost recovery procedure is agreed with WUAs and pump operators as part of the design programme and that it is established as soon as each area is completed with full charges imposed from year 1 at a rate close to that given above but to be amended annually in accordance with surveyed needs.

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 13.1A 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 14.1 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 13/2 will need to address such issues since all tertiary irrigation is now in the private sector.

14.5 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 PCC 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.

The existing staffing levels at Feni, Noakhali and Lakshmipur are probably adequate but may require some redistribution to achieve equitable workloads in the with project situation. It is also foreseen that there may be a need for additional survey and administrative capability to deal with the annual workloads for budget estimation (needs assessment) and negotiation/agreement with WUA for funding contributions. In general additional survey and engineering capability should be hired or contracted and not added to permanent payroll since the work will be seasonal. Also redistribution of labour from the existing regulator to the new regulator and to nearby khal survey work, should avoid the need for hire of new labour on the permanent staff. Retraining of O&M staff should proceed during implementation.

CHAPTER 15

ECONOMICS

15.1 Methodology

The methodology used to evaluate project interventions is based on FPCO Guidelines for Project Appraisal and is described in Annex J. 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). Economic and financial prices used in the analysis are presented in Table 15.1. Crop budgets in economic and financial prices based on the yields and crop inputs discussed in Chapter 3 are presented in Table 15.2.

15.2 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.

15.2.1 Increased Agricultural Production

As there is limited scope for increase in the use of groundwater in the project area, mainly due to salinity and the need to preserve the restricted reserves of freshwater for human consumption, increases in irrigated areas are unlikely without an improvement in surface water supplies. In these circumstances it is quite legitimate for the project to claim any increases in irrigation as a benefit, as they would not occur otherwise. Thus there are two major sources of increased agricultural production:

- increased areas of boro through the provision of increased surface water supplies.
- improvements in the flooding regime which will permit greater areas of T. aman to be grown.

A shortage of dry season water for irrigation is the most frequently mentioned complaint by farmers and there is little doubt that any increases will be enthusiastically received and utilised. Boro is the farmers first choice of crop as it is both profitable and less risky than most other crops if a reliable source of irrigation is available.

TABLE 15.1

Financial and Economic Prices for Agricultural Products and Inputs (Taka)

Commodities	Unit	Financial Prices (1991)	Financial Prices (1992)	Conversion Factor	Economic Prices (1991)
Main Products					
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	0.66
Spices (onion)	kg	8.73	8.64	0.87	7.60
Spices (chilli)	kg	7.64	8.40	0.87	6.65
Veg. (brinjal)	kg	3.73	3.79	0.87	3.25
Veg. (tomatoes)	kg	4.50	4.50	0.87	3.92
Veg. (taro)	kg	4.26	4.99	0.87	3.71
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
Inputs					
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 (onion)	kg	600.00	600.00	0.87	522.00
Spices (chilli)	kg	600.00	600.00	0.87	522.00
Veg. (brinjal)	kg	400.00	350.00	0.87	348.00
Veg. (tomatoes)	kg	400.00	350.00	0.87	348.00
Veg. (taro)	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
Diesel fuel	litre	14.00	14.00	0.63	8.82

TABLE 15.2

Gross Income, Costs and Net Income per Hectare (Taka) — **1992 Financial Prices**

Crop	Gross Income			Production Costs						Net Income
	Main Crop	By–Product	Total	Labour	Draught	Seed	Irrig.	Fert.& Pest.	Total	
B Aus, local	9872	1600	11472	5917	2565	787		769	11041	431
B Aus, HYV	14808	1200	16008	6192	2565	787		950	11543	4465
T Aus, local	14808	2400	17208	6622	2679	278		950	11581	5627
T Aus, HYV irri	20053	1625	21678	7633	2679	278	2185	1539	15744	5933
T Aus, HYV n–ir	17585	1425	19010	7461	2679	278		1539	13152	5858
Mixed aus/aman	15686	1150	16836	7108	2508	930		790	12470	4366
B Aman local dw	11952	800	12752	4627	2508	930		275	9175	3577
T Aman local dw	14940	1000	15940	5590	2280	493		538	9792	6148
T Aman, local	15687	2100	17787	6063	2280	493		913	10724	7063
T Aman HYV irri	28013	1875	29888	7289	2451	336	1639	2070	15163	14724
T Aman HYV n–ir	26518	1775	28293	7117	2451	336		2070	13171	15122
Boro, local	17332	2800	20132	5074	1425	371	3355	631	11942	8190
Boro, HYV irrig	30950	2500	33450	9030	2451	278	6710	2775	23369	10081
Boro HYV p–irr.	27855	2250	30105	8815	2451	278	6679	2775	23099	7006
Wheat irrig.	16155	1125	17280	5461	2565	1404	3460	1580	15917	1363
Wheat unirrig.	12924	900	13824	4369	2565	1404		1125	10409	3415
Potato irrig.	62400	0	62400	8342	2508	10000	4734	6050	34796	27604
Potato unirrig.	41600	0	41600	7525	2508	10000		5550	28141	13459
Jute	14573	4218	18791	9224	2565	198		1243	14552	4239
Pulses: ave.	9211	1015	10226	2169	1710	744		0	5085	5141
Mustard	9953	173	10125	2473	2109	190		2669	8184	1941
Spices (chilli)	33600	0	33600	6751	1710	600		2796	13042	20558
Veg. (brinjal)	30320	0	30320	11610	2508	175		1672	17561	12759
Economic prices										
B Aus, local	8687	1392	10079	4128	1566	693		872	7985	2094
B Aus, HYV	13031	1044	14075	4320	1566	693		1098	8444	5631
T Aus, local	13031	2088	15119	4620	1636	244		1098	8358	6761
T Aus, HYV irri	17646	1414	19060	5325	1636	244		1751	9852	9208
T Aus, HYV n–ir	15474	1240	16714	5205	1636	244		1751	9720	6994
Mixed aus/aman	13288	1000	15088	4959	1531	763		959	9033	6055
B Aman local dw	9800	696	10496	3228	1531	763		293	6396	4100
T Aman local dw	12250	870	13120	3900	1392	404		588	6912	6207
T Aman, local	12862	1827	14689	4230	1392	404		1083	7821	6869
T Aman HYV irri	22968	1631	24599	5085	1496	276		2341	10118	14482
T Aman HYV n–ir	21743	1544	23287	4965	1496	276		2341	9986	13302
Boro, local	14513	2436	16949	3540	870	311		708	5972	10977
Boro, HYV irrig	25916	2175	28091	6300	1496	233		3279	12440	15651
Boro HYV p–irr.	23324	1958	25282	6150	1496	233		3279	12275	13007
Wheat irrig.	21157	979	22136	3810	1566	1835		1918	10041	12095
Wheat unirrig.	16926	783	17709	3048	1566	1835		1339	8566	9143
Potato irrig.	53375	0	53375	5820	1531	8265		7033	24914	28461
Potato unirrig.	35583	0	35583	5250	1531	8265		6598	23808	11775
Jute	15991	3670	19661	6435	1566	210		1494	10676	8985
Pulses: ave.	8074	883	8957	1513	1044	647		0	3525	5432
Mustard	9194	150	9344	1725	1288	167		3252	7075	2269
Spices (chilli)	26587	0	26587	4710	1044	522		3488	10740	15847
Veg. (brinjal)	25961	0	25961	8100	1531	174		1914	12891	13069

Calculation of wieghted average for pulse budget — NOAKALI

	Total area of sampled plots in farmer surveys		Percent weight		Market price Tk/kg 1991	Tk/kg 1992	Yield t/ha
	ha.	%					
Keshari (lathyrus)	9.63	54.7%	67.3%		12.63	12.31	0.70
Masur (lentil)	0.32	1.8%					
Chola (chick pea)	0.65	3.7%					
Mung (greem gram)	3.27	18.6%	22.8%		17.62	17.05	0.60
Mash (black gram)	1.41	8.0%	9.8%		12.11	14.57	0.70
Barbati (cowpea)	0.00	0.0%					
Other pulses	2.33	13.2%					
Total	17.61	100.0%	100.0%	weighted ave.	13.71	13.61	0.68

Another important source of agricultural benefits is expected to arise from decreased flooding depths in the wet season which enables farmers to switch from either low yielding deep water rice varieties to local varieties of transplanted aman or from locally transplanted varieties of aman to high yielding short strawed varieties. Reductions in flood depths which would in theory permit increased areas of deepwater aman to be grown are not expected to materialise as there are conflicts between the cultivation of boro which is virtually certain to increase and broadcast deepwater aman. The methodology used to determine the areas of T Aman in the "future with" situation is described in Annex J. It is based on the hydro-dynamic model which predicts flooding depths at various probabilities which when combined with the land level database to give areas flooded to certain depths in each 10 day period, are checked against histograms of submergence tolerance for the crop (i.e. maximum depths which the crop can tolerate throughout its life cycle) to obtain the maximum area of crop which can be safely grown at a specified probability level. Any submergence of the crop for more than three consecutive days was deemed to result in failure and the area associated with such an event excluded from the "safely grown" total.

By assessing both the Model results and farmers' attitudes to planting these crops, increased areas of T aman incorporated within proposed cropping patterns.

15.2.2 Decreased Flood Damage

Estimates of flood damage have been based on the following data sources:

housing and livestock	-	Farmer and landless survey
groundwater property	-	Thana Engineering offices
crop damage	-	BBS and DAE Thana offices
Fish pond losses	-	Culture fishpond survey

Analysis of the hydrodynamic output indicates that significant reductions in flood depths will be achieved in Zones B and C, with far smaller improvements in Zone D. Zone A is already mostly highland and will consequently be less affected. As a result benefits accruing to reduced flood damage are restricted to Zones B and C.

Estimates of these damages are presented below:

	Annual Expected Loss (%)			
Crop Damage	Aus LV	Aus HYV	B. Aman	T Aman
Zone B	2.9	3.1	3.1	1.2
Zone C	2.8	2.8	3.3	1.3

Damage to property (Tk/cultivated ha/year)

	Government Property	Housing	Livestock	Fishponds	Total
Zones B and C	14	57	14	221	306

15.3 Costs

15.3.1 Capture Fish Losses

Losses of output of capture fisheries are assumed to be caused by:

- obstruction of fish migration and spawn by the construction of embankments and regulators
- reduction in the area of flood plains and in the duration of flooding

Reducing the area of flood plain is expected to result in a straightforward decline in their productivity in direct proportion to their loss. Obstructing migration of fish and spawn is expected to result in a change in the catch composition with substantial losses of the higher value fish species which are generally migratory.

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's time

Surveys by FAP 17 show that fishermen receive about 69% of the market prices for fish. Surveys in the project area collected the following data on fish catch and market prices which are converted to fishermens' prices by deducting 31%.

	Tonnage	**Market Price**	**Fishermen's Price**
High value fish	3825	Tk 58 / kg	40.02
Medium value fish	4443	Tk 39 / kg	26.91
Low value fish	12037	Tk 27 / kg	18.63
	20305	Weighted average 24.5	

Obstruction of migratory passage reduces the value of the catch by reducing the proportion of high value carp in the catch. In Noakhali no increase in obstruction is anticipated, indeed it should be slightly improved but no benefit has been claimed.

The cost of catching has been estimated as Tk 30 for one day of labour plus Tk 10 per day for gear with a daily catch of 3 kg. In fact most fishermen are self employed and the Tk 30 represents a low season agricultural wage (being lower than the Tk. 43 used in crop budgets). It could be argued that a lower figure than Tk 30 should be used as fishermen have few alternative sources of income but it could also be said that a catch of 3 kg per day is on the high side. a catch of 2 kg and a wage of Tk 20 per day would result in a similar cost per kg of fish. As the yield potential of the flood plain falls, the amount of time needed to catch the remaining fish will increase; daily catches will decline and costs per kg fish caught 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 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 Tk. 30 nominal wage plus Tk 10 gear cost - in this case fishermens' income falls below Tk 30. 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.

Assuming a catch of 3 kg per day catching costs at economic prices are Tk 10.4 / kg. With a catch of 2.5 kg/day. Catching costs increase to Tk 12.4 per kg. Thus the net value of fish is calculated as follows:

Financial Price of fish Tk/kg	Economic Price of fish Tk/kg	Catch per day kg	Cost of Catching Tk/kg	Net Value Tk/Kg
24.5	21.32	3	10.4	10.92
24.5	21.32	2.5	12.4	8.92

Capture fishery losses are not limited to the project area alone as it is anticipated that drainage will be improved in areas on the periphery of the project area and that a decline in fish catches will result. these losses have been excluded from the analysis presented in Section 15.4 on the grounds that they will be at least equalled by improvements in agricultural productivity brought about by the improvements in drainage which caused the fish losses in the first place. In fact it is likely that agricultural gains will exceed fish losses by wide margin, as they do within the project area.

15.3.2 Capital and O&M Costs

Capital costs are presented in Chapter 13 and O&M Costs in Chapter 14.

For the economic analyses these have been converted in accordance with the FPCO guidelines (See Annex J).

15.4 Results of the Economic Analysis

15.4.1 General

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 amalgamated cropping pattern (ie the sum of Zones A, B, C and D) presented in Chapter 3. 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.

15.4.2 Results of the Economic Analysis

Tables 15.3 to 15.11 present the results of the analysis and include the following:

- annual net income and cropped area by crop
- calculation of agricultural flood loss
- labour requirement and paddy production
- irrigation phasing and net crop income - future without
- irrigation phasing and net crop income - future with
- fisheries losses
- non-agricultural flood damage
- project cash flows
- summary of benefits in financial prices
- summary of cropping pattern changes
- summary of results and sensitivity analysis

The analysis of the main option (land acquisition for spoil disposal through the construction of embankments) produces an IRR of 18.4%.

TABLE 15.3

Annual Total (Net) Income, and Cropped Area by Crop

economic prices

Economic prices	Net Income (Tk/ha)	Project Year 1 Area (ha)	Project Year 1 Total Income (Tk'000)	Future WO (1) Area (ha)	Future WO (1) Total Income (Tk'000)	Future WO (2) Area (ha)	Future WO (2) Total Income (Tk'000)	Future With (1) Area (ha)	Future With (1) Total Income (Tk'000)	Future With (2) Area (ha)	Future With (2) Total Income (Tk'000)
B Aus, local	2094	11786	24684	11786	24684	11786	24684	8637	18090	8637	18090
B Aus, HYV	5631	4984	28066	4984	28066	4984	28066	4984	28066	4984	28066
T Aus, local	6761	3910	26439	3910	26439	3910	26439	3488	23584	3488	23584
T Aus, HYV irri	9208	287	2642	287	2642	287	2642	464	4273	464	4273
T Aus, HYV n−ir	6994	9098	63635	9098	63635	9098	63635	8921	62395	8921	62395
Mixed aus/aman	6055	8254	49977	8254	49977	8254	49977	6070	36750	6070	36750
B Aman local dw	4100	28621	117345	28621	117345	28621	117345	21240	87081	21240	87081
T Aman local dw	6207	4843	30060	4843	30060	4843	30060	4356	27041	4356	27041
T Aman, local	6869	35022	240549	35022	240549	35022	240549	43036	295592	43036	295592
T Aman HYV irri	14482	0	0	0	0	0	0	0	0	0	0
T Aman HYV n−ir	13302	6225	82803	6225	82803	6225	82803	13836	184048	13836	184048
Boro, local	10977	0	0	0	0	0	0	0	0	0	0
Boro, HYV irrig	15651	49979	782234	49979	782234	49979	782234	68458	1071466	68458	1071466
Boro HYV p−irr.	13007	0	0	0	0	0	0	0	0	0	0
Wheat irrig.	12095	32	385	32	385	32	385	32	385	32	385
Wheat unirrig.	9143	127	1163	127	1163	127	1163	127	1163	127	1163
Potato irrig.	28461	63	1780	63	1780	63	1780	63	1780	63	1780
Potato unirrig.	11775	250	2945	250	2945	250	2945	250	2945	250	2945
Jute	8985	796	7151	796	7151	796	7151	0	0	0	0
Pulses: ave.	5432	9685	52612	9685	52612	9685	52612	9226	50118	9226	50118
Mustard	2269	2324	5272	2324	5272	2324	5272	1819	4126	1819	4126
Spices (chilli)	15847	3513	55670	3513	55670	3513	55670	3513	55670	3513	55670
Veg. (brinjal)	13069	816	10669	816	10669	816	10669	816	10669	816	10669
Total		180614	1586079	180614	1586079	180614	1586079	199336	1965241	199336	1965241

Notes:
Total income is net of all on−farm costs except for irrigation which is analysed separately
Project Year 1: assumed 1994/95
Future Without (1): Future Without Project Conditions, Year 10
Future Without (2): Future Without Project Conditions, Year 30
Future With (1): Future With Project Conditions, Year 10
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)

economic prices

Calculation of Agricultural Flood Loss

	percent loss	income/ha lost*	Year 1 area	Year 1 Tk'000	Year 1 tons	Future without (1) area	Future without (1) Tk'000	Future without (1) tons	Future without (2) area	Future without (2) Tk'000
B Aus, local	2.86%	8083	133	1077	213	133	1077	213	133	1077
B Aus, HYV	2.96%	11964	58	698	140	58	698	140	58	698
T Aus, local	2.96%	13030	46	596	110	46	596	110	46	596
T Aus, HYV irri	2.96%	16597	3	56	11	3	56	11	3	56
T Aus, HYV n−ir	2.96%	14284	106	1520	303	106	1520	303	106	1520
Mixed aus/aman	3.20%	12829	104	1339	240	104	1339	240	104	1339
B Aman local dw	3.20%	8897	362	3220	579	362	3220	579	362	3220
T Aman local dw	3.20%	11392	61	698	122	61	698	122	61	698
T Aman, local	1.27%	12734	176	2242	370	176	2242	370	176	2242
T Aman HYV irri	1.27%	22070	0	0	0	0	0	0	0	0
T Aman HYV n−irr.	1.27%	20791	31	651	111	31	651	111	31	651
Boro, local	0.00%	15456	0	0	0	0	0	0	0	0
Boro, HYV irrig	0.00%	24981	0	0	0	0	0	0	0	0
Boro HYV p−irr.	0.00%	22213	0	0	0	0	0	0	0	0
Jute	0.00%	16992	0	0	0	0	0	0	0	0
percent of area to which damage reduction applies	39.6%	total	1082	12096	2200	1082	12096	2200	1082	12096

* lost income is gross crop income less 25% of costs

TABLE 15.4

Labour requirements and paddy production

	Labour	LABOUR REQUIREMENTS					PADDY PRODUCTION				
		Present	FWO (1)	FWO (2)	FW (1)	FW (2)	Present	FWO (1)	FWO (2)	FW (1)	FW (2)
	md/ha	Labour md ('000s)	Labour md ('000s)	Labour md ('000s)	Labour md ('000s)	Labour md ('000s)	tonnes	tonnes	tonnes	tonnes	tonnes
B Aus, local	138	1622	1622	1622	1188	1188	18857	18857	18857	13820	13820
B Aus, HYV	144	718	718	718	718	718	11962	11962	11962	11962	11962
T Aus, local	154	602	602	602	537	537	9385	9385	9385	8372	8372
T Aus, HYV irri	178	51	51	51	82	82	932	932	932	1508	1508
T Aus, HYV n−ir	174	1578	1578	1578	1548	1548	25929	25929	25929	25424	25424
Mixed aus/aman	165	1364	1364	1364	1003	1003	18984	18984	18984	13960	13960
B Aman local dw	108	3080	3080	3080	2285	2285	45794	45794	45794	33983	33983
T Aman local dw	130	630	630	630	566	566	9685	9685	9685	8712	8712
T Aman, local	141	4938	4938	4938	6068	6068	73546	73546	73546	90375	90375
T Aman HYV irri	170	0	0	0	0	0	0	0	0	0	0
T Aman HYV n−ir	166	1030	1030	1030	2290	2290	22099	22099	22099	49119	49119
Boro, local	118	0	0	0	0	0	0	0	0	0	0
Boro, HYV irrig	210	10496	10496	10496	14376	14376	249893	249893	249893	342292	342292
Boro HYV p−irr.	205	0	0	0	0	0	0	0	0	0	0
Wheat irrig.	127	4	4	4	4	4					
Wheat unirrig.	102	13	13	13	13	13					
Potato irrig.	194	12	12	12	12	12					
Potato unirrig.	175	44	44	44	44	44					
Jute	215	171	171	171	0	0					
Pulses: ave.	50	489	489	489	465	465					
Mustard	58	134	134	134	105	105					
Spices (chilli)	157	552	552	552	552	552					
Veg. (brinjal)	270	220	220	220	220	220					
Total		27746	27746	27746	32078	32078	487067	487067	487067	599528	599528

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TABLE 15.5

Irrigation Phasing and Net Crop Income – Future Without

Year	Irrigated Area (ha) LLP	STW/SFMTW	DSSTW	DTW	Manual	Total	On–Farm Irrigation Cost (Tk'000)	Crop Income (1) (Tk'000)	Net Crop Income(2) (Tk'000)
1	38020	1086	0	2173	8690	49969	93449	1586079	1492630
2	38020	1086	0	2173	8690	49969	93449	1586079	1492630
3	38020	1086	0	2173	8690	49969	93449	1586079	1492630
4	38020	1086	0	2173	8690	49969	93449	1586079	1492630
5	38020	1086	0	2173	8690	49969	93449	1586079	1492630
6	38020	1086	0	2173	8690	49969	93449	1586079	1492630
7	38020	1086	0	2173	8690	49969	93449	1586079	1492630
8	38020	1086	0	2173	8690	49969	93449	1586079	1492630
9	38020	1086	0	2173	8690	49969	93449	1586079	1492630
10 FWO 1	38020	1086	0	2173	8690	49969	93449	1586079	1492630
11	38020	1086	0	2173	8690	49969	93449	1586079	1492630
12	38020	1086	0	2173	8690	49969	93449	1586079	1492630
13	38020	1086	0	2173	8690	49969	93449	1586079	1492630
14	38020	1086	0	2173	8690	49969	93449	1586079	1492630
15	38020	1086	0	2173	8690	49969	93449	1586079	1492630
16	38020	1086	0	2173	8690	49969	93449	1586079	1492630
17	38020	1086	0	2173	8690	49969	93449	1586079	1492630
18	38020	1086	0	2173	8690	49969	93449	1586079	1492630
19	38020	1086	0	2173	8690	49969	93449	1586079	1492630
20	38020	1086	0	2173	8690	49969	93449	1586079	1492630
21	38020	1086	0	2173	8690	49969	93449	1586079	1492630
22	38020	1086	0	2173	8690	49969	93449	1586079	1492630
23	38020	1086	0	2173	8690	49969	93449	1586079	1492630
24	38020	1086	0	2173	8690	49969	93449	1586079	1492630
25	38020	1086	0	2173	8690	49969	93449	1586079	1492630
26	38020	1086	0	2173	8690	49969	93449	1586079	1492630
27	38020	1086	0	2173	8690	49969	93449	1586079	1492630
28	38020	1086	0	2173	8690	49969	93449	1586079	1492630
29	38020	1086	0	2173	8690	49969	93449	1586079	1492630
30 FW0 2	38020	1086	0	2173	8690	49969	93449	1586079	1492630

Note: (1) Net of costs other than on–farm irrigation
(2) Net of costs including on–farm irrigation

PV (12%),Tk Mn 12023

TABLE 15.6

Irrigation Phasing and Net Crop Income – Future With

Year	Irrigated Area (ha) LLP	STW/SFMTW	DSSTW	DTW	Manual	Total	On–Farm Irrigation Cost (Tk'000)	Crop Income (1) (Tk'000)	Net Crop Income (2) (Tk'000)
1	38020	1086	0	2173	8690	49969	93449	1586079	1492630
2	38020	1086	0	2173	8690	49969	93449	1586079	1492630
3	38020	1086	0	2173	8690	49969	93449	1586079	1492630
4	38020	1086	0	2173	8690	49969	93449	1586079	1492630
5	38020	1086	0	2173	8690	49969	93449	1586079	1492630
6	43017	1086	0	2173	7387	53662	97631	1661912	1564281
7	48014	1086	0	2173	6344	57616	102517	1737744	1635227
8	53010	1086	0	2173	5510	61779	107966	1813577	1705611
9	58007	1086	0	2173	4842	66108	113866	1889409	1775543
10 FW 1	63004	1086	0	2173	2173	68436	114359	1965241	1850882
11	63004	1086	0	2173	2173	68436	114359	1965241	1850882
12	63004	1086	0	2173	2173	68436	114359	1965241	1850882
13	63004	1086	0	2173	2173	68436	114359	1965241	1850882
14	63004	1086	0	2173	2173	68436	114359	1965241	1850882
15	63004	1086	0	2173	2173	68436	114359	1965241	1850882
16	63004	1086	0	2173	2173	68436	114359	1965241	1850882
17	63004	1086	0	2173	2173	68436	114359	1965241	1850882
18	63004	1086	0	2173	2173	68436	114359	1965241	1850882
19	63004	1086	0	2173	2173	68436	114359	1965241	1850882
20	63004	1086	0	2173	2173	68436	114359	1965241	1850882
21	63004	1086	0	2173	2173	68436	114359	1965241	1850882
22	63004	1086	0	2173	2173	68436	114359	1965241	1850882
23	63004	1086	0	2173	2173	68436	114359	1965241	1850882
24	63004	1086	0	2173	2173	68436	114359	1965241	1850882
25	63004	1086	0	2173	2173	68436	114359	1965241	1850882
26	63004	1086	0	2173	2173	68436	114359	1965241	1850882
27	63004	1086	0	2173	2173	68436	114359	1965241	1850882
28	63004	1086	0	2173	2173	68436	114359	1965241	1850882
29	63004	1086	0	2173	2173	68436	114359	1965241	1850882
30 FW 2	63004	1086	0	2173	2173	68436	114359	1965241	1850882

Note: (1) Net of costs other than on–farm irrigation
(2) Net of costs including on–farm irrigation

PV (12%),TK Mn 13289

TABLE 15.7

Fisheries losses

Year	Fish production tons FWO	tons FW	Financial Value per kg Tk. FWO	Tk. FW	Economic value net of catching Value per kg Tk. FWO	Tk. FW	Economic price net of catching Total value Tk'000 FWO	Tk'000 FW	Tk'000 FWO–FW	financial prices Net of catching Total value Tk'000 FWO	Tk'000 FW
1	8139	8139	24.50	24.50	10.92	10.92	88837	88837	0	90886	90886
2	8017	8017	24.50	24.50	10.92	10.92	87506	87506	0	89523	89523
3	7895	7895	24.50	24.50	10.92	10.92	86174	86174	0	88161	88161
4	7773	7773	24.50	24.50	10.92	10.92	84842	84842	0	86799	86799
5	7651	7651	24.50	24.50	10.92	10.92	83511	83511	0	85436	85436
6	7529	3884	24.50	24.50	10.92	8.92	82179	34645	47534	84074	33014
7	7529	3884	24.50	24.50	10.92	8.92	82179	34645	47534	84074	33014
8	7529	3884	24.50	24.50	10.92	8.92	82179	34645	47534	84074	33014
9	7529	3884	24.50	24.50	10.92	8.92	82179	34645	47534	84074	33014
10	7529	3884	24.50	24.50	10.92	8.92	82179	34645	47534	84074	33014
										fin.	econ.
Fish labour use	present	FWO 1	FWO 2	FW 1	FW 2		gear cost per day			10.00	8.70
kg per day	3.0	3.0	3.0	2.5	2.5		labour cost per day			30.00	22.50
'000 days	2713	2510	2510	1554	1554						
TK per day	54	54	54	41	41	(fishermans total income per day less gear cost in financial prices)					

Non–agricultural flood damage

value of reduction per ha	306 Tk/ha
@ economic prices	266 Tk/ha
damage reduction applies to	40% of NCA
Total damage reduction	11447 Tk'000

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TABLE 15.8

Project Cash Flows (1991 Economic Prices)

(Million Taka)

Year	Benefits						Costs				Net
	Net Crop Income FWO	Net Crop Income FW	Incre- mental Crop Income	Flood damage Non-agr	Flood damage Crop	Total Benefits	Capture Fisheries Losses	Capital Costs	O&M Costs	Total Costs	Incremental Benefits
1	1493	1493	0	0.0	0.0	0.0	0.0	20.4	0.0	20.4	-20.4
2	1493	1493	0	0.0	0.0	0.0	0.0	174.4	0.0	174.4	-174.4
3	1493	1493	0	0.0	0.0	0.0	0.0	297.0	0.0	297.0	-297.0
4	1493	1493	0	0.0	0.0	0.0	0.0	232.4	0.0	232.4	-232.4
5	1493	1493	0	0.0	0.0	0.0	0.0	122.2	0.0	122.2	-122.2
6	1493	1564	72	13.3	12.1	97.0	47.5	0.0	26.9	74.4	22.6
7	1493	1635	143	13.7	12.1	168.4	47.5	0.0	26.9	74.4	93.9
8	1493	1706	213	14.1	12.1	239.2	47.5	0.0	26.9	74.4	164.7
9	1493	1776	283	14.5	12.1	309.5	47.5	0.0	26.9	74.4	235.1
10	1493	1851	358	14.9	12.1	385.3	47.5	0.0	26.9	74.4	310.9
11	1493	1851	358	15.4	12.1	385.7	47.5		26.9	74.4	311.3
12	1493	1851	358	15.8	12.1	386.2	47.5		26.9	74.4	311.8
13	1493	1851	358	16.3	12.1	386.7	47.5		26.9	74.4	312.2
14	1493	1851	358	16.8	12.1	387.2	47.5		26.9	74.4	312.7
15	1493	1851	358	17.3	12.1	387.7	47.5		26.9	74.4	313.2
16	1493	1851	358	17.8	12.1	388.2	47.5		26.9	74.4	313.7
17	1493	1851	358	18.4	12.1	388.7	47.5		26.9	74.4	314.3
18	1493	1851	358	18.9	12.1	389.3	47.5		26.9	74.4	314.8
19	1493	1851	358	19.5	12.1	389.8	47.5		26.9	74.4	315.4
20	1493	1851	358	20.1	12.1	390.4	47.5		26.9	74.4	316.0
21	1493	1851	358	20.7	12.1	391.0	47.5		26.9	74.4	316.6
22	1493	1851	358	21.3	12.1	391.6	47.5		26.9	74.4	317.2
23	1493	1851	358	21.9	12.1	392.3	47.5		26.9	74.4	317.8
24	1493	1851	358	22.6	12.1	392.9	47.5		26.9	74.4	318.5
25	1493	1851	358	23.3	12.1	393.6	47.5		26.9	74.4	319.2
26	1493	1851	358	24.0	12.1	394.3	47.5		26.9	74.4	319.9
27	1493	1851	358	24.7	12.1	395.0	47.5		26.9	74.4	320.6
28	1493	1851	358	25.4	12.1	395.8	47.5		26.9	74.4	321.3
29	1493	1851	358	26.2	12.1	396.5	47.5		26.9	74.4	322.1
30	1493	1851	358	27.0	12.1	397.3	47.5		26.9	74.4	322.9
Present Value @12%		13289	1266	73.4	53.8	1393.0	211.5	585.7	119.7	916.9	476.0
										EIRR (%)	18.43

TABLE 15.9

Summary of Benefits

	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	33.6	33.6	11	11
Paddy Production	'000 tonnes	487	487	487	600	600	23	23
Cropping Intensity (excl. orchard) % NCA		166%	166%	166%	184%	184%	10	10
Irrigated area	% NCA	46%	46%	46%	63%	63%	37	37
Net Crop Income	million Taka	1 264	1 264	1 264	1 572	1 572	24	24
Net 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 1991 financial prices

TABLE 15.10

Summary of Cropping Pattern Changes

(% of NCA)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(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−ir	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 p−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 15.11

Summary of Results and Sensitivity Analyses (Land Purchase Option)

Capital cost	846.4 Tk.m.(economic pric	construction period 5 years
Annual O&M cost	26.9 Tk.m.(economic prices)	
Net Present Value @12%	476.0 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	15.9	13.9	19.7	22.1	27.8	81.28
O&M Costs	18.4	18.3	18.1	17.7	18.6	18.8	19.2	397.63
Fisheries Losses	18.4	18.2	17.8	17.1	18.7	19.1	19.7	225.03
Reduced flood losses	18.4	18.6	18.8	19.2	18.3	18.0	17.6	174.25
Total Benefits	18.4	20.0	22.1	25.4	16.8	14.0	8.0	34.17
Incremental Net Crop Income	18.4	19.8	21.8	24.7	16.9	14.4	9.2	37.61
Delay in full benefits								
2 years	16.4							
4 years	14.9							
Delays in completion								
2 years	15.7							
4 years	14.1							

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Inspection of Table 15.8 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 15.11 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 = 17.1%.

2) In addition to the above, no infrastructural damage benefits are included : IRR = 16.2%.

3) In addition to 1) and 2) above, no crop damage protection benefits are included : IRR = 15.4%.

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 13.0%, clearly demonstrating where the project may be vulnerable.

15.4.3 Project Mitigation

A major disadvantage of the project as formulated above is that it requires the compulsory purchase of over 450 hectares of agricultural land. This is likely to be socially disruptive and, if past experience is a guide, may well delay the project's implementation. A strategy to overcome this has been devised whereby 3600 hectares are rented by the project for one season (3-4 months) and used to dispose of the spoil, raising ground levels by about 30 cms. In order to preserve soil fertility, costs for removing and replacing the top soil have been included for half of the area (1816 ha) where sandy soils which farmers would not welcome on their lands are likely to be encountered. Overall this option is less expensive than the former, but not significantly so. It produces an IRR of 18.6%. A summary of results for this option is presented in Table 15.12.

It is this option which is recommended for implementation.

15.5 Financial Analysis

15.5.1 Farm Models

Financial analysis of farm models is restricted to Zones A, B and C. Zone D is excluded only minor changes in both dry and wet season cropping are expected.

Farm models have been prepared for each farm size (marginal small, medium and large farmers) and for sharecroppers where small and medium sized farmers constitute over 90% of their number. The modelling of sharecropping systems is based on analysis of the farmer survey where it can be seen that of those farmers who sharecrop land, the area of land rented (ie sharecropped) represents about 50 and 40 per cent of the cultivated area for small and medium farmers respectively. Systems for sharecropping are based on an equal sharing of output for all crops with all input costs borne by the grower with the single exception of boro, where the owner of the land generally makes a contribution amounting to 50% of the fertiliser and irrigation costs. Thus a typical sharecropper receives 75% of the product over the entire farm if he is a "small sized" farmer and 80% if he is a "medium sized" farmer.

The results of the farm model analysis are presented in Tables 15.13, 15.14, 15.15 for Zones A, B, and C. They are based on average cropping patterns and farm sizes for each Zone, and demonstrate that both owner occupiers and sharecroppers will benefit from the project if they adopt the proposed cropping patterns. Clearly some farmers will benefit more than others, most notably those who are either enabled to grow a boro crop or who are benefitted by an improvement in flooding regimes. Equally important is the fact that the farm models suggest that noone will be worse off, although those farmers whose flooding regime is not significantly improved and who do not have access to increased irrigation supplies will experience little change.

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TABLE 15.12

Summary of Results and Sensitivity Analyses
(Land Renting Option)

Capital cost	867.4	Tk.m. (economic prices) construction period	years
Annual O&M cost	26.9	Tk.m. (economic prices)	
Net Present Value @12%	476.7	Tk. m. (economic prices)	
Economic Internal Rate of Return	18.6	%	

Sensitivity Analyses		**Economic IRR (%)**						
	Base	**Change in Variable**						**Switching**
Variable	**Case**	**+10%**	**+25%**	**+50%**	**−10%**	**−25%**	**−50%**	**Value (%)**
Capital Costs	18.6	17.5	16.0	14.0	19.9	22.3	28.3	81.49
O&M Costs	18.6	18.4	18.2	17.8	18.8	19.0	19.4	398.22
Fisheries Losses	18.6	18.3	17.9	17.2	18.9	19.3	20.0	225.36
Reduced flood losses	18.6	18.8	19.0	19.4	18.4	18.2	17.8	174.80
Total Benefits	18.6	20.2	22.4	25.8	16.9	14.0	7.9	34.22
Incremental Net Crop Income	18.6	20.1	22.1	25.1	17.0	14.5	9.2	37.66
Delay in full benefits								
2 years	16.5							
4 years	14.9							
Delays in completion								
2 years	15.5							
4 years	13.9							

TABLE 15.13

Returns per Ha at Financial Prices assuming no change in land type

Noakhali ZONE A Farm Models

	Marginal HL	Small HL	Medium HL	Large HL	Marginal ML	Small ML	Medium ML	Large ML	Marginal LL	Small LL	Medium LL	Large LL
Present	24626	20582	19326	17366	20834	16800	15510	14691	0	0	0	0
Future Without	24626	20582	19326	17366	20834	16800	15510	14691	0	0	0	0
Future With	31448	25462	23353	21464	29176	23303	21155	19567	0	0	0	0
FW less FWO	6821	4880	4027	4098	8342	6504	5645	4876	0	0	0	0

Returns per Ha at Financial Prices assuming changes in land type

	ML to HL	ML to HL	ML to HL	ML to HL	LL to ML	LL to ML	LL to ML	LL to ML
Present	20834	16800	15510	14691	0	0	0	0
Future Without	20834	16800	15510	14691	0	0	0	0
Future With	31448	25462	23353	21464	0	0	0	0
FW less FWO	10613	8663	7843	6773	0	0	0	0

Returns per average farm size at Financial Prices assuming changes in land type

Farm size	0.12	0.53	1.83	5.75	0.12	0.53	1.83	5.75
Present	3125	10080	23266	57295	0	0	0	0
Future Without	3125	10080	23266	57295	0	0	0	0
Future With	4717	15277	35029	83711	0	0	0	0
FW less FWO	1592	5198	11764	26416	0	0	0	0

Sharecropper Returns per ha at Financial Prices assuming no changes in land type

	Small HL	Medium HL	Small ML	Medium ML	Small LL	Medium LL
Present	12790	13093	9640	9783	0	0
Future Without	12790	13093	9640	9783	0	0
Future With	13361	13672	11655	11837	0	0
FW less FWO	571	579	2015	2054	0	0

Sharecropper Returns per average farm size at Financial Prices assuming changes in land type

	ML to HL	ML to HL	LL to ML	LL to ML
	0.53	1.83	0.53	1.83
Present	9640	9783	0	0
Future Without	9640	9783	0	0
Future With	13361	13672	0	0
FW less FWO	3721	3889	0	0

TABLE 15.14

Returns per Ha at Financial Prices assuming no change in land type

Noakhali ZONE B Farm Models

	Marginal HL	Small HL	Medium HL	Large HL	Marginal ML	Small ML	Medium ML	Large ML	Marginal LL	Small LL	Medium LL	Large LL
Present	25674	21948	20735	18978	26821	21595	19826	17653	20297	15565	13782	13268
Future Without	25674	21948	20735	18978	26821	21595	19826	17653	20297	15565	13782	13268
Future With	30516	24653	22593	20884	29660	23421	21107	19822	20791	15929	14064	13782
FW less FWO	4842	2705	1858	1906	2840	1826	1281	2169	493	364	283	515

Returns per Ha at Financial Prices assuming changes in land type

	ML to HL	ML to HL	ML to HL	ML to HL	LL to ML	LL to ML	LL to ML	LL to ML
Present	26821	21595	19826	17653	20297	15565	13782	13268
Future Without	26821	21595	19826	17653	20297	15565	13782	13268
Future With	30516	24653	22593	20884	29660	23421	21107	19822
FW less FWO	3695	3057	2767	3231	9363	7856	7325	6554

Returns per average farm size at Financial Prices assuming changes in land type

Farm size	0.15	0.53	1.69	3.26	0.15	0.53	1.69	3.26
Present	4023	12957	29739	68846	3045	9339	20672	51745
Future Without	4023	12957	29739	68846	3045	9339	20672	51745
Future With	4577	14792	33890	81448	4449	14053	31660	77304
FW less FWO	554	1834	4151	12602	1404	4713	10988	25559

Sharecropper Returns per ha at Financial Prices assuming no changes in land type

	Small HL	Medium HL	Small ML	Medium ML	Small LL	Medium LL
Present	12910	13472	12203	12266	8233	7892
Future Without	12910	13472	12203	12266	8233	7892
Future With	14428	14414	12814	12621	8497	8118
FW less FWO	1518	942	612	355	264	227

Sharecropper Returns per average farm size at Financial Prices assuming changes in land type

	ML to HL	ML to HL	LL to ML	LL to ML
	0.53	1.69	0.53	1.69
Present	12203	12266	8233	7892
Future Without	12203	12266	8233	7892
Future With	14428	14414	12814	12621
FW less FWO	2226	2148	4581	4730

TABLE 15.15

Returns per Ha at Financial Prices assuming no change in land type

Noakhali ZONE C Farm Models

	Marginal HL	Small HL	Medium HL	Large HL	Marginal ML	Small ML	Medium ML	Large ML	Marginal LL	Small LL	Medium LL	Large LL
Present	27381	22183	20493	17985	24552	19634	18000	16224	19395	14725	13015	12818
Future Without	27381	22183	20493	17985	24552	19634	18000	16224	19395	14725	13015	12818
Future With	32040	25741	23458	21841	30062	23802	21482	19851	19968	15256	13539	13314
FW less FWO	4659	3558	2965	3856	5510	4168	3482	3626	573	531	525	496

Returns per Ha at Financial Prices assuming changes in land type

	ML to HL	ML to HL	ML to HL	ML to HL	LL to ML	LL to ML	LL to ML	LL to ML
Present	24552	19634	18000	16224	19395	14725	13015	12818
Future Without	24552	19634	18000	16224	19395	14725	13015	12818
Future With	32040	25741	23458	21841	30062	23802	21482	19851
FW less FWO	7488	6108	5458	5617	10667	9076	8467	7033

Returns per average farm size at Financial Prices assuming changes in land type

Farm size	0.13	0.50	1.72	3.33	0.13	0.50	1.72	3.33
Present	3683	11780	27000	63274	2909	8835	19522	49990
Future Without	3683	11780	27000	63274	2909	8835	19522	49990
Future With	4806	15445	35187	85179	4509	14281	32223	77417
FW less FWO	1123	3665	8187	21906	1600	5446	12701	27427

Sharecropper Returns per ha at Financial Prices assuming no changes in land type

	Small HL	Medium HL	Small ML	Medium ML	Small LL	Medium LL
Present	12801	12931	11015	11064	7349	7095
Future Without	12801	12931	11015	11064	7349	7095
Future With	14679	14608	13178	12983	7761	7544
FW less FWO	1879	1678	2162	1919	413	448

Sharecropper Returns per average farm size at Financial Prices assuming no changes in land type

	ML to HL	ML to HL	LL to ML	LL to ML
	0.50	1.72	0.50	1.72
Present	11015	11064	7349	7095
Future Without	11015	11064	7349	7095
Future With	14679	14608	13178	12983
FW less FWO	3664	3545	5829	5888

While the farm models suggest that it would be in their own interests for farmers to make use of the opportunities which the project should generate, there are constraints which may hinder development. There is little doubt that the major crop rotation proposed, boro followed by T. aman, is the most preferred amongst farmers. It is popular because it allows farmers plenty of time between crops to organise and prepare for the next one and a reasonable window in which to plant and harvest the crop. In addition there is no doubt that LLPs are the preferred (and cheapest) mode of irrigation. The constraint which might delay its implementation is the poor access which farmers have to credit with which to finance the purchase of LLPs. In the past, this has not proved a constraint when farmers have been able to finance the purchase of LLPs out of savings and loans from other family members. Whether the sudden availability of extra water and consequent high demand for LLPs will stretch these resources too severely is unknown. It is possible that the banks will also see that the project will provide an opportunity for them to do more business and streamline their procedures to make credit more accessible.

15.5.2 Funding of operation and maintenance costs.

It has never been the practice in Bangladesh to recover operation and maintenance costs for improved drainage. There are many reasons for this but the most important are that it would be extremely difficult to devise a system that is fair and more practically, very hard to collect the fees.

Irrigation charges are simpler to organise because they can be levied on the pump owner / operator whom it would not be difficult to register.

The justification for such an irrigation fee is that those with access to irrigation are likely to benefit from the project more than those with none. In financial prices, operation and maintenance of the project will cost Tk. 39 million per year which is equivalent to Tk 1325 per hectare of land irrigated from the khals. Provided that the fee is used to maintain the system in such a way that water supplies are guaranteed and those paying the fee can see their money is well spent such a charge would not be excessive.

It is likely that irrigation charges which are currently rather high in Noakhali and probably include a "scarcity" value of water will decline after implementation of the project to similar levels charged in Gumti. With increased competition between pump owners' farmers may even experience no increase in charges beyond current levels.

15.5.3 Capture Fishery Losses.

It is extremely difficult to mitigate against losses of "common good" low value wild fish as these are thought to provide a significant proportion of the animal protein consumed by poorer sections of the community. While commercial aquaculture can make good the loss in fish catches (which in Noakhali North Project requires less than a 20% increase in pond production over current production levels), production from commercial ponds is high value carp which are beyond the budgets of the poor. In these circumstances the most realistic mitigation which can be made is to increase incomes sufficiently to enable the purchase of replacement protein.

Employment in agriculture is expected to increase from 27.8 million to 32.11 million days per year in the future, an increase of 4.3 million days. The amount of time spent catching fish is expected to decline from 2.5 million days to 1.6 million days, a decline of 0.9 million days, which gives an incremental net gain of 3.4 million days.

These 4.3 million days at Tk 43 per day are worth Tk 185 million in wages which exceeds the value of the fish by two times even, if they are valued at Tk 25/Kg (an assumption which places no value on the fishermen's time). In addition it is unrealistic to assume that subsistence fishermen catch 100% of the fish caught. Thus provided those sections of the community who are vulnerable in this respect secure the same proportion of the additional work as their share of the fish catch, they will have the choice as to whether to replace the lost protein or not.

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REFERENCES

A full list of references and an environmental bibliography is given as Appendix * of Annex H, the Environmental Impact Assessment.

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ANNEX A

TERMS OF REFERENCE

BANGLADESH

SOUTH EAST REGION WATER RESOURCES DEVELOPMENT PROGRAM

Terms of Reference

I. Background

Introduction

1. The Government of Bangladesh (GOB) aims to achieve foodgrain self sufficiency. With this objective in mind, GOB has selected in its priority program the development of the South East Region and has conducted surveys, investigations and modelling programs to be used as essential planning tools for the selection of projects for implementation. These activities have been undertaken under the UNDP assisted Surface Water Simulation Modelling Program for the South East Region, the hydro-morphological study of the Gumti-Titas basin, the aerial photogrammetry survey of the Gumti-Titas basin, the hydrographical surveys for the rivers and khals, and the hydrological data collection program for the basin. GOB requested the assistance of UNDP for financing the preparation of a development plan for the Region and a proposal for specific investments. The World Bank was requested and accepted to serve as executing agency. Assistance for the implementation of projects is expected from the International Development Association (IDA) and other donors.

2. GOB proposes to conduct the study through consultancy services provided by a consortium of foreign and local firms. These firms will prepare a regional plan at prefeasibility level for the development of water resources in the region to support agricultural production (crops, livestock, fisheries) and make recommendations for phasing of proposed development programs. The consultants will then carry out a feasibility study for a first phase development program. The prefeasibility study shall be completed within nine months, the feasibility study in the following 24 months. This timing is a mere estimate. The consultants will be expected to provide their own assessment of how the activities should proceed, keeping in mind that GOB attaches great importance to the preparation of an effective regional development plan for the South-East area.

Project Area

3. The project area has the following approximate boundaries: to the North, the line from Hasvinagar to Madhabpur; to the East, the border with India and the Eastern border of the Muhuri Project; to the West, the main stream of the Meghna River; and to the South, the Bay of Bengal.

4. The project area has an extensive system of waterways for irrigation and drainage, including major channels such as the Dakatia and Gumti rivers and the Noakhali Khal, and a dense network of natural khals. Many man-made

khals were excavated several hundred years ago and still function without appreciable maintenance. Improvement of channels has been included in recently constructed works, such as the Chandpur and Meghna Dhonagoda projects, and works carried out under the Special Canal Excavation Program and the Food for Work Program (FFW). The project area covers approximately 9000 km2 with a population density approaching 1000/km2 in some parts. Present agricultural development is particularly constrained by flooding in the monsoon season and shortage of water during the dry season.

Justification for the Project

5. The project area suffers from problems of flood and drought. During the monsoon (May to October) high concentration of rainfall, high sediment discharges, storm surges and tides in coastal areas create difficult hydrological conditions and lead to silting up of outfall canals. The main rice crops, aus and aman, that are grown in the monsoon season, are frequently subjected to flooding to depths which severely reduce yields. These crops are also frequently affected by erratic rainfall and by a late onset or early cessation of the monsoon rains. Increase in cropping intensity, by expanding the area of boro rice and other rabi crops during the dry season, depends upon the provision of irrigation. The study will produce a plan for addressing these and other constraints to agricultural production (crops, livestock, fisheries).

Present Situation

6. Completed and on-going major water resources development activities in the South-East Region include:

(a) Chandpur Irrigation Project, which provides flood control and drainage to an area of 52,000 ha and irrigation to 27,000 ha, was completed in 1980;

(b) Muhuri Irrigation Project, which provides flood control, drainage and control of saline intrusion to an area of 27,000 ha and irrigation to 20,000 ha, was completed in June 1986;

(c) Meghna-Dhonagoda Project;

(d) Gumti Phase I Subproject being implemented under the Third Flood Control and Drainage Project provides flood control and drainage to a cultivable area of about 29,500 and irrigation to 10,000 ha. A second phase of the development of Gumti-Titas basin is under preparation. The proposed development comprises flood control and drainage to 100,000 ha and irrigation development to the extent permissible by the available dry season flow of the Lower Meghna River;

(e) other developments include:

(i) assistance in the Rural Development sector by DANIDA under the NRD II Project in the Noakhali District. This project supports minor surface water irrigation schemes, agricultural extension, credit and cooperative services;

(ii) land reclamation with Dutch assistance in the newly accreted lands in the south of the region; and

(iii) completed and ongoing Food for Work schemes, implemented by BWDB field divisions, involving mainly re-excavation of khals and resectioning of embankments.

Previous and Ongoing Studies

7. The results of earlier studies should be evaluated and the data base underlying them assessed. The Surface Water Simulation Model developed under UNDP project BGD/85/045 is expected to provide the analytical base for this preparation work. The Consultants will be expected to work closely with teams involved in the implementation of projects and studies in the Region, including Gumti Phase II, and the hydro-morphological study of the Gumti/Titas, and with teams working on the preparation of a National Water Plan and Flood Policy initiatives.

II. Terms of Reference

8. The first output of the project will be Regional Development Plan at pre-feasibility level, including: (i) a comprehensive data base for water resources, agriculture (crops, livestock and fisheries) and socio-cultural characteristics of the South-East Region; (ii) an assessment of the development potential in the Region and the associated requirements for water resources development; and (iii) identification of potential investment programs to help achieve the production potential. This plan shall include alternative scenarios for effective utilization of intra regional ground and surface water and transfer of surface water from boundary streams. Pertinent to the latter would be the transfer of the Meghna flows to meet requirements of existing /proposed schemes within the project area and the Muhuri Irrigation Project.

9. The regional plan should identify, how potential investment opportunities could be implemented in the contract of a well defined and phased development program. It should broadly describe the areas proposed and outline specific investment programs to be studied at feasibility level.

Scope of the Consultancy Services

10. For preparation of the regional plan using the participatory approach the consultants shall undertake the necessary work in relation to:

(a) Analysis of the Social Setting. The consultants will use the guidelines given in Attachment A to obtain information necessary to

prepare Regional Plan and identify investment programs responsive to local needs and providing opportunities for various socio-economic groups in the area.

(b) Topographic Survey and Mapping. The consultants will use existing photographs, maps and surveys, recent topographical surveys on the region's khal and river systems conducted in connection with SWSM and the feasibility study of the Gumti-Titas basin. They will update this information to identify waterways, cultivable and irrigable land, and fisheries facilities.

(c) Hydrology. The Consultants will have access to surface water and geotechnical data available with GOB agencies. They will work closely with the MPO, BUET, BWDB and the consultant conducting the hydrological-morphological study of the Gumti-Titas rivers and the Gumti Phase II study. It should be specifically noted that the output from the SWSM will be a major input into this regional planning effort. All hydrological data needed for the study, including discharge, sediment, salinity and climatological data shall be collected from pertinent sources and presented in the prefeasibility studies, along with analyses to establish parameters for subsequent feasibility studies. An appraisal shall be made of the available water resources. Assessments shall be made of reliable flows, storm rainfall, flood frequencies, sediment loads and salinity. Crop water requirements shall be estimated for alternative cropping patterns, taking into account effective rainfall.

(d) Land Classification and Flood Depths. The Consultant shall make an assessment of flood depths and the capabilities of the soils in the area. Necessary soil surveys shall be conducted in selected locations as required.

(e) Crop, Livestock and Fisheries. The Consultant shall report on the present land use in the project area. The existing agricultural and fisheries practices in each area proposed for development shall be described, including varieties, fish species, current yields, inputs, labor requirements, cultivation methods, incidence of disease and pests and any other relevant aspects. The Consultant shall make estimates of future levels of production indicating suitable cropping patterns and technology for crop, livestock and fish production.

(f) Engineering:

(i) The Consultants shall assess all water resources schemes, partly or completely constructed in the project area. They shall review existing reports, surveys and designs to generally establish lessons learnt form and the impact made by existing schemes for the development of water resources in the project area. The Consultants shall identify all potential water

resources in the project area, assess the availability of groundwater and define the role of groundwater in the development of the region. Account shall be taken of the requirements for domestic water supply and in-land water transport. Outline designs and alignments shall be prepared for major works and order-of-magnitude costs shall be calculated. Projects identified for feasibility level study shall be ranked according to their suitability for rapid development and potential for contribution to growth, employment creation and poverty alleviation.

(ii) Augmentation of Muhuri Reservoir. Irrigation withdrawals by riparians above the Muhuri Irrigation Project boundaries and the dry season discharge requirements for flushing of tidal silts accumulation in the outfall canal of the Feni regulator led to inadequate water in the reservoir during February/March to command the irrigable area of 20,000 ha. The Consultants shall, with the available stream flow data of Feni and Muhuri rivers collected since 1982 and the discharge records of the Feni regulator make an operational study of the reservoir for the existing cropping pattern and the post-project recommended cropping pattern to determine the augmentation requirements of the reservoir for the original command area of 20,000 ha, the additional area that could be taken up above the project boundaries and for flushing requirements to keep the outfall canal free of silt to facilitate operation of the regulator gates at the onset of the monsoons. The Consultant will them make recommendations on the potential engineering and economic feasibility of a Meghna-Muhuri link to transfer water.

(iii) Improvement of Drainage. Assess drainage problems of the area and suggest solutions.

(g) Environmental Considerations. The Consultant shall consider the impact on the environment of each alternative development option and recommend appropriate actions to mitigate adverse effects. The prefeasibility study shall clearly set forth the environmental consequences of recommended improvements and actions including the impact of displacing farmers and other residents resulting from proposed investment programs. Particularly consultants would broadly identify (a) the natural resources, ecosystems and human groups likely to be affected, and highlight actual vulnerable areas. Both direct and indirect impacts should be considered, (b) assess the reliability of data and information on environment, (c) make recommendations for further work and measures that may be needed, (d) identify institutions needed to manage environmental considerations related to the project and assess capacity in this regard of existing Bangladesh institutions particularly staff of BWDB and prepare a proposal for training of BWDB staff.

(h) Economics. The Consultant shall assemble relevant socio-economic information on the project area. Constraints to development shall be identified and their impact on the achievement of future production estimated. The consultant shall assess existing infrastructure and future requirements for increased agricultural production in the project area. All benefits and costs for proposed projects shall be estimated. The economic feasibility of each project shall be assessed. Particular attention shall be paid to land tenure and incentive systems for fishermen and farmers to adopt improved technology.

11. Feasibility Studies: The second project output will consist of two feasibility studies, one for a project covering a priority area of about 100,000 ha and the other one covering the augmentation of the Muhuri Project. The final decision on the location of the first project will be made during the first interim review (about six months following project start-up). Augmentation of the Muhuri Project will be the subject of a separate feasibility study unless otherwise agree by GOB, UNDP and the Bank to either modify its scope or combine it with the previous feasibility study. In that case, any additional resources required will be discussed and agreed with the consultants prior to initiation of the work. Specific tasks relating to the feasibility studies include:

(a) discussions/consultations with local officials and potential beneficiaries (Attachment A);

(b) discussions with Ministries of Agriculture, Forests, Environment, Shipping and IWT, Fisheries and Livestock, Irrigation, Water Development and Flood Control, Planning Commission, Roads and Highways Department, BADC, NGOS and other institutions involved in promoting local participation;

(c) assessment of the data base, review of topographical surveys, hydrological and morphological data, agro-economic and socio-economic data and assessment of ongoing surveys and data collection activities, with particular reference to their adequacy and the need for additional work, including a benchmark survey to be conducted as part of the Consultant work program (Attachment A);

(d) using the results of the simulation modelling program and other sources of data for the SE region, obtain information needed for determining design levels of embankments and discharge data for fixing capacities for drainage structures and for the design of drainage/supply khals or canals;

(e) assessment of the extent of benefitted area, the potential impact of the proposed project works on the adjacent areas and the region as a whole and on existing economic activities (fisheries, navigation, etc.); identification possible negative effects in the project area and preparation of proposals for possible remedial measures;

(f) establish design criteria and planning concepts, prepare project layouts, feasibility level engineering designs and drawings of relevant project components. In this respect, due consideration shall be given to:

- the possibility to improve irrigation facilities through pumping water from the Meghna and conveying it through an improved khal system, taking into consideration present and planned use of Meghna waters;

- the design height of embankments and the associated risk of failure;

- the special maintenance requirements of high embankments and the increased damage in case of failure (in particular in those areas where embankments have to be significantly raised as a result of river confinement and where the polder inundation levels will be considerably lowered through pumping);

- current groundwater abstractions in the project area and the potential for further development; and

- the need for access and service roads, necessary to construct, maintain and operate the embankments, structures and other project facilities;

(g) preparation of cost estimates of project works on the basis of recent actual contract rates, including annual expenditure schedules in both local and foreign exchange currencies;

(h) preparation of operation and maintenance schedules, including staff, equipment and budget requirements;

(i) preparation of realistic implementation schedules, showing project components in quantitative and monetary terms, equipment and staff requirements and procurement schedules, as well as specifications for engineering and other surveys required for detailed design and implementation; World Bank formats to be used for implementation schedules and procurement of equipment, vehicles and civil works;

(j) preparation of proposals for improved water management and an organizational structure for project implementation, and for improving the institutional infrastructure (e.g., extension, research, credit, marketing, and farmers' organization) in the area;

(k) assessment of benefits for relevant project alternatives and evaluation of project economics, including farm budgets, internal rates of return and sensitivity analysis; and

(l) for a sample of ongoing FCD&I projects, identify the implementation problems at the preconstruction and construction phases and

recommend solutions to overcome such constraints under the proposed program.

III. Important Activities

Mapping

(a) produce a project works plan indicating the project area, embankments, khals and minor drainage channels, rivers, structures, roads, etc. The map should clearly indicate the existing and proposed works and the changes of the embankment and the major khals;

(b) preparation of a map indicating the preproject and post project flooding conditions, the proposed drainage compartments and a schedule indicating the proposed completion dates for the drainage compartments, and the items of work to be completed;

Flood Control and Drainage Improvement

(c) Flood data should be classified along the lines below:

Flood Depth (meters)	Area Ha	% of Total Area
0.3 to 0.6		
0.6 to 1.5		
1.5 to 3.0		
over 3		
Total		

The above data to be given separately for:
- average annual flood level and duration;
- maximum (historic) flood level and estimate of probability of occurrence;

(d) trends in water level at selected locations for different development scenarios. The return periods to be 20 and 30 years;

(e) determination of the required capacity of regulators. The following design criteria shall be adopted:

- the drainage system shall be capable of releasing runoff of 10 days rainfall with a return period of 5 years during the critical period, not exceeding a submergence duration of 3 days and/or;

- the drainage system shall be capable of releasing runoff of a 10 day rainfall with a return period of 10 years during the critical period not exceeding a submergence duration of 6 days;

(f) for the determination of the capacity of main drainage canals (usually an existing khal) the design criteria is the runoff of a storm with a return period of 10 years and drainage within a period of 3 days;

(g) the provision for new secondary canals on the basis of a minimum of 1.5 Km for 200 ha of drainage area with due consideration given to irrigation requirements if low lift pumps are utilized.

Irrigation Development

(a) assess water resources of the Lower Meghna River, taking into account the present withdrawals by the users and their future requirements and determine the availability of water for use in the project area, as well as that for a possible transfer to the Muhuri Irrigation Project;

(b) study the development options available, such as primary pumping with the secondary distribution system provided either by low lift pumps or gravity. Study the possibility of using lined canals or underground pipes and flexible pipes to reduce land acquisition and save water;

(c) study the existing irrigation systems in the project area (LLPs, STWs and DTWs) the organization and management of farm groups and water users associations as a means to improved water distribution and management; the condition of farm canals, designed and actual command areas; identify the constraints and suggest solutions;

(d) propose a strategy for development of irrigation;

Pump Drainage

12. Study the possibility of lowering flood levels in the protected area by designing the primary pumps to be able to function on a reversible basis. Determine the additional area that could be brought into cultivation using improved technology. Analyze the economics of the pump drainage system and make appropriate recommendations.

Navigation Facilities

13. Study the existing boat traffic during the wet and dry seasons in khals, major streams and rivers plying within the project area, serving the growth centers with special reference to markets, inter connecting the feeder roads and national road network.

Fisheries Development

14. Study the existing fisheries in floodplains, beels and ponds. Determine the reduction in area which may result from polder development. Study the possibility of incorporating design in the hydraulic structures to

reduce any such adverse effect on the floodplain fisheries and detail the operation of these structures; provide guidelines for intensifying existing fisheries and developing new ones to compensate for unavoidable losses and fully develop the fisheries potential in the area.

Land Acquisition

15. Assess the land acquisition requirements. Interview land owners and local leaders to identify potential problems and suggest feasible solutions.

Development Support Communications

16. Study the institutions and facilities available in the project area for development support communications, viz., BWDB field staff capability, KSS and other farmers organization, Union Council and Upazila staff, Deputy Commissioner staff and agricultural support services (extension, research, credit, marketing, input supply) and make proposals for the effective participation of local organizations in the proposed development program for the Region.

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Water Control Structures

(a) list the structures required as in the example format below:

Identifying Number	Type of Structure	Describe Why the Structures are Needed
1	Regulator	To prevent river flood from entering protected area through drainage channel, and to drain excess water form the area when necessary.
2	Culvert	Drainage channel must be enlarged; the present culvert is too small and backs up water, etc.

(b) prepare a single line drawing for each structure in the list above. Show dimensions of opening or important features of structure. Indicate the top elevation, floor elevation, length, width, etc. Attach a standard drawing;

(c) prepare hydraulic calculations for structures;

(d) for a pumping plant, indicate the number, size and type of pumps. Show calculations to substantiate the size and number of pumps. Evaluate and compare diesel and electric power alternatives;

(e) show the cost of each structure and total cost of structures in the scheme, using the same identifying number as in the list above;

(f) show the typical cross-section of each existing embankment as designed and built, and for each new embankment to be constructed. Show the elevation of embankment and flood levels (annual and 20-year probability) and describe the present condition of the embankment; estimate quantity of earthwork for new construction required;

(g) show the typical cross-sections of each drainage channel as designed, built, to be re-excavated and/or for new excavation. Give bed levels. Show the hydraulic computation for the amount of water required to be removed and the capacity of the drainage channel and describe its present condition; estimate the quantity of earthwork;

(h) for existing earthworks, indicate the status of completion and calculate the quantity of earthwork required to improve them to an acceptable standard and to proper elevation (with drawings of new cross-sections);

(i) indicate the elevation of top of embankment at every two miles along the length. Indicate minimum freeboard above normal (annual) flood level.

Cost Estimates

17. Estimate capital costs by construction year along the lines of components which would generally follow the undermentioned guidelines:

1. Preconstruction Activities

a. Land acquisition;
b. Engineering surveys and foundation investigations;
c. Preparation of bidding documents for procurement of goods, services and for award of civil works contracts;

2. Civil Works

Flood Control and Drainage

a. Embankments

(1) New
(2) Resectioned
(3) Protection works

b. Drainage channels

(1) Khal resectioning
(2) New
(3) Appurtenant structures:

(a) Road bridges
(b) Culverts
(c) Footbridges

(4) Hydraulic Structures

(a) 1 vent regulator
(b) 2 vents regulator
(c) etc.
(d) Flushing sluice
(e) Contingency for additional regulators to be decided at detailed engineering phase
(f) Navigation locks

Irrigation Development

(1) Primary pump stations;
(2) Inlet and outlet canals;
(3) Main canal;
(4) Secondary canal;
(5) Canal structures, siphons, flumes, bridges, turnouts, etc.;
(6) Outlets in flood embankment for low lift pumps utilization.

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Access Roads Needed for Construction and O&M

(1) New roads -paved, brick soling, bitumen;
(2) Improvement of existing roads - earthwork, paved, brick soling, bitumen;
(3) Embankment paving - brick soling, bitumen;
(4) Road bridges, culverts.

3. Fisheries Infrastructure

4. Procurement of equipment and vehicles

5. Support Services

6. Studies

7. Technical assistance and training

8. Engineering and administration

9. Operation and maintenance during the construction period and after project facilities become operational.

Cost Recovery

18. Prepare a program and procedures for recovery of O&M costs, making use of procedures developed under the BWDB System Rehabilitation Project.

Project Management

19. Prepare a proposal for project management during the construction period and after projects become operational.

Production

(a) Cropping Pattern, Yields and Production:

Without Project

Crops	Area (ha)	Yield (Kg/ha)	Total Production (Tons)
Aus	.....	.....	.....
Aman	.....	.....	.....
Boro	.....	.....	.....
T. Boro	.....	.....	.....
Wheat	.....	.....	.....
Sugarcane	.....	.....	.....
Other Crops			

Yields shall be considered on a "normal year", flood year" and "average year" basis. Cropped areas shall be subdivided into irrigated and non-irrigated areas.

With Project (same format as Without Project).

(b) Cropping Intensities

Without Project.....
With Project.....

(c) Fisheries Production (with and without Project)

(d) Livestock Production (with and without Project)

Describe potential for change in cropping pattern, yields and cropping intensities resulting from the project. The major agricultural production constraints would be identified, the extent of the impact of such constraints would be quantified and cost of production will be estimated. Constraints to intensification/ diversification shall be identified and suggestions made as to how they can be addressed.

Farm Budgets

20. Prepare farm models for representative farm types, including tenants and/or share-croppers and analyze the financial benefits of the project and their distribution between different classes of beneficiaries. Estimate the potential for cost recovery and calculate levels of cost recovery consistent with farmers capacity to pay.

Economic Analysis

21. Estimate project net economic benefits and rates of return on the investments.

Employment

22. Analyze the expected impact of the project on employment in the project area, considering male, female and landless employment.

IV. BWDB's Responsibility

23. The consultants shall work with the Planning Schemes Unit headed by a Superintending Engineer (SE) under the Chief Engineer (CE) Planning. The specialized departments of BWDB shall assist the Project Team as required, particularly with regard to the hydrological, morphological and foundation aspects of the study. BWDB's Central Designs Organization shall provide guidance in the design of major structures as required.

24. The SE shall ensure that the objectives of the study as detailed in the TOR would be achieved within the agreed time schedule and that the contents of the report are acceptable to GOB. He would, in the context of the TOR, direct the planning process and work programming, supervise the execution of the study and monitor progress according to the set objectives. He would have regular meetings with the BWDB professional staff and the consultants to discuss technical and project management issues. Any unresolved issue, technical or otherwise, should be taken up with BWDB's senior staff (Chief Engineer Planning, Chief Engineer Designs, Director General of River Research Institute, Chief Engineer Hydrology etc.) or other GOB agencies as required.

25. BWDB shall make arrangements for SE's staff and the consultants to meet concerned GOB agencies in Dhaka and the project area to enable these agencies to be aware of the objectives of projects and be involved from the inception in adapting it to their needs, particularly in relation to such matters as extension, research, pump irrigation, input supply, credit, farmers organization, land acquisition, fisheries infrastructure, domestic water supply, environmental impact etc.

26. BWDB shall provide the following data, services and facilities:

(a) all hydrological, morphological, meteorological data and records or river stages;

(b) contour maps, mouza maps, aerial photographs, previous reports on surface and groundwater development of the project area;

(c) results of mathematical modelling studies;

(d) standard design manuals and type plans for hydraulic land other civil engineering structures and buildings; and

(e) transport vehicles, office and drawing equipment, including computers all of which to be procured through the Executing Agency using project funds.

27. The Consultant's contract shall include, in addition to funding for consultacny services, provision for funding the following items to be financed through UNDP contribution

(a) additional topographical surveys, foundation investigations and hydrological data collection needed for the prefeasibility, feasibility and detailed designs for the first year's construction program. These works shall be undertaken through contract according to IBRD procurement guidelines;

(b) adequate office space to accommodate Consultant and BWDB staff;

(c) support staff including administrative and financial staff needed for the effective delivery of the consultancy services; and

(d) operation and maintenance of the office, including operation of transport vehicles, office equipment, stationery, printing reproduction, and utilities.

V. TIME SCHEDULE

28. The study period is estimated at 9 months for preparation of the regional plan and 24 months for the feasibility study. This is a tentative schedule which consultants should feel free to change while preparing their proposals to ensure that they can produce an effective regional development plan and an adequate feasibility study.

Operation or Event	Responsibility	Date
Project start-up	Consultants	Sept. 90
Inception Report	Consultants/ BWDB	Oct. 90
Prefeasibility Study (Development Plan)	Consultant/ BWDB	July 91
Benchmark Surveys for proposed project(s)	Consultant/ BWDB	Oct. 91
Feasibility Study Report	Consultant/ BWDB	Sept. 92

VI. DURATION OF CONSULTANCY SERVICES AND COMPOSITION OF TEAM

29. Based on the above schedule the consultancy will commence about January 1990 and end about September 30, 1992, giving a duration of 33 months. It is estimated that 345 man-months of specialist input will be required, of which 95 man-months would be internationally recruited specialists and 250 man-months of local specialists. In addition, the consultant would provide junior planning and design engineers, surveyors, draftsman, field staff for the socio-economic survey, benchmark survey, fisheries and navigation studies. The following composition is provided as a guide and the invited firms are free to suggest variations:

Internationally Recruited Specialist	Man-Months
Senior Planning Engineer (Team Leader)	33
Senior Design Engineer -	9
Senior Hydraulics Engineer -	5
Senior River Training and Dredging Specialist -	3
Senior Mechanical Engineer -	3
Senior Economist - 15	
Senior Irrigation Engineer -	9
Senior Coastal Engineering Specialist -	2
Senior Agronomist -	6
Environmental Specialist	4
Short Term Specialist	6
Total:	95

Local Professionals	Man-Months
Senior Water Resources Engineer	33
Planning Engineer	18
Senior Hydraulic Engineer	18
Senior Design Engineer	40
Senior Irrigation/Drainage Engineer & River Training Specialist	34
Senior Hydrologist	12
Senior Agronomist	20
Senior Agriculture Economist	12
Soils Specialist	4
Economist	18
Fisheries Specialist	6
Environmental Specialist	4
Mechanical Engineer	4
Socio-Economist	8
Hydro-Geologist	6
Unallocated	13
Total:	250

VII. REPORTING REQUIREMENTS

30. The prefeasibility and feasibility report shall generally follow the outlines given in the FAO/IBRD cooperative program publication "Guidelines for the Preparation of Feasibility Studies" published in December 1970. The report outline shall be agreed with the World Bank. The feasibility report shall be a comprehensive document and shall determine that the project is:

- in conformity with the country's development objectives and immediate priorities;

- technically sound, and the best of the available alternatives under existing technical and other constraints;

- administratively workable; and

- economically, financially, socially and institutionally viable.

31. The Consulting firm shall work directly with BWDB professionals and keep the SE informed of the progress and problems. They will prepare discussion papers for weekly (or as needed) meetings to be conducted by the SE and monthly meetings by Chief Engineer Planning. In particular, they will submit to the World Bank for subsequent transmittal to GOB and UNDP:

(a) an inception report in 20 copies. This report, which should be submitted within 6 weeks after the contract award, will include the work plan, along with detailed task specific manpower allocation budget for the whole project team, the program for surveys, investigations and hydrological data collection needed for the prefeasibility study and actions taken and progress on these activities during the first 6 weeks. The inception report should also include the program for the feasibility study and the detailed engineering documents. Staffing requirements, transport, office accommodation and other relevant matters should also be discussed;

(b) quarterly progress report in 20 copies. These reports should be utilized by consultants to inform the World Bank, GOB and UNDP on progress, outstanding issues and to suggest solutions to any problems facing them in their work;

(c) the draft final reports in 20 copies for the prefeasibility and the feasibility study; and

(d) final reports in 30 copies within 2 weeks after the tripartite meeting is convened to discuss the draft reports.

VIII. PROFILE OF SPECIALISTS

Team Leader and Deputy Team Leader

32. They should possess as a minimum a degree in civil engineering with broad experience in water resources planning and as a team leader in the preparation of feasibility studies for flood control, drainage and irrigation projects in countries with similar conditions as Bangladesh. Experience in regional planning is required along with significant past involvement in assessment of land and water resources for the integrated development of crops, livestock and fish production. He should also be fully literate about streamflow simulation and computer assisted water resources planning. The Team Leader will be nominated with the concurrence of all the members of the consortium.

Senior Design Engineer

33. He shall have a degree in civil engineering with substantive experience in the design and construction of hydraulic structures, embankments, including pump stations, navigation locks, etc. He should have at least 5 years of such experience in developing countries, preferably Bangladesh.

Senior Hydraulic Engineer

34. He shall have a degree in civil engineering. He should be a specialist in modelling of river basins including surface water and sedimentation. In addition, he should be able to advise and assist in the design of physical models if required to be conducted in BWDB's River Research Laboratory. His experience should include planning of river basins, preferably under conditions similar to those existing in Bangladesh.

Senior River Training and Dredging Specialist

35. He should have broad experience in dredging and in the planning, design and construction of river training works. His experience should include physical and mathematical modelling for determination of protection measures to arrest erosion of river banks, using available local resources.

Senior Mechanical Engineer

36. He should have a degree in mechanical engineering with a varied experience of at least 12 years including at least 8 years experience in designing controlled gates for hydraulic structures, gates for navigation locks, etc.

Senior Coastal Engineering Specialist

37. He should possess a degree in engineering with proven experience in coastal engineering works. He should understand the application and development of mathematical and physical models to assist in the hydraulic design of coastal works.

Senior Economist

38. He shall possess at least a master degree in economics or agricultural economics. He should have broad experience in collection, computation, analysis and evaluation of socio-economic data. He should have had experience as a lead member in the preparation of feasibility reports.

Senior Agronomist

39. He shall possess a degree in agriculture, with broad experience in irrigated agriculture. He should have proven experience in planning effective water management program for the conditions prevailing in Bangladesh. He should have had experience as a lead member in the preparation of feasibility reports.

40. Environment Specialist. He should possess at least a Master's degree in environmental/natural science, with over 10 years experience in countries with similar conditions as Bangladesh where vulnerability to natural disasters, pollution due to agrochemicals, resettlement of displaced persons, landlessness, etc. are major factors.

Senior Water Resources Engineer

41. He should possess a degree in civil engineering and broad experience in planning, design and construction of flood control, drainage and irrigation facilities. he should have had experience in the preparation of feasibility reports and should have past experience in the management of multi-disciplinary teams.

Senior Construction Engineer

42. He shall possess a degree in civil engineering with wide experience in construction, operation and maintenance of flood control, drainage and irrigation facilities. His experience on similar types of projects should enable him to identify the constraints in project implementation both in procedural matters and at the construction sites. He should be able to detail the implementation problems and suggest solutions. He, together with the team leader, should be able to detail the O&M requirements and work out realistic budgets.

Senior Hydrologist

43. He shall possess a post-graduate degree in civil engineering and have experience in surface water hydrology with basic knowledge in groundwater. He should be proficient in computation and analysis of hydrological data to assist the planning and design engineer in formulation project planning and design works.

44. Environmental Specialist. He should possess at least a Master's degree in environmental or natural science/ecology/biology and a minimum of 5 years experience in environmental studies or an individual consultant or as a staff of a consulting firm/university specialized in conducting environmental studies.

Local Participation
(Detailed Guidelines for the Study Team)

1. The consultants are expected to identify methodologies and means for ensuring meaningful local participation in the preparation of the Regional Plan and design of associated investment programs.

2. The consultants will require the services of at least two social scientists and necessary support services:

(a) a national social scientist, familiar with the methods of analysis of the social structure of communities in Bangladesh, trained in rural development and in field implementation strategies, and fully familiar with the socio-economic complexities of the project area;

(b) an internationally recruited social scientist with expertise in the participatory approach, who will be capable of identifying any lacunae in the information gathered and in the methodology identified for promoting local participation.

3. The consultants are expected to:

(a) undertake a thorough study of the society and communities in the area.

The content of the study should include a description of the characteristics of the different social strata, their social and cultural prerogatives, their control of the resources necessary for project implementation, and how they interact within the project area. It should include an analysis of the modes of existing community participation (under what circumstances does it occur, for what types of activities, who are the actors, their roles and so forth).

(b) owing to the complexity of women's status in Bangladesh, to their relative lack of viability, and to their vulnerability to the negative effects of technological change; the study should pay special attention to the analysis of their roles in the project areas and to the identification of the resources required to promote their full participation in the project from its inception.

Women's roles in the division of labor, and the manner in which they may be affected directly and indirectly by the project should be explored in detail. As such the study should identify the women in their different social categories, their spheres of activities, their roles in the various units of production, and the areas in which they have authority and decision making power. This analysis should be applied to women's roles in all strata of the society. (The objective is to avoid the portrayal of women as a single group to which inappropriately uniform methods of eliciting participation are applied.)

(c) undertake a social soundness analysis to identify the effects o the project on the different segments of the communities.

A social soundness analysis, which usually completes the socio-economic study, provides the basis for identifying the specific interests of the different segments of the communities in the proposed intervention. It will show who the winners and losers are what is at stake in each case, and therefore the motivation to promote; block or ignore the project.

(d) conduct a test for motivation amongst the different segments of the population in the project area.

One of the most useful tools for defining the methods of eliciting local participation is the test for motivation. It should follow the social soundness analysis and corroborate the findings therein. Because of the nature of the information sought, an accurate test for motivation requires a well thought out design based on the social structure and the values of the communities in question. As such it will disclose the extent to which people are informed about the proposed project, their eagerness to achieve the goals envisioned by the project, their objections to it and so forth. The test will provide the first clues as to what should be done to promote local participation.

(e) define the minimum resources required for project participation and how they are distributed among the potential participants.

At any level of implementation, participation requires of the population a minimum amount of resources. Thus participation in this project will require the investment of land, labor, time, skills, and so forth. It is important to define the minimum resource base required for participation and which segments of the population do or do not have it.

(f) Identify the decision makers in the communities and associate them to the process of the definition of how the members of the communities should participate in project implementation.

Participation, if it is to be effective, should occur at all stages of the project from its definition to the final evaluation. It should occur within the boundaries of socially acceptable behavior and not contribute to the existent antagonisms in any community. Thus the study should provide the basis for the identification of those who play the determinant role of decision makers in each area (of production, allocation of land, allocation of labor, distribution of goods and so forth) that will be affected by the project. It is these decision makers that should be associated to the process of defining the who, how, where, and why of participation. Involving the decision makers will help to insure that they do not block participation of those who they influence, especially women.

It is also important that potential participants define the manner in which they believe they should participate. It will be on this basis that the level of participation will be evaluated in the future; during the implementation phase. Thus the different segments of the population will participate in the definition of needs, the identification of blocks to, and of the types of participation appropriate to the resources of which they dispose.

(g) Appraise the national resources available to guarantee minimum levels of local participation in the project, and subsequently analyze the amount and types of resources which the project must bring to the area to promote local participation.

Setting the stage for participation requires an active feed back and information structure as well as the organization of groups and cooperatives. This is crucial in eliciting the participation of certain segments of the population which are not visible and who have a limited sphere of activity and authority. (This is usually the case of women and the poor.) Thus one of the tasks of the study team will be to identify the structures available nationally and locally for disseminating information, obtaining feedback, fostering the creation of groups and monitoring participation. As such the study should identify NGO's, local associations and so forth, their location, their resources (human and other) and their expertise in the participatory approach. These organizations should function as the implementators of the participatory program at least at the inception of the project.

Benchmark Survey

4. The benchmark survey should be undertaken with the objective of providing or verifying data on engineering, agricultural, economic and socio-cultural (Attachment A) aspects prevailing prior to project implementation. The engineering data would include existing flood control, drainage and irrigation infrastructure, the flooding condition in the project area and adjacent areas, impact of floods on road accessibility, on buildings and homesteads. The agronomic and socio-economic data collection would cover crops, livestock, fisheries, minor irrigation equipment, surface water irrigation, population, land tenure, land acquisition for project infrastructure, marketing, transport and communication, prices and agricultural and institutional support services. More specifically the survey would cover the following.

Engineering Aspects

5. The various Engineering aspects are:

(a) Inventorying the existing infrastructure, such as embankments, regulators, water control structures, irrigation inlets and comments on their operative condition. The structures shall be located on a plan;

(b) minor irrigation equipment (STW, DTW and LLP) fielded and the areas actually commanded under each type of equipment;

(c) the preparation of a plan indicating the shallow, medium and deeply flooded areas for normal annual floods and above normal floods experienced over the last 10 years;

(d) information on present flooding conditions including overbank spill (average and maximum height above bank level), discharge through inoperative or non-existent regulators of khals, damage due to flooding, the level of existing embankments (average), breaches or reaches of embankment not yet constructed and structured to be completed;

(e) the road network, accessibility condition during the wet and dry season (usability by car, four-wheeled drive, rickshaw, bicycle and pedestrains). Condition of the bridges, culverts, foot bridges. The plan prepared for item (a) above should include the road network;

(f) assessment of damages to educational buildings, markets and homesteads caused by normal annual floods and above normal floods. The report should include years of abnormal floods, height and duration; and

(g) assessment of cost of relief work needed for rehabilitation of roads, resectioning of embankments, desilting of khals, etc.

Agro-Socio-Economic Aspects

3. Data would have to be collected through sample surveys. These surveys would include information on representative farms in different flood zones on cropping patterns, yields, cultivation practices, production, employment, cost of production income levels for various classes of project beneficiaries. This information would serve as a basis for an assessment of the present agricultural and socio-economic conditions and of agricultural potentialities in the project area. The surveys would also seek information on marketing channels used by various categories of farmers, characteristics of the local population (family size, family labor), land tenure system, land fragmentation, relative importance of crops, livestock and fisheries activities as a source of income/subsistence, local institutions serving agriculture and their effectiveness, the extent of development of rural infrastructure, and the quality of soils. The following approach to data collection is provided by way of example:

(a) total number of village in the project area is stratified, for example, on the basis of population, predominant topography, land tenure system;

(b) a weighted sample of 10% of villages would be selected by random sampling method without replacement;

(c) a sample of 25% of the household in each selected village would be chosen by random sampling; and

(d) the modes of participation by beneficiaries including landless and women in planning, construction and O&M.

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6. Medium-Term Food Production Plan, Feb. 1981.
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8. Barisal Irrigation Project Completion Report, FAO/GP, 1985.
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12. Coastal Embankment Project, LDL, 1968.
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15. Surface Water Simulation Modelling Programme, Final Report.

South East Regional Study
Proposed Amendments to TOR

Page 5 of 20

Add to paragraph 10(f) the following:

iv) The final Regional Plan will incorporate upgraded proposals for development of a Dakatia/Little Feni project using available data. The approach to the treatment of local sediment and drainage problems in the headwater areas of the catchments will be empirical with different assumptions being made to assess the sensitivity of the development scenarios to possible sediment transport/deposition situations. Recommendations will be made for the formulation of draft Terms of Reference for follow up studies and suggestions presented for the establishment of a sediment and hydrometric gauging programme by the BWDB/Surface Water Modelling Centre or other appropriate agency.

Page 6 Para 11 - Feasibility Studies

The overall objective of the feasibility study is to examine in detail ways in which flooding and drainage problems can be alleviated and to formulate proposals for development of the Noakhali North project area. This will also be of relevance to both upgrading the Regional Planning Report and to future project planning studies elsewhere.

The study will involve an examination of a range of technically feasible project options for alleviating the problems in the Noakhali North area, including non-structural and complementary flood proofing measures where appropriate. The study will take full account of the O&M implications of the options, and will include an assessment of their economic viability and social and environmental acceptability. The level of analysis will be that expected of a feasibility-level study. At each stage there will be close consultation between all the disciplines involved.

The second interim progress report will be submitted at the end of September 1992, outlining programming and methods of study to be used and a draft feasibility study report will be submitted at the end of May 1993. The outcome of the study will be presented in sufficient detail and in an appropriate format in order to arrive at an investment decision to be taken by the Government of Bangladesh and external funding agencies.

The consultants are required to perform all the work necessary to attain the above objectives. Specific tasks will include the following:

Hydraulic Studies

- Develop the hydrodynamic model for the area, based as appropriate on the SERM and using additional survey, topographic and hydrological data as and when it comes available.

- Calibrate and verify the developed model as necessary.

- Run the model for the past 25 years data with the current geometry to set the baseline conditions for the comparison of the effects of project proposals. Carry out appropriate statistical analysis of results.

- Run the model for selected years to determine design conditions for proposed measures.

- Run the model for 25 years historic data for proposed option or options.

- Assess the impact of the proposals and impacts of possible upstream projects on the option.

- Assess the morphological, sediment and salinity implications of the proposals.

Engineering

- Carry out topographic survey for design to feasibility level of civil works and structures needed for flood control/drainage options.

- Assess the present status of existing flood control and drainage structures including the drainage system in the project area.

- In conjunction with other disciplines, assess the capacity for, and effectiveness in, operating and maintaining flood control and drainage systems, taking account of the findings of other components of FAP and of other current projects in particular social, institutional and financial aspects of O&M to be fully covered.

- In conjunction with other disciplines, identify realistic measures for flood proofing covering both structural and non-structural components and systems for flood preparedness, including embankment patrolling, materials stockpiles and contingency action plans for embankment repair, orderly embankment retirement, and responses to flood forecasts.

- In conjunction with other disciplines, identify project options which are technically feasible for alleviating flooding and drainage problems. Attention should be given to the multiple use of borrow pits and the disposal and use of spoil. Assess the cost of works for each component, including the requirement of land and rights of way, based on the hydrological and hydraulic studies as well as the topographic data obtained above.

- In conjunction with other disciplines, evaluate as far as possible the feasible options, taking a full account of operation and maintenance constraints, and make recommendations where appropriate.

- Prepare the design to feasibility study level of all the main engineering works for the recommended option or options and refine cost estimates where necessary.

- Formulate an implementation programme for the recommended option or options including phased construction and the establishment of the required operation and maintenance capacity.

Agriculture

- Establish the present status of agriculture in the project area, including identification of current cropping patterns in relation to flood depths, yields, input use, land tenure and distribution, irrigation, livestock, agricultural institutions etc.

- Identify farmers' current responses to flooding and their priorities for flood reduction.

- Assess likely changes in cropping patterns, yields, input use, livestock numbers etc. and timing of such changes due to each of the project options.

- Assess the likely constraints to development e.g. seasonal labour shortages, and any supporting programmes needed to bring about project benefits. This is to be carried out in consultation with other specialists especially the social scientist.

Fisheries

- Assess the present status of culture fisheries in the project area, including existing management systems, with special reference to any benefits or disbenefits from FCD and constraints to further development such as technology transfer, availability of credit and pond ownership problems.

- Assess the present status of the capture fisheries, including existing management systems, both inside the project area, e.g. in khals, beels and other internal waters, and outside in the adjacent sections of the Lower Meghna river. The impact of FCD to data on all these fish stocks and the dependent fishing communities is of particular concern.

- Assess the project options in the light of experience, i.e. FAP 12 evaluations of past FCD projects and conclusions from earlier FAP 5 studies in order to determine the likely beneficial and or adverse consequences for fisheries within and in the vicinity of the project area.

- After consultation with local informed opinion, prepare fisheries options for the area aimed at mitigating any identified negative consequences and optimising the beneficial effects of the different project options on the fisheries sector.

Environmental Impact Analysis

- Carry out necessary field work and survey to create an environmental database for the EIA. It is acknowledged that, in certain areas such as aquatic ecology, data collected during the feasibility studies will be limited owing to the duration of the studies.

- Carry out detailed analyses of probable beneficial and adverse impacts which the project options will have on the environment. These will include a comparison of the impacts of the different options. The analyses will focus on both direct and indirect impacts. Where these impacts would be adverse or would involve irretrievable commitment of resources, they will be so indicated.

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Identify and recommend the possible means of environmental safeguard, minimising detrimental impacts, enhancing beneficial impacts and suggest practical solutions to environmental problems which might arise as a result of project implementation.

- Prepare a holistic, multidisciplinary EIA which embraces all important aspects of the physical, social, economic, and ecological interactions in the living and non-living environment. The depth of analyses and length of description of each environmental resource should be commensurate with the magnitude of the probable impact on that resource.

Social Impact Studies

- In conjunction with other disciplines, identify a range of project options potentially acceptable in the study area. Define the criteria by which "acceptability" is judged.

- Make a detailed examination of household economies and survival strategies in relation to local social, ecological and institutional factors. Experiences of and responses to floods should be assessed within this framework.

- Define within the context of the study, the role and importance of the household as a unit of social analysis, paying attention to gender differentials. Describe and analyze, where appropriate, alternative social institutions which are influential.

- Review the findings of other studies on social organisations and institutions in the study area in order to analyse what exists. Prescribe the steps necessary for developing new social institutions capable of engaging in selection, design, operation and maintenance of structural and non-structural options and make recommendations on how to involve disadvantaged groups in these. In doing, so, the following issues should be examined in conjunction with other disciplines, including the institutional specialist:

    - role of social groups in mitigation planning.

    - local institutional resources available to provide assistance to disadvantaged categories of people affected by the project options.

    - identification of rehabilitation packages for those losing land and livelihood.

    - role of local government and NGOs in the area.

    - organisation and operation of relevant local social groups which could be involved in project construction and maintenance works.

    - opportunities for targeting women and children.

- In conjunction with other disciplines, undertake a process of consultation, the aim of which should be to allow local people's views to be incorporated into the development of options and the determination of preferences.

- Assemble and test, where possible, a fully documented methodological approach, to participatory planning for use during the later design stages and project implementation. Where the study identifies that it will be necessary to be prescriptive, a fully documented account of objectives and methods will be required.

- Identify and analyse social institutions which may be mobilised to resolve conflict arising from different options, particularly those arising from modified land or common property access. Propose institutionalised forms of appeal, challenge and resolution to be used when disputes arise.

Economic Appraisal/Project Planning

- Examine and attempt to quantify non-agricultural benefits, for example reduction in flood damage to infrastructure, increased availability of land for housing, increased mobility along embankments etc. for each of the project options.

- In conjunction with other disciplines, discuss alternative project concepts (including non-structural measures) and identify project need with relevant Government agencies and NGOs.

- In conjunction with other disciplines, liaise with other FAP studies to ensure that results of relevance from those studies are taken into account in the project preparation.

- Carry out economic and financial appraisal of the project options, including, where possible, quantification of social and environmental effects and appraisal of components to mitigate adverse impacts on the environment, particularly fisheries.

- In conjunction with other disciplines, make recommendations concerning the preferred option or options, where appropriate.

- Revise the economic and financial appraisal of the recommended option or options.

- Prepare full details of financing requirements for construction and O&M. Cost recovery options should be investigated in conjunction with FAP-13.

Pages 8 and 9

Delete the existing sections and substitute as follows:

(e) determine the capacity of all major regulators for drainage and irrigation as appropriate.

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(f) determine the capacity of main drainage channels.

(g) make adequate provision for new or improved secondary drainage channels with due consideration given to the needs of irrigation requirements where LLPs are to be utilised.

Page 14

Delete the first sentence and replace as follows:

Yields shall take into account the variations from year to year resulting from floods and the method of calculation shall be clearly set out.

Page 15 para 27(a)

Delete the words "foundation investigations" and in the last sentence change "shall" to "may".

Page 16

Sections V, VI and VII to be replaced as follows:

V. Time Schedule

28. The study period is estimated at 33 months for preparation of the regional plan and the feasibility study. The outline programme for studies is as follows:

Operation or Event	Responsibility	Date
Project start-up	Consultants	November 1990
Inception Report	Consultant/BWDB	February 1991
Draft Regional Plan	Consultant/BWDB	January 1992
Draft Feasibility Study Report	Consultant/BWDB	May 1993
Final Regional Plan and Feasibility Study Report	Consultant/BWDB	July 1993

VI. Duration of Consultancy Services and Composition of Team

29. Based on the above schedule the consultancy will commence about November 1990 and end about July 31, 1993 giving a duration of 33 months. It is estimated that 338 man-months of specialist input will be required, of which 103 man-months would be internationally recruited specialists and 235 man-months of local specialists. In addition, the consultant would provide field staff for the socio-economic survey, benchmark survey, fisheries and navigation studies. The composition of the team will be that agreed between the Bank and the consultants as attached to the contract in Appendices B and C and taking into account the profiles given in section VIII of these terms of reference.

VII. Reporting Requirements

30. The prefeasibility and feasibility report shall generally follow the outlines given in the FAO/IBRD cooperative programme publication "Guidelines for the Preparation of Feasibility Studies" published in December 1970. The report outline shall be agreed with the World Bank. The feasibility report shall be a comprehensive document and shall determine that the project is:

- in conformity with the country's development objectives and immediate priorities;
- technically sound and the best of the available alternatives under existing technical and other constraints;
- administratively workable; and
- economically, financially, socially, environmentally and institutionally viable.

31. The Consulting firm shall work directly with BWDB professionals and keep the SE informed of the progress and problems. They will prepare discussion paper for weekly (or as needed) meetings to be conducted by the SE and monthly meetings by Chief Engineer Planning. In particular, they will submit to the World Bank for subsequent transmittal to GOB and UNDP:

(a) an inception report in 20 copies. This report will include the work plan, along with detailed task specific manpower allocation budget for the whole project team, the program for surveys, investigations and hydrological data collection needed for the prefeasibility study and actions taken and progress to date on these activities. The inception report should also include the program for the feasibility study and the detailed engineering documents. Staffing requirements, transport, office accommodation and other relevant matters should also be discussed.

(b) quarterly progress report in 20 copies. These reports should be utilized by consultants to inform the World Bank, GOB and UNDP on progress, outstanding issues and to suggest solutions to any problems facing them in their work;

(c) the draft final reports in 20 copies for the regional plan in January 1992 and the feasibility study in May 1993.

(d) final feasibility report in 30 copies within 2 weeks after the tripartite meeting is convened to discuss the draft reports or within two months of submittal of the draft report whichever is earlier.

(e) final Regional Plan Report in July 1993.

Page 20

Amend heading of paragraph 40 to read "Environmental Specialist (International)".
Amend heading of paragraph 44 to read "Environmental Specialist (Local)".

ii) Amendments (1992/93)

ATTACHMENT NUMBER ONE

ARTICLE III : Costs and Payments

Section 3.01 line 6 the amount of 'US$2,002,000' shall be deleted and replaced by 'US$2,245,184'

APPENDIX A : Terms of Reference

II Terms of Reference

Clause 10, page 5 of 20, add after 10 (iii)

"vi)The final Regional Plan will incorporate upgraded proposals for development of a Dakatia/Little Feni project using available data. The approach to the treatment of local sediment and drainage problems in the headwater areas of the catchments will be empirical with different assumptions being made to assess the sensitivity of the development scenarios to possible sediment transport/deposition situations. Draft Terms of Reference for follow up studies will be prepared and also suggestions presented for a programme of sediment and hydrometric gauging to be undertaken by the BWDB/Surface Water Modelling Centre or other appropriate agency".

Clause 11, Page 6 of 20, delete whole Clause and replace by:

"Feasibility Study. The overall objective of the feasibility study is to examine in detail ways in which flooding and drainage problems of the Noakhali North project area can be alleviated and to formulate proposals for development. This will also be of relevance to both upgrading the Regional Planning Report and to future project planning studies elsewhere.

The study will involve the examination of a range of technically feasible options for alleviating the problems in the area, including non-structural and complementary flood-proofing measures, where appropriate. The study will take full account of the O&M implications, and will include an assessment of economic viability and social and environmental acceptability. The level of analysis will be appropriate to feasibility-level study. At each stage, there will be close coordination between all the various disciplines involved.

The Second Interim Progress Report will be submitted at the end of September, 1992. This will outline the programme and methods to be adopted. A draft feasibility study will be submitted at the end of May 1993. The outcome of the study will be presented in sufficient detail to enable investment decisions to be taken by the Government and external funding agencies.

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The Consultants are required to perform the work necessary to attain the above objectives and specific tasks are described below.

a) **Hydraulic Studies**

i) Develop the hydrodynamic model for the area, based, as appropriate, on the SERM and using additional survey, topographic and hydrological data as and when it comes available.

ii) Calibrate and verify the developed model as necessary.

iii) Run the model for the past 25 years data with the current geometry to set the baseline conditions for the comparison of the effects of project proposals. Carry out appropriate statistical analysis of results.

iv) Run the model for selected years to determine design conditions for proposed measures.

v) Run the model for 25 years historic data for proposed option or options.

vi) Assess the impact of the proposals and impacts of possible upstream projects on the option.

vii) Assess the morphological, sediment and salinity implications of the proposals.

b) **Engineering**

i) Carry out topographic survey for design to feasibility level of civil works and structures needed for flood control/drainage options.

ii) Assess the present status of existing flood control and drainage structures including the drainage system in the project area.

iii) In conjunction with other disciplines, assess the capacity for, and effectiveness in, operating and maintaining flood control and drainage systems, taking account of the findings of other components of FAP and of other current projects in particular social, institutional and financial aspects of O&M to be fully covered.

iv) In conjunction with other disciplines, identify realistic measures for flood proofing covering both structural and non-structural components and systems for flood preparedness, including embankment patrolling, materials stockpiles and contingency action plans for embankment repair, orderly embankment retirement and responses to flood forecasts.

v) In conjunction with other disciplines, identify project options which are technically feasible for alleviating flooding and drainage problems. Attention should be given to the multiple use of borrow pits and the disposal and use of spoil. Assess the cost of works for each component, including the requirement of land and rights of way, based on the hydrological and hydraulic studies as well as the topographic data obtained above.

vi) In conjunction with other disciplines, evaluate as far as possible the feasible options, taking a full account of operation and maintenance constraints, and make recommendations where appropriate.

vii) Prepare the design to feasibility study level of all the main engineering works for the recommended option or options and refine cost estimates where necessary.

viii) Formulate an implementation programme for the recommended option or options including phased construction and the establishment of the required operation and maintenance capacity.

c) **Agriculture**

i) Establish the present status of agriculture in the project area, including identification of current cropping patterns in relation to flood depths, yields, input use, land tenure and distribution, irrigation, livestock, agricultural institutions etc.

ii) Identify farmer's current responses to flooding and their priorities for flood reduction.

iii) Assess the likely changes in cropping patterns, yields, input use, livestock numbers etc. and timing of such changes due to each of the project options.

iv) Assess the likely constraints to development e.g. seasonal labour shortages, and any supporting programmes needed to bring about project benefits. This is to be carried out in consultation with other specialists especially the social scientist.

d) **Fisheries**

i) Assess the present status of culture fisheries in the project area, including management systems, with special reference to any benefits or disbenefits from FCD and constraints to further development such as technology transfer, availability of credit and pond ownership problems.

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ii) Assess the present status of the capture fisheries, including existing management systems, both inside the project area, e.g. in khals, beels and other internal waters, and outside in the adjacent sections of the Lower Meghna river. The impact of FCD to date on all these fish stocks and the dependent fishing communities is of particular concern.

iii) Assess the project options in the light of experience, i.e. FAP:12 evaluations of past FCD projects and conclusions from earlier, FAP:5 studies in order to determine the likely beneficial and or adverse consequences for fisheries within and in the vicinity of the project area.

iv) After consultation with local informed opinion, prepare fisheries options for the area aimed at mitigating any identified negative consequences and optimising the beneficial effects of the different project options on the fisheries sector.

e) **Environmental Impact Analysis**

i) Carry out necessary field work and survey to create an environmental database for the EIA. It is acknowledged that, in certain areas such as aquatic ecology, data collected during the feasibility studies will be limited owing to the duration of the studies.

ii) Carry out detailed analyses of probable beneficial and adverse impacts which the project options will have on the environment. These will include a comparison of the impacts of the different options. The analyses will focus on both direct and indirect impacts. Where these impacts would be adverse or would involve irretrievable commitment of resources, they will be so indicated.

iii) Identify and recommend the possible means of environmental safeguard, minimising detrimental impacts, enhancing beneficial impacts and suggest practical solutions to environmental problems which might arise as a result of project implementation.

iv) Prepare a holistic, multidisciplinary EIA which embraces all important aspects of the physical, social, economic, and ecological interactions in the living and non-living environment. The depth of analyses and length of description of each environmental resource should be commensurate with the magnitude of the probable impact of that resource.

f) **Social Impact Studies**

i) In conjunction with other disciplines, identify a range of project options potentially acceptable in the study area. Define the criteria by which "acceptability" is judged.

ii) Make a detailed examination of household economies and survival strategies in relation to local social, ecological and institutional factors. Experiences of and responses to floods should be assessed within this framework.

iii) Define within the context of the study, the role and importance of the household as a unit of social analysis, paying attention to gender differentials. Describe and analyze, where appropriate, alternative social institutions which are influential.

iv) Review the findings of other studies on social organisations and institutions in the study area in order to analyses what exists. Prescribe the steps necessary for developing new social institutions capable of engaging in selection, design, operation and maintenance of structural and non-structural options and make recommendations on how to involve disadvantaged groups in these. In doing, so, the following issues should be examined in conjunction with other disciplines, including the institutional specialist:

- role of social groups in mitigation planning.
- local institutional resources available to provide assistance to disadvantaged categories of people affected by the project options.
- identification of rehabilitation packages for those losing land and livelihood.
- role of local government and NGOs in the area.
- organisation and operation of relevant local social groups which could be involved in project construction and maintenance works.
- opportunities for targeting women and children.

v) In conjunction with other disciplines, undertake a process of consultation, the aim of which should be to allow local people's views to be incorporated into the development of options and the determination of preferences.

vi) Assemble and test, where possible, a fully documented methodological approach, to participatory planning for use during the later design stages and project implementation. Where the study identified that it will be necessary to be prescriptive, a fully documented account of objectives and methods will be require.

v) Identify and analyse social institutions which may be mobilised to resolve conflict arising from different options, particularly those arising from modified land or common property access. Propose institutionalised forms of appeal, challenge and resolution to be used when disputes arise.

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g) Economic Appraisal/Project Planning

i) Examine and attempt to quantify non-agricultural benefits, for example reduction in flood damage to infrastructure, increased availability of land for housing, increased mobility along embankments etc. for each of the project options.

ii) In conjunction with other disciplines discuss alternative project concepts (including non-structural measures) and identify project need with relevant Government agencies and NGOs.

iii) In conjunction with other disciplines, liaise with other FAP studies to ensure that results of relevance from those studies are taken into account in the project preparation.

iv) Carry out economic and financial appraisal of the project options, including, where possible, quantification of social and environmental effects and appraisal of components to mitigate adverse impacts on the environment, particularly fisheries.

v) In conjunction with other disciplines, make recommendations concerning the preferred option or options, where appropriate.

vi) Revise the economic and financial appraisal of the recommended option or options.

v) Prepare full details of financing requirements for construction of O&M. Cost recovery options should be investigated in conjunction with FAP:13.

III Important Activities

Flood Control and Drainage Improvements, pages 8 and 9 of 20, delete Clauses (e), (f) and (g) and replace with:

"(e) determine the capacity of all major regulators for drainage and irrigation as appropriate"

(f) determine the capacity of main drainage channels.

(g) make adequate provision for new or improved secondary drainage channels with due consideration given to the needs of irrigation requirements where LLPs are to be utilised.

Page 14

Delete the first sentence and replace as follows:

> Yields shall take into account the variations from year to year resulting from floods and the method of calculation shall be clearly set out.

Page 15 para 27(a)

Delete the words "foundation investigations" and in the last sentence change "shall" to "may".

Page 16

Sections V, VI and VII to be replaced as follows:

V. Time Schedule

28. The study period is estimated at 33 months for preparation of the regional plan and the feasibility study. The outline programme for studies is as follows:

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Draft Feasibility Study Report	Consultant/BWDB	May 1993
Final Regional Plan and Feasibility Study Report	Consultant/BWDB	July 1993

VI. Duration of Consultancy Services and Composition of Team

29. Based on the above schedule the consultancy will commence about November 1990 and end about July 31, 1993 giving a duration of 33 months. It is estimated that 338 man-months of specialist input will be required, of which 103 man-months would be internationally recruited specialists and 235 man-months of local specialists. In addition, the consultant would provide field staff for the socio-economic survey, benchmark survey, fisheries and navigation studies. The composition of the team will be that agreed between the Bank and the consultants as attached to the contract in Appendices B and C and taking into account the profiles given in section VIII of these terms of reference.

342

VII. Reporting Requirements

30. The prefeasibility and feasibility report shall generally follow the outlines given in the FAO/IBRD cooperative programme publication "Guidelines for the Preparation of Feasibility Studies" published in December 1970. The report outline shall be agreed with the World Bank. The feasibility report shall be a comprehensive document and shall determine that the project is:

- in conformity with the country's development objectives and immediate priorities;
- technically sound and the best of the available alternatives under existing technical and other constraints;
- administratively workable; and
- economically, financially, socially, environmentally and institutionally viable.

31. The Consulting firm shall work directly with BWDB professionals and keep the SE informed of the progress and problems. They will prepare discussion paper for weekly (or as needed) meetings to be conducted by the SE and monthly meetings by Chief Engineer Planning. In particular, they will submit to the World Bank for subsequent transmittal to GOB and UNDP:

(a) an inception report in 20 copies. This report will include the work plan, along with detailed task specific manpower allocation budget for the whole project team, the program for surveys, investigations and hydrological data collection needed for the prefeasibility study and actions taken and progress to date on these activities. The inception report should also include the program for the feasibility study and the detailed engineering documents. Staffing requirements, transport, office accommodation and other relevant matters should also be discussed.

(b) quarterly progress report in 20 copies. These reports should be utilized by consultants to inform the World Bank, GOB and UNDP on progress, outstanding issues and to suggest solutions to any problems facing them in their work;

(c) the draft final reports in 20 copies for the regional plan in January 1992 and the feasibility study in May 1993.

(d) final feasibility report in 30 copies within 2 weeks after the tripartite meeting is convened to discuss the draft reports or within two months of submittal of the draft report whichever is earlier.

(e) final Regional Plan Report in July 1993.

Page 20

Amend heading of paragraph 40 to read "Environmental Specialist (International)".
Amend heading of paragraph 44 to read "Environmental Specialist (Local)".

APPENDIX B: Consultants Staffing Schedule

Delete **APPENDIX B** and replace with attached **APPENDIX B**

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APPENDIX B

Consultants Staffing Schedule

Post No	Post	Name	Firm	F	L
		Reports			
F1	Sr Planning Engineer/Team Leader	J W Dunn/M J Politzer	MMG	33.0	
L1	Sr. Water Res. Eng/Co-Team Leader	M Mohsin Uddin	HoC		32.0
F2	Snr Irr Planning Eng/I&D Eng	R M Dyer	MMG	19.9	
L2	Planning Engineer	D S S Abalin/N Islam	HoC		30.5
L3	Senior Hydrologist	Dr Afzal Hossain	HoC		9.7
L4	Hydro-geologist	Prof. M. Hoque	DU		3.3
L5	Soils Specialist	B K Chowdhury	HoC		4.0
F3	Senior Agronomist	H Thewedia	NK	4.8	
L6	Agronomist	A Hossain/Dr Ali Imam	HoC		19.5
L7	Fisheries Specialist	Dr S Shah/Shahadat Ali	HoC		9.0
F4	Environmentalist 1	B Spooner	MMG	1.2	
L8	Environmentalist 2	Prof. S D Shamsuddin	HoC		5.8
FA	EIA Coordinator	A Bird	MMG	2.5	
FB	Senior Ecologist	P C Almeda Villela	MMG	3.0	
FC	Senior Sociologist	J Moosen/J L Leierme	MMG	2.3	
L9	Sociologist	Mrs A Duza/Dr Jharna Nath	HoC		10.5
LA	Water Quality Chemist	Dr AKMH Talukder	HoC		2.5
LB	Aquatic Ecologist	Dr M Khondker	HoC		3.0
LC	Terrestrial Ecologist	Dr K K Anam	HoC		3.5
LD	Public Health Sp/Nutrition Sp	Azam Ali	HoC		2.5
LE	Programmer/Field Methodology Sp	M A Latif	HoC		5.0
L10	Local Participation Expert	Dr N U Ahmed/H Patuary	HoC		20.0
F5	Senior Economist	D K V Marsh	MMG	2.8	
F5	Senior Economist	E Mallorie/J Youngman	MMG	4.8	
L11	Senior Agro-economist	Dr. Ziaus Shams Haq	HoC		13.0
L12	Economist	Dr M Huq/Dr A Chowdhury	HoC		12.0
F8	Regional Planning Economist	A. Baker	MMG	3.0	
FD	Computer Modeller	C. Karavasili	MMG	2.0	
FD	Hydrologist/Modeller	P Laurentis	MMG	2.8	
F6	Senior Design Engineer	G N Iglesia	NK	6.0	
L13	Design Engineer 1	Mosaadeq Khan	HoC		23.0
L14	Design Engineer 2	A Zaman	DU		10.0
F7	Senior Hydraulics Engineer	N Karunaratne	RDC	2.5	
L15	Hydraulics Engineer	M Uddin/S M K Rahman	HoC		8.0
F9	Senior Coastal Engineer	P D Chandrawansa	RDC	1.0	
F10	Senior Mechanical Engineer	Dr A P Jayasinghe	RDC	2.5	
L16	Mechanical Engineer	Masih-ur-Rahman	DU		4.0
L17	Acting Co Team Leader	Solaiman Ali	HoC		3.3
L14	Assistant Engineer	Subash Chandra Roi	HoC		0.8
	Visiting Specialists and Head Office Backup				
	Project Director	M H Khan	MMG	1.2	
	Hydrology & Hydraulic Model Spec.	Dr R Wardlaw/Dr P Samuels	MMG	5.8	
	Planning Adviser	D N Moore	MMG	0.5	
	Groundwater Modelling Specialist	J van Wonderen	MMG	2.0	
		Total		103.5	235.1

