World Bank
Government of the People's Republic of Bangladesh

Gumti Phase II
Sub-Project Feasibility Study

FINAL REPORT

MAIN REPORT

September, 1993

Mott MacDonald Limited
in association with
Nippon Koei Company Limited
House of Consultants Limited
Desh Upodesh Limited

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(Annexes B to J will be submitted in separate volumes)

Annexes

Glossary and Acronyms

Aman	-	Rice planted before or during the monsoon and harvested in November or December
AST	-	Agricultural Sector Team (funded by CIDA)
Aus	-	Rice planted during March to April and harvested during June and July
B aman	-	Broadcast Aman
BBS	-	Bangladesh Bureau of Statistics
BIWTA	-	Bangladesh Inland Water Transport Authority
Boro	-	Rice transplanted in December or January and harvested in April to May
BUET	-	Bangladesh University of Engineering Technology
BWDB	-	Bangladesh Water Development Board
CIDA	-	Canadian International Development Agency
DAE	-	Department of Agricultural Extension
DHI	-	Danish Hydraulics Institute
DOF	-	Department of Fisheries
DTW	-	Deep Tube Well
ECNEC	-	Executive Committee of the National Economic Council
EIA	-	Environmental Impact Assessment
EIRR	-	Economic Internal Rate of Return
EMP	-	Environmental Management Plan
FAP	-	Flood Action Plan - also projects under the FAP eg FAP1, FAP2 etc
FCD	-	Flood Control and Drainage
FCDI	-	Flood Control Drainage and Irrigation
FCD+I	-	FCD initially, then converted to include Irrigation
FFW	-	Food For Work
FMTW	-	Forced Mode Tubewell
FPCO	-	Flood Plan Coordination Organization
FRSS	-	Fishery Resources Survey System
GM	-	General Model
GPA	-	Guidelines for Project Assessment (from FPCO)
HTW	-	Hand Tubewell
HYV	-	High Yield Variety
JICA	-	Japanese International Cooperation Agency
JRC	-	Joint Rivers Commission
KSS	-	Krishni Sambaya Samity
LGED	-	Local Government Engineering Department
LIV	-	Locally Improved Variety
LLP	-	Low Lift Pump
MIKE11	-	Surface water computer model developed by Danish Hydraulics Institute
MLGRD	-	Ministry of Local Government Rural Development
MOFL	-	Ministry of Fisheries and Livestock
MOIWDFC	-	Ministry of Irrigation, Water Development and Flood Control
MPO	-	Master Plan Organization
NAM	-	Computer model which derives run-off and groundwater recharge from rainfall
NCA	-	Net Cultivable Area
NCS	-	National Conservation Strategy
NEMAP	-	National Environmental Management Action Plan
NFC	-	National Flood Council
NPV	-	Net Present Value
NPVR	-	Net Present Value Ratio
NWC	-	National Water Council
NWP	-	National Water Plan
ODA	-	Overseas Development Administration (UK)
Paddy	-	Unhusked rice
RRI	-	Rivers Research Institute
SCF	-	Standard Conversion Factor
SERM	-	South East Regional Model - a computer hydraulic model of the south-east region of Bangladesh

SERS	-	South East Regional Study - also known as FAP5
SIA	-	Social Impact Assessment
SPARRSO	-	Space Research and Remote Sensing Organization
SRDI	-	Soil Research Development Institute
STW	-	Shallow Tubewell
SWMC	-	Surface Water Modelling Centre - the MPO office responsible for the computerized modelling of flows, levels and groundwater
SWSMP	-	Surface Water Simulation Modelling Project
SSFCDIP	-	Small Scale Flood Control Drainage and Irrigation Project
T Aman	-	Transplanted Aman
TCCA	-	Thana Central Cooperative Association
Thana	-	Small administrative unit (formerly termed upazila)
TNO	-	Thana Nirbahi Officer
UNDP	-	United Nations Development Programme
Union	-	Division of a thana
[W]	-	With project - economic evaluation of the future situation with the proposed project
[WO]	-	Without project - economic assessment of the probable future value of production if no project is implemented
WRPO	-	Water Resources Planning Organization

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GUMTI PHASE II FEASIBILITY STUDY

SUMMARY

1 Introduction

The Gumti Phase II project area lies to the north-west of Comilla. It is bounded to the south by the Gumti River, to the west by the Meghna River, to the north by the Titas (or Pagla) River and to the east by the border with India. The gross area is approximately 141,000 ha with a net cultivable area of approximately 118,000 ha.

The population within the Gumti Phase II project area is estimated to be 1.9 million, with an average density of 1300 persons per square kilometre. This value is much higher than the national average and shows the significant population pressure on the area.

The Gumti Phase II area includes some of the major wetland habitats within the country. The direct economic impact of flood control and drainage works upon capture fisheries and poor fishermen, resulting in socio-economic impact and nutritional consequences, is now well recognised. The area is very rich in capture fisheries, particularly in the Meghna floodplain in the west and the central areas in Nabinagar and Muradnagar. The actual fish production in the Gumti Phase II area, caught by full time and part time fishermen, is estimated to be 32,500 Tonnes per year. Of this, approximately 24,000 Tonnes are caught in the floodplains.

A feasibility study was carried out in 1990, which recommended extensive polderization around the project area and included approximately 100 cumecs of pumped surface water irrigation. BWDB and the World Bank undertook the present study in order to evaluate less capital-intensive options and to review the previous report, using more up to date information.

2 People's Participation

The Gumti Phase II project area is very diverse. There is high ground in the south-east, towards the border with India. There is also relatively high ground in the central eastern area near Kasba. In the west of the area, the land is low and there is extensive annual flooding each monsoon. Because the area is so diverse, it was considered very likely that each section would have different water related problems and therefore different solutions. The project area was therefore split into 4 zones, based on topographic and agricultural considerations. Four villages were randomly selected in each zone, to represent the grass root opinions within the project area.

In order to establish the requirements of the villagers in the project area, two meetings were held in each of the 16 selected villages. The proposed project interventions were formulated from the conclusions from these meetings.

During the first round of meetings the project team listened to the water related problems of villagers from the 16 villages. Possible interventions were then considered, and discussed at the same villages during the second round of meetings. A third round of meetings was then carried out in each of the Thana Headquarters, where the reviewed proposals were discussed with thana officials, union chairmen and NGOs.

The main concerns of the people in the east of the project were related to flash flooding. Anther concern voiced everywhere, but mainly in the west, was related to supply of irrigation water. It was interesting to note that the normal, Meghna related, annual flooding was not cited as a problem anywhere in the area. In the western zone, villagers were hostile to provision of a flood protection embankment along the Meghna.

3 Development Options

Based on what was learned during the meetings, development options were considered. Good liaison between the project environmentalists and engineers during the planning stage ensured a set of options which were as sympathetic as possible to the environment.

Eight different interventions were considered and modelled. These interventions were in some cases merged, forming five schemes which were then considered for implementation. The layout of these developments is shown in Figure 1 and discussed below.

Scheme A

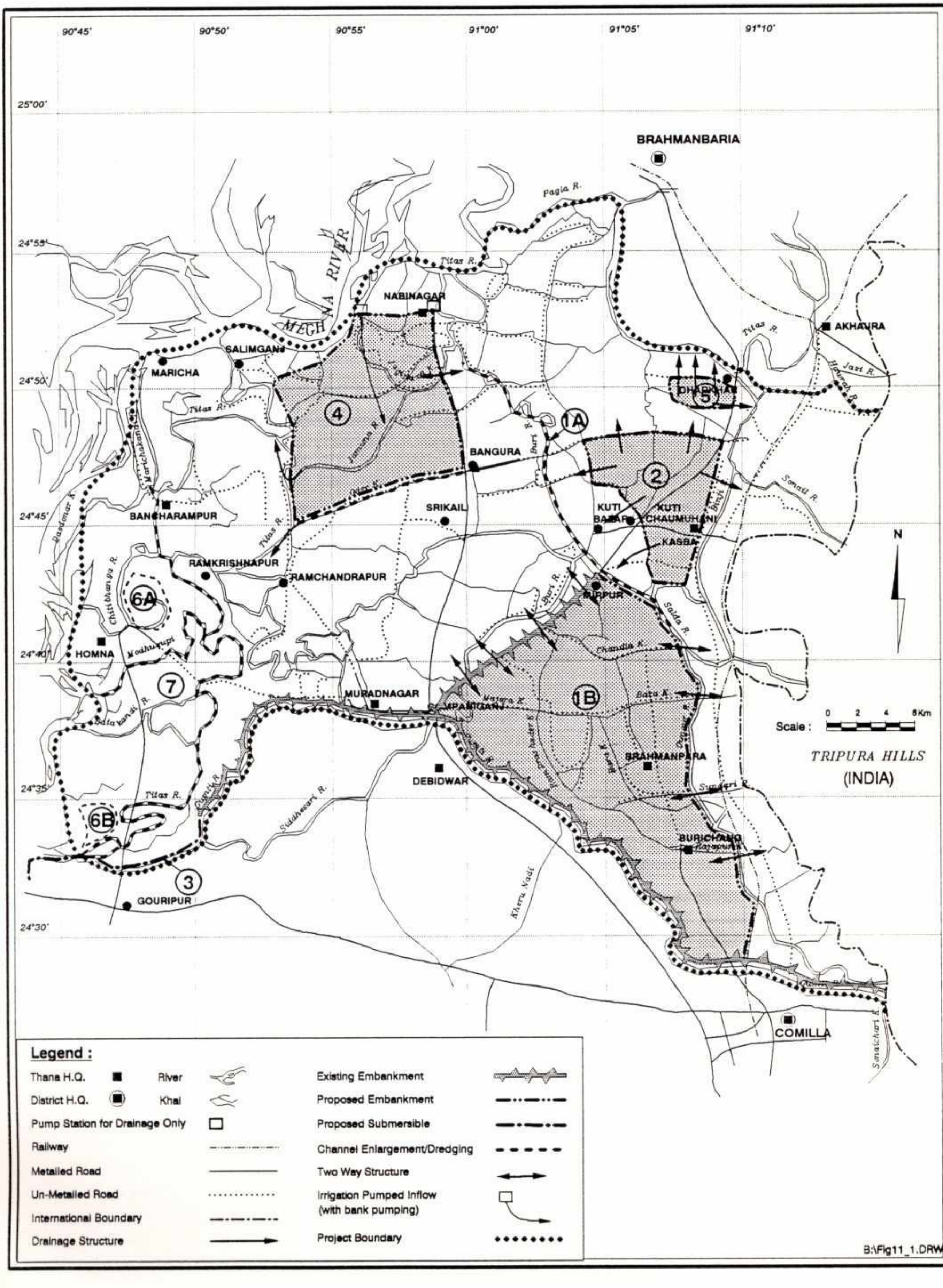
Scheme A includes Interventions 1A, 1B and 2 in Figure 1. Intervention 1B includes a 25.4 km long flood protection embankment along the left bank of the Gunghur River and an 11.3 km embankment along the Salda River as well as four regulators. Also, the Comilla to Sylhet road will be sealed, providing a further four fish friendly drainage regulators. 1A is excavation of 19 km of the Salda and Buri Rivers, which will help drain the area inside and outside the 1B protected area. Intervention 2 raised the level of 27 km of existing roads and provided four regulators to form a protected area around Kasba. It is included in Scheme A as it also benefits from the river excavation works in Intervention 1A.

Increased crop production and protection from flash floods overcome the fisheries losses, giving the scheme an EIRR of 15%. The total cost of the scheme is estimated to be 385 million Taka.

Scheme B

Scheme B includes extending the Gumti north embankment 10.8 km to Gouripur to prevent flash flooding in the area (Intervention 3). Because protection is only required for boro crops, a submersible embankment is being proposed. The scheme is therefore inexpensive (approximately 16 million Taka) and is not expected to incur fishery losses. It has an EIRR of 24%.

Figure 1
Layout of Interventions



Scheme C

Scheme C includes excavation to 78.7 km of the existing network of khals in Zone D (Intervention 7). This will provide LLP irrigation to approximately 10,000 ha. This type of intervention is very beneficial to the area as it helps fisheries by extending the area of perennial khal as well as providing the cheapest source of irrigation to the area. This scheme has an EIRR of 28%. The estimated cost for this scheme is 69 million Taka.

Scheme D

Scheme D includes an embanked area north of Oder khal, two pump stations in the north and channel excavation for the provision of surface water supply and pumped drainage (Intervention 4). As well as the pump stations, this Scheme entails 46.4 km of embankment and 12 regulators. Pumped surface water is to be supplied to an area of approximately 9,800 ha, within the gross area of 20,000 ha, both north and south of the Oder khal. During the monsoon season, both pump stations will reverse and drain rainwater from the embanked area north of the Oder khal. It should be noted that this drainage pumping will eradicate the floodplain fisheries from within the embanked area of approximately 9 000 ha.

Groundwater analysis has shown that, despite present gas and salinity constraints, the whole project area can be effectively irrigated using tubewell technology. While shallow force mode tubewells can be more expensive than shallow suction mode tubewells, they are economically cheaper than double lift surface water.

If farmers take up force mode tubewell technology in the next ten years, the "without project" situation will have full irrigation, the scheme will therefore have an EIRR of only 9%. However, after Schemes A, B and C have been completed, if farmers have not taken up new tubewell technology, then this scheme should be seriously considered. Assuming a "future without" situation where tubewells are not adopted by farmers increases the EIRR to 18%. The estimated cost for this scheme is 496 million Taka.

Scheme E

Two submersible embankment schemes were identified in Zone D, Intervention 6A consists of 6.3 km of embankment, north-east of Homna and Intervention 6B consists of 8.7 km of embankment north of Gouripur. Under present circumstances, these schemes do not produce benefits, as farmers plant their boro early and therefore do not suffer losses. However, if FAP 6 alter the timing of the floods with their interventions, then it is quite possible farmers in these areas will have difficulty in harvesting in time. In this case, the schemes could be recommended.

4 The 1990 Report

The recommendation of the 1990 Report was for full polderization of the project area along with provision of reversible pumping stations of approximately 100 cumecs. This concept was consistent with the thinking in the late 1980's, when the report was written. An alternative of flood control and drainage without surface water irrigation was also presented.

These options were tested during the present project but were not found to be feasible. The main reasons for this were :

a) the latest information available showed that the existing area presently under irrigation was much higher than adopted in the 1990 report.

b) the proposed interventions produced a much smaller area of land converted to F0 (< 0.3 m depth) than was used in the 1990 Report.

c) fisheries losses were higher than those used in the 1990 Report.

5 Conclusions

Schemes A, B and C are being recommended for immediate design and implementation, while Scheme D should be delayed until it is known if tubewell technology has been taken up by farmers. Scheme E should be delayed until the FAP 6 intervention downstream effects are known. If required, Scheme E should be taken up as a FAP 6 mitigation measure.

1 Introduction

1.1 Background

The Government of Bangladesh, in implementing the third Flood Control and Drainage Project financed under IDA Credit 591-BD, undertook the preparation of a feasibility study of Phase II of the Gumti Project. This study was to formulate a project that would mitigate the effects of periodic flooding and poor drainage in the project area, develop its irrigation potential and alleviate any adverse effects of the Gumti Phase I Project on the adjoining Gumti Phase II area. The study report, referred to hereafter as the "1990 Report" was accepted by the Bangladesh Water Development Board (BWDB) but not IDA, who believed that less capital-intensive options should also have been investigated and evaluated. In addition, IDA considered that the study should be compatible with the framework and guidelines of the Flood Action Plan (FAP) and current IDA project preparation policy. This implied the need for an environmental impact assessment of the project and consideration of any dis-economies and their mitigation measures in the economic analysis. In order to continue its support of project preparation, IDA requested that the feasibility study be revised and extended.

New Terms of Reference for the Study, reproduced in Appendix A, were drawn up and funds were provided from a Japanese Grant Facility executed by the World Bank.

1.2 The Project Area

1.2.1 Location

The Gumti Phase II project area lies to the north-west of Comilla. It is bounded to the south by the Gumti River, to the west by the Meghna River, to the north by the Titas (or Pagla) River and to the east by the border with India.

The project area, shown on Figure 1.1, is 141,000 hectares in size and generally varies between 2.5 and 6 metres above sea level. An exception to this is a small area of relatively high land, rising to 9 m asl, just north of Comilla.

The area lies within the two districts of Comilla and Brahmanbaria and 11 thanas of Comilla Sadar, Burichang, Debidwar, Brahmanpara, Kasba, Akhaura, Nabinagar, Muradnagar, Bancharampur, Homna and Daudkandi. The most remarkable feature of the project area is the difference of topography and water problems, with comparatively high ground and flash flooding to the east and low ground, high fisheries content and Meghna related flooding to the west.

1.2.2 Population

On the basis of the 1981 census data and an annual growth rate of 1.8%, the population within the Gumti Phase II project area is estimated to be 1.9 million, with an average density of 1300 persons per square kilometre. The population density is thus nearly twice the national average (although the figures may not be directly comparable because of differences in the treatment of open water areas in the major rivers) and substantially

Figure 1.1
Location of the Gumti Phase II Project Area

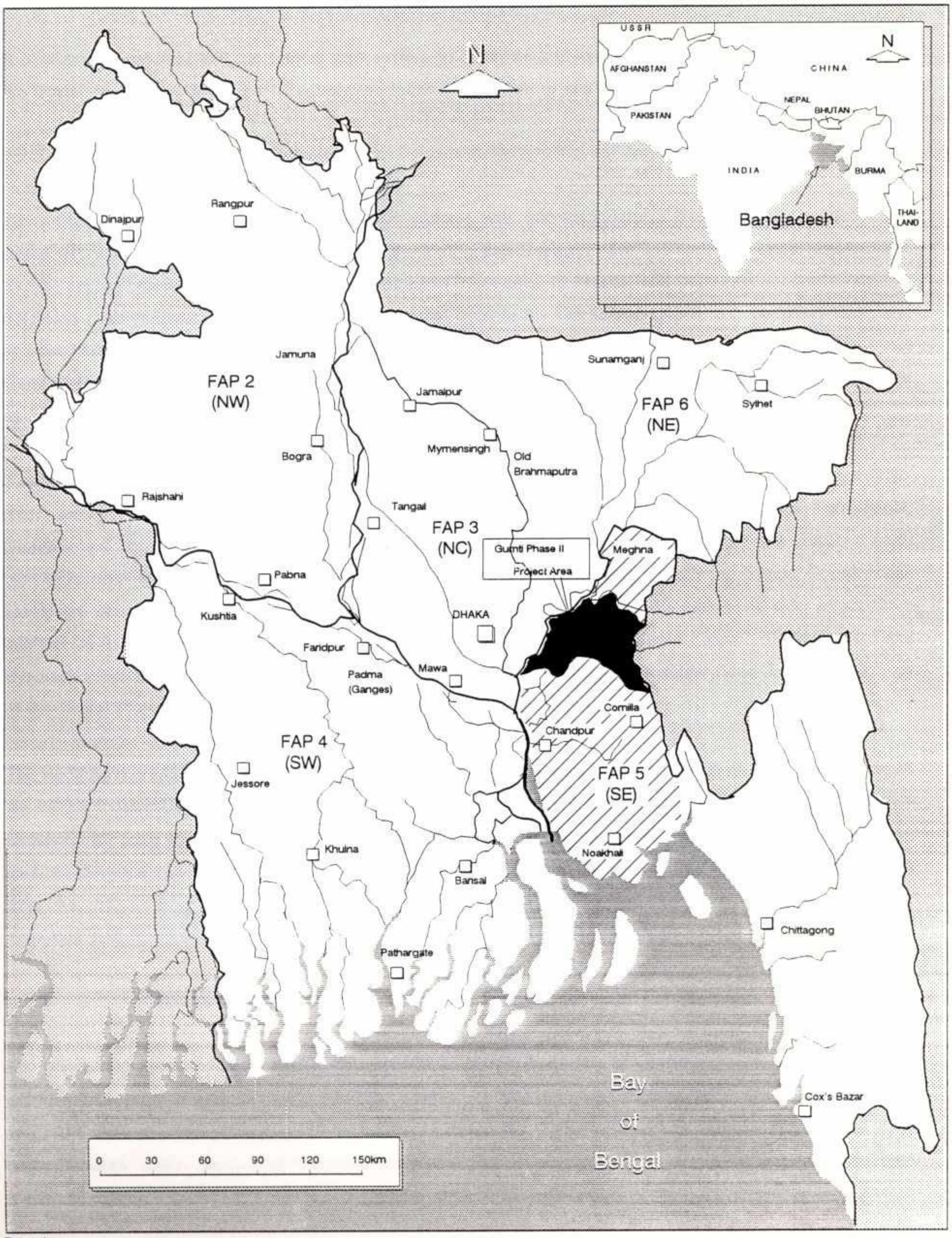


Fig1_1.drw

higher than that for the South-East Region as a whole (1078 persons per square kilometre). The average annual growth rate between 1981 and 1991 was 1.9% (for Comilla and Brahmanbaria districts, taken as representative of the project area) or slightly below the national average of 2.2%, but the same as the South-East Region as a whole.

It is therefore apparent that the project area suffers from severe population pressure even by the standards of the densely populated South-East Region, and there is little sign of any change in this situation.

1.2.3 Climate and Hydrology

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 Comilla and Nabinagar are 2365 and 1874 mm respectively. Evapotranspiration exceeds rainfall for the months of November to March, and boro rice generally requires irrigation. An analysis of rainfall records shows that even in the wet season (April to September) there are, in most years, 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 project area, but damage is limited to that caused by high winds rather than tidal surges.

The project area is drained by the Upper Meghna River, which forms its western boundary. Other significant rivers are the Gumti River (forming the southern boundary) and the Titas and its tributaries Buri, Salda, Gunghur and Bijni. In the western half of the area the rivers generally have flat slopes and come under a small tidal influence. In the eastern half of the area, the channels draining the Tripura hills (eg Gumti, Gunghur and Salda) are steeper and more liable to flash flooding. The Gumti River is fully embanked over about three quarters of its length from the Indian border under the recently completed Gumti Phase I Flood Control and Drainage Project. Although alleviating flash floods in the east, this project increases flood depths in the west of the Gumti Phase II area, downstream of the existing protection embankment.

The flooding regimes in the area are directly related to the river characteristics. The low lying western areas are subject to deep flooding from the Meghna as it rises, whilst the higher land in the east, although not deeply inundated for long periods, is vulnerable to damaging flash floods. Between the two is a transition area of medium elevation which is unable to evacuate either the run-off from internal rainfall or the run-off it receives from the east, as long as the Meghna levels remain high. It is clear that any flood control and drainage proposals therefore have to take account of these three distinct flooding problems.

1.2.4 Hydrogeology

The whole of the project area is underlain by productive alluvial aquifers of Quaternary age. Most of the area has a surface cover of 5 to 15 metres of silts, overlying a thick fine sand aquifer from which hand tubewells and some shallow tubewells pump. This, in turn, overlies the main, medium sand aquifer from which deep tubewells draw water. In the south-central part of the project area the two aquifer layers are separated by a sandy silt aquitard, which is as much as 40 metres thick in Muradnagar.

The proportion of cultivable land under irrigation in the project area is approximately 50%, but is unevenly distributed. In the north-east (Akhaura) 80% of cultivable land is irrigated, while in the southern central area (Muradnagar) the figure drops to 28%. Within different thanas, deep tubewells, shallow tubewells, manual tubewells and low lift pumps all play major roles in existing irrigation.

The 1990 feasibility study did not fully expound the development constraints imposed by the extensive occurrence of saline groundwater. Based on chemical data from the 1982 UNDP Groundwater Survey, it concluded that groundwater contains generally low total dissolved solids and is of good quality irrigation water. However, a recent survey of new and operating wells by the IDA/ODA Deep Tubewell II Project has shown a broad band of slightly saline groundwater in the west of Comilla and Brahmanbaria districts. In parts of Muradnagar (the most affected thana), Debidwar, Daudkandi and Bancharampur groundwater from DTWs has electrolytic conductivities in excess of 2 000 μs/cm. Although a small number of wells have been abandoned because of crop damage, the feasibility of groundwater is demonstrated by the fact that there are more than 50 DTWs operating successfully in Muradnagar but these will need more detailed monitoring to assess their performance. It has been shown that high salinity (EC $>$2 000 μs/cm) is mainly restricted to the lower aquifer in areas where there is a thick lower aquitard; but not in all such areas.

Groundwater development is also constrained by discharges of gas, which interfere with the operation of pumps. The gas, which may be either methane or carbon dioxide, is probably derived from the decomposition of organic matter in the shallow aquifer. Discharge of gas mainly affects the operation of shallow tubewells breaking the suction and necessitating frequent 'restarts', which is not popular with farmers, but is generally only of nuisance value at deep tubewells.

1.2.5 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 Gumti Phase II area are the Middle Meghna River Floodplain in the west; the Old Meghna Estuarine Floodplain in the centre; and the Northern and Eastern Piedmont Plain, Northern and Eastern Hills and Akhaura Terrace in the east. The two floodplain regions account for the bulk of the area. Apart from some substantial sandy areas occurring in the Middle Meghna River Floodplain, the principal determinants of agricultural development are the flooding regime and availability of irrigation, rather than any intrinsic soil properties. Primarily on the basis of flooding, most of the area falls into land capability Classes II and III. Mainly Class II in the east and Classes III (and some IV) in the west. In the centre, between Muradnagar and Nabinagar, lies a small area of Class I land.

The net cultivable area (NCA) within the Gumti Phase II area is estimated at 118 000 ha out of a gross area of 140 700 ha. Following surveys and updated secondary data, the total cropping intensity was taken as 171% as an average over the four zones. The difference compared with the 1990 report value of 188% is due to the increase in irrigated boro, which tends to replace more diverse, but less attractive, crops.

Almost all the boro is irrigated, and about two or three hundred hectares each of the wheat and potatoes. The value of irrigated area given in the 1990 report was 28 747 ha. Estimation from February/March 1989 SPOT satellite imagery suggests that this area may have increased to about 50 000 ha and further survey work shows this area has further increased to approximately 63 000 ha.

Rice yields range from 1.8 t/ha for broadcast local aus to 5.4 t/ha for irrigated HYV boro.

1.2.6 Fisheries

The Gumti Phase II area is very rich in capture fisheries, particularly in the Meghna floodplain in the west and the central areas in Nabinagar and Muradnagar. Survey work and data collection carried out by the project have shown that the actual fish production in the Gumti Phase II area is 31,500 Tonnes per year. This value, which is consistent with the findings of FAP 17 is over 3 times the amount assumed in the 1990 report.

In the riverine thanas of Nabinagar, Bancharampur and Homna it is estimated that 8% of the population are full-time fishermen, whilst a further 65% are part time or occasional fishermen.

Pond culture fisheries are possibly less well developed in the project area than in the Noakhali and Lakshmipur districts, where the Raipur fish hatchery gave great impetus to the spread of this technology. Nevertheless they are still an important component of the present total catch. Nine hatcheries are planned for Nabinagar and Bancharampur thanas under the Department of Fisheries Integrated Fisheries Development Programme. There is however already a very substantial private sector hatchery capacity in Comilla district.

1.2.7 Environment

The Gumti Phase II area includes some of the major wetland habitats within the country. The direct economic impact of flood control and drainage works upon capture fisheries and poor fishermen, resulting in socio-economic impact and nutritional consequences, is now well-recognised although methodologies for quantification are so far very crude. There are, however, less obvious impacts which affect the well being of certain sectors of the community, and in particular the free resources which are an essential part of the survival strategies of the disadvantaged. Even more imponderable is the loss of floral and faunal species diversity and changes in soil chemistry, the role of which within the natural environment biological process is not well understood.

Apart from the loss of wetlands, there are a number of adverse impacts which can be identified arising from almost any programme of agricultural intensification including.

- loss of crop species biodiversity through promotion of high yielding varieties
- increased pollution of groundwater and surface water from agrochemicals
- loss of grazing and fodder for draft animals
- reduction of crop residues from longer stem rice varieties for fuel, building materials, etc

- increased inequity in income distribution as the poorer and particularly landless sections of the community may not benefit to the same extent as landholders.

Other impacts may arise from specific interventions; for instance morphological changes, worse flooding outside the project area through embankment construction, navigation disruption and water born disease vector patterns.

1.2.8 Infrastructure

Although the project area is crossed by two major roads from south to north, and the south-west is linked to the south-east by the Daudkandi to Comilla road, internal road communications, even in the dry season, are very poor. During the wet season the thana headquarters of Bancharampur is barely accessible by road, as the embankment tends to become submerged. Unfortunately in some cases the road embankments themselves may have an adverse effect upon drainage, through a lack of cross-drainage structures. The main Chittagong to Sylhet railway passes through the east of the area but contributes little to internal communications.

Waterways are of major importance in the project area. The Chitibhanga River from near Homna to beyond Bancharampur and the Buri/Salda River upstream of Nabinagar are classified as Class II navigation routes (2.0 m draft) by the Bangladesh Inland Water Transport Authority (BIWTA), whilst the remainder of the Salda River almost to the Indian border is a class IV route (1.5 m draft). Unclassified routes serve Daudkandi, Debidwar, Gouripur and Ramchandrapur, whilst during the flood season country boats ply over the whole western part of the area.

The Gumti Phase II area is crossed by the 230 kV electricity transmission line under construction from Comilla to Ashuganj, whilst all thana headquarters are linked by 33 kV lines.

1.2.9 Flood Control and Drainage Works

The Gumti River on the southern boundary of the project area has been fully embanked (or the existing embankment retired/re-sectioned) from the Indian border to approximately 10 km downstream of Muradnagar, under the Gumti Phase I flood control and drainage project. The southern area is thus be protected from Gumti flash floods, although the river is no longer available as a drainage route. Meanwhile in the west, downstream of the end of the right embankment, some worsening of flooding occurs, although peak flood depths are largely determined by Meghna water levels in this area.

The only flood control schemes of significance in this area are two small submersible embankment schemes, Chandal Beel (813 ha gross) and Satdona Beel (5153 ha gross) in the west near Bancharampur.

1.3 Objectives and Targets of the Project

The principal objectives of the current project are that technically and economically viable project alternatives are to be identified and evaluated, in addition to those put forward in the 1990 report. These alternatives must fulfil regional development objectives in a cost effective manner.

The economic objectives of the project are maximization of the net present value of aggregate consumption benefits and employment generation, with as large a private sector participation in project investment as possible. Fulfilment of these objectives should minimize any regressive effects on the poorer population's income and welfare and adverse impacts on the physical environment.

The targets to achieve the above objectives are as follows:

- reduction of crop losses due to seasonal and flash flooding
- creation of controlled flooding in the aman season to facilitate the transformation of areas normally under deep water broadcast rice to HYV or LIV transplanted rice cultivation.
- increase of the area under boro and rabi cultivation by facilitating surface irrigation by low lift pumps and further groundwater development
- conserve and if possible improve capture fisheries potential and develop pond fisheries
- improve physical infrastructure needed to complement flood control
- improve agricultural support services needed to sustain increased agricultural production
- minimize the new land required for embankments and its associated resettlement by using existing roads and embankments wherever possible

1.4 The Approach

1.4.1 Relationship with South East Regional Study (FAP 5)

The South East Regional Study (SERS) is an ongoing Flood Action Plan study financed by UNDP and administered by the World Bank. As shown by Figure 1.1, the Gumti Phase II area lies within SERS project boundary and actually forms Planning Unit 11 of the regional study.

In addition to the regional study, SERS was required to identify and carry out a Feasibility Study within one of the planning units. The Noakhali North Feasibility Study was selected and work on this started in August 1992.

In order to minimize the costs associated with the Gumti Phase II study, it was decided that resources were to be shared with the SERS Feasibility Study, which was run in tandem with the Gumti Project. This brought about the advantages of shared methodology, where viable, as well as reduced air travel costs. It did however produce problems of resource use, with both projects requiring key resources at critical times. The problem was further exacerbated by the fact that both studies had the comparatively short duration of approximately 11 months in which to complete the final reports.

1.4.2 Staffing

Suggested personnel inputs were given in the Terms of Reference, split into man-months for expatriate and local staff. The TOR and actual inputs, as presented in the Inception Report, are presented in Table 1.1.

The most notable alteration is the increase in expatriate and local man-months for environmental work. Although it is beyond the scope of the present study to follow the FPCO guidelines for Environmental Analysis, it was considered essential to devote more time to this aspect of the study in order to arrive at an environmental impact assessment which is compatible with the framework and guidelines of the Flood Action Plan.

As the study budget could not be increased, the additional man-months used for the environmental side of the study had to be taken from the engineers' and economists' time.

1.4.3 FPCO Guidelines

The Flood Plan Coordination Organisation (FPCO) produced a set of guidelines for project assessment which was finalised in May 1992. The guidelines for Environmental Impact Assessment were produced in October 1992, after submission of the project Inception Report.

The purpose of the guidelines is to assist members of teams undertaking the Regional Water Resource Planning Studies and feasibility studies for investment projects under the Flood Action Plan. One of the main objectives of the guidelines is to standardise methods and procedures for Flood Action Plan Projects, so different projects may be appraised on an equal basis.

The Gumti Phase II feasibility study does not come under the FPCO, however, the project follows these guidelines wherever possible. It should be noted that due to the constraints concerning the 11 month duration of the study it has not always been possible to follow the guidelines comprehensively. In addition, the very low water levels of the 1992 wet season were detrimental to achieving the databases required by the Guidelines.

1.4.4 Surveys and Investigations

The 1990 report contains a great deal of valuable data which has been used during the course of this project. In addition to this, there is a substantial amount of secondary data available from agencies such as the Bangladesh Bureau of Statistics (BBS), Agricultural Sector Team (AST), Department of Agricultural Extension (DAE) and individual thanas. A considerable effort has been made to collect and use this data for the project.

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TABLE 1.1

Personnel Inputs

Personnel/ Discipline	Suggested in TOR		Actual Used	
	Expatriate	Local	Expatriate	Local
Supervisor			1	
Team Leader/WR Planner	11		10.5	
Senior I & D Engineer	9		7	
I & D Engineer		10		10
Design/Costing Engineer		6		4
Hydraulic Engineer	1		-	
Snr Agric Economist	6		4.5	
Agric. Economist		8		5
Hydrogeologist	2		2.5	
Groundwater Engineer		3		2
Snr Hydrologist/Modeller	3		4	
Hydrologist/Modeller		5		5.5
Snr Agronomist	2		2.5	
Agronomist		3		5
Snr Fisheries Specialist	2		3.5	
Fisheries Specialist		3		4
Snr Environmentalist	1		2	
Environmentalist		1		12.5
Sociologist	1	3	2	3
Architect		3		2
Civil Engineer		3		-
Unallocated	2	2	-	-
Total	40	50	39.5	53

In order to check and update this data as well as to obtain information that is not presently available, a large proportion of our resources has been spent in the field, obtaining primary data. This survey work, described in detail in the respective annexes, is summarised below.

Farmer Survey

The farmer survey 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 tenure
- 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 was selected for a more detailed case study questionnaire. This gathered additional data on the above topics and investigated ongoing 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), as shown in Figure 9.1 in the Peoples Participation Section. A sample of 12 mouzas/villages was selected at random in each zone. A list of all farmers in the selected mouzas was drawn up and a random selection made of 8 farmers in each mouza for interview.

Plot Surveys

A survey of 60 fields, with some questions about the farms in which they are located, was conducted in each of the four 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 assessment of the impact of the project on agriculture.

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 which concentrated on individual fields where water levels and land heights could be measured.

Landless People, Fishermen and Women

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 96 fish pond operators, 165 professional fishermen, 96 landless people and 100 women.

The survey of professional fishermen was carried out in 20 villages where fishing is important. Therefore there were more interviews in Zone D (65) than in Zone A (25).

Irrigation Pumps

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 groundwater etc). Stratification of the sample was based on hydrological and secondary data. The sample frame was based on the DAE block with a list of all pumps in the block being drawn up with assistance of the Block Supervisor.

Water Quality

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 at their inflow and outflow from the study area and at confluences. It also included sample sites from the internal rivers, floodplains and beels. This covered both seasonal and permanent beels and a sub-division into those that are only rain fed, those that are river fed and those fed from both sources. 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 industrial pollution sources.

Aquatic Ecology

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 interdependent 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

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. Species were classified by habitat type and an assessment made of likely changes as a result of interventions and the consequential changes in species type, distribution and number.

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Health and Nutrition

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 was likely to change as a result of intervention in the land and water management system. Mental illness levels in the area were 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 Keller Institute and BBS. These indicated the recent past and present levels of nutrition amongst the population in the area.

Topographical Surveys

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

- additional channel cross sections
- checking the zeros of all water level gauge stations
- detailed topographic survey of 4 nr 2 km square sample areas

In addition, 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.

Infrastructural Surveys

The infrastructure surveys fell into two parts. The first was the preparation of an inventory and the collection of design data on all existing hydraulic structures (bridges, culverts etc) which would be affected by project proposals.

The second was the preparation of a broader inventory of all public buildings and infrastructure (railways, roads, embankments, electricity distribution) for the assessment of flood damage with and without projects, both for major flood control interventions and for flood options.

Fish Catch Survey

During the initial stages of the project, a requirement for fish catch and fish market surveys was determined. Five sample areas were selected within the project boundary from which questionnaires concerning fish catches in floodplains, beels and rivers, as well as their market prices, were completed.

1.5 Nomenclature of Planning Developments

1.5.1 Zones

The Gumti Phase II project area is very varied, containing a wide variety of topographic levels and water related problems. In order to properly represent all regimes and aspects, the project area has been split into four Zones, labelled A, B, C and D. A map presenting the location and boundary of these zones is given in Figure 9.1, after page number 9-2.

The zones were determined on topographic and agro-ecological grounds and correspond to different flooding and irrigation characteristics. The zones are as follows:

- **Zone A** representing the high ground with problems relating to flash flooding from the Tripura Hills.

- **Zone B**, also to the east of the project area, is still relatively high, but does not have nearly as much F0 land as Zone A. Zone B has a border on the Titas River and is therefore more susceptible to Meghna-related flooding.

- **Zone C** is the central, medium lowland, with very significant floodplain fisheries.

- **Zone D** is lowland, often supporting only one crop per year. The area is completely dominated by the Meghna River flooding regime.

A further benefit of assuming four zones, of approximately equal area, was to provide statistical validity from both our surveys and People's Participation Meetings.

1.5.2 Strategies

In Section 4 of the Terms of Reference (see Appendix A at the back of this Main Report) six alternatives have been given for the Consultant to address. These alternatives have been termed "Strategies" and are as follows:

- **Strategy (a)** Without Project Scenario

- **Strategy (b)** Basic Flood Response and Development

- **Strategy (c)** Intermediate Flood Response and Development

- **Strategy (d)** Flood Control and Drainage (FCD) Polder

- **Strategy (e)** Flood Control, Drainage and Irrigation (FCDI) Polder

- **Strategy (f)** Phased Development

Development Strategies (d) and (e) were put forward in the 1990 Report and are reviewed in this report. However, this report recommends a set of proposals pertaining to Strategies (b), (c) and (f).

1.5.3 Interventions

In order to properly investigate development Strategies (b), (c) and (f), based on our People's Participation Meetings, a set of "Interventions" were considered. These interventions were a result of the best sets of design options which were investigated using the hydraulic Model MIKE II.

A layout of these interventions is shown in Figure 11.1. They are as follows:

- **Intervention 1A** (River excavation)
- **Intervention 1B** (Polderisation in Zone A)
- **Intervention 2** (Polder in Zone B)
- **Intervention 3** (Extension of Gumti River right embankment with a submersible embankment)
- **Intervention 4** (Polderisation and pumped surface water supply)
- **Intervention 5** (Small polder to the north of Zone B)
- **Intervention 6** (Two separate submersible embankments for boro crop protection)
- **Intervention 7** (Khal excavation for irrigation water supply in Zone D)

These individual Interventions were carefully analyzed in our environmental section, as they were considered to be environmentally distinct.

1.5.4 Schemes

The above listed Interventions have been separately identified for environmental assessment, however, they were not always individually viable from an engineering or economic point of view.

The term Scheme has therefore been used to group the prospective developments into discrete engineering packages, which have undergone economic analysis. The Schemes are also listed (A to E) in order of priority. The Schemes, as discussed in the Summary at the beginning of the Main Report, are as follows:

- **Scheme A** includes Interventions 1A, 1B and 2. Because polder schemes 1B and 2 both depend on river excavation (1A), the three interventions have been placed together in one Scheme.

- **Scheme B** is Intervention 3, extension of the Gumti right embankment.

- **Scheme** C is Intervention 7, excavation of existing khals in Zone D.

- **Scheme D** is Intervention 4, embankment construction and surface water supply in Zone C.

- **Scheme E** is Intervention 6, construction of 2 submersible embankments in Zone D.

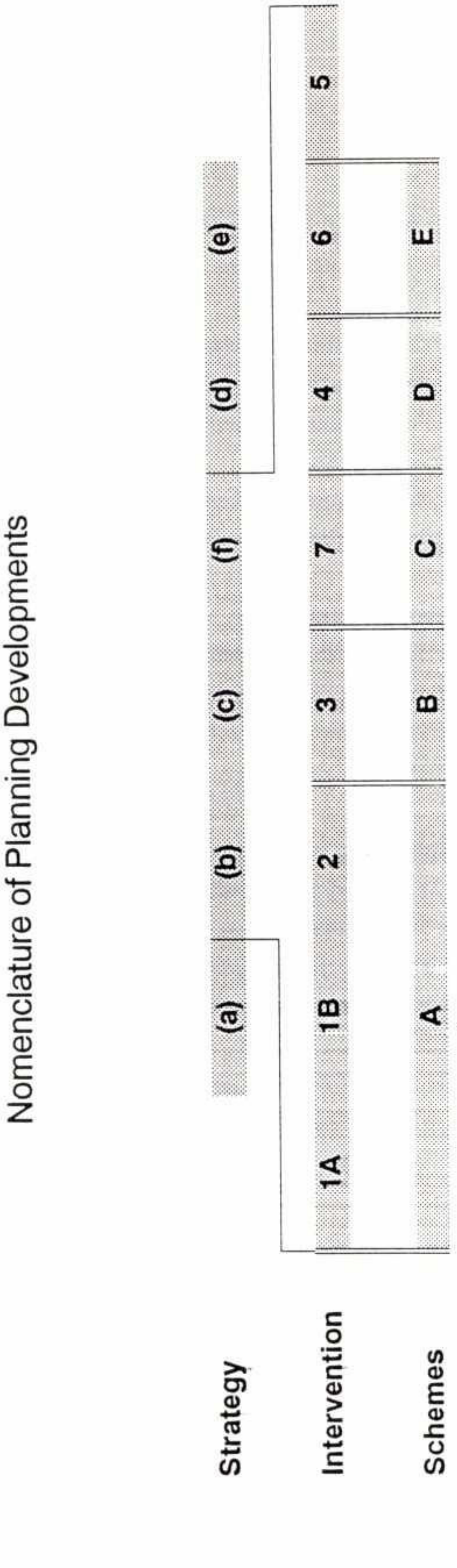
The Schemes A, B and C are all recommended for immediate implementation, while Schemes D and E are only recommended, given certain conditions.

Intervention 5, the small embankment in the north of Zone B, was shown in the model runs to produce insignificant benefits. This Intervention was therefore not carried forward to become a Scheme.

Likewise, Strategies (d) and (e), the full embankment around the whole project area (as recommended in the 1990 report) are not recommended, and have not therefore been accorded a Scheme letter.

A summary of the nomenclature is given in Figure 1.2.

Figure 1.2
Nomenclature of Planning Developments



2 Water Resources and Flood Control

2.1 Hydrology

2.1.1 Climate

The monsoonal climate which affects the Gumti Phase II 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 late 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 project area can be a problem.

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 project area 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 period, 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 project area, being of the order of 28°C. From October, temperatures begin to decline, and mean daily temperatures reach a minimum of about 19°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. February generally produces the lowest values of 71% at Chandpur, and about 67% at Comilla.

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 2300 mm in the south to about 2100 mm at Brahmanbaria. At 80% exceedance probability, annual rainfall drops to about 2000 mm at Comilla, and to about 1700 mm at Brahmanbaria.

The peak rainfall months are June, July and August. During these three months, about 55-60% of the annual rainfall total can be expected.

The average monthly rainfall is exceeded by the average monthly evaporation between mid October and the end of April. Even going into May supplemental irrigation will often 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 entire area is bounded to the west by the River Meghna, and it is this which dominates drainage of the greater part of the project area. The mean annual flow at Bhairab Bazar is of the order of 4600 m^3/s, but the discharge varies seasonally between a mean monthly minimum of 260 m^3/s in February and a mean monthly maximum of 12,400 m^3/s in August. The Meghna is joined by the Padma about 100 km downstream of Bhairab Bazar. The Padma carries the combined discharges of the Ganges and Jamuna (Brahmaputra) Rivers. Mean annual runoff in the Padma is of the order of 30,000 m^3/s, and on average varies between 75,000 m^3/s in August and 6000 m^3/s in February. There are backwater influences in the Meghna upstream of its confluence with the Padma, and the project area is thus affected by the major river systems. The coincidence of seasonal rainfall with peak flood discharges in the Meghna does, however, exacerbate internal drainage problems. Figure 2.2 shows hydrographs of mean decade water level in the major rivers in or near the project area along with mean decade rainfalls over the project area. The basic parameters of the internal drainage problem of the project area are the same as those for the country as a whole.

The Meghna is the outfall water level control on drainage for the entire project area. The seasonal range in Meghna water levels reduces in a southerly direction towards the Bay of Bengal. Seasonal water surface profiles between Bhairab Bazar and Satnal are included in Figure 2.3. The profiles shown are for 1980/81, but the year chosen is of no significance. At Bhairab Bazar, the seasonal range of water levels is of the order of three metres, and there is very little tidal influence in the dry season. At Satnal the seasonal range in water levels is of the order of 2.5 m, and the dry season tidal range of the order of 300 mm. There is a notable change in water surface slope in the Meghna between wet and dry seasons.

Figure 2.1

General Map of Main Drainage System and Data Collection Stations

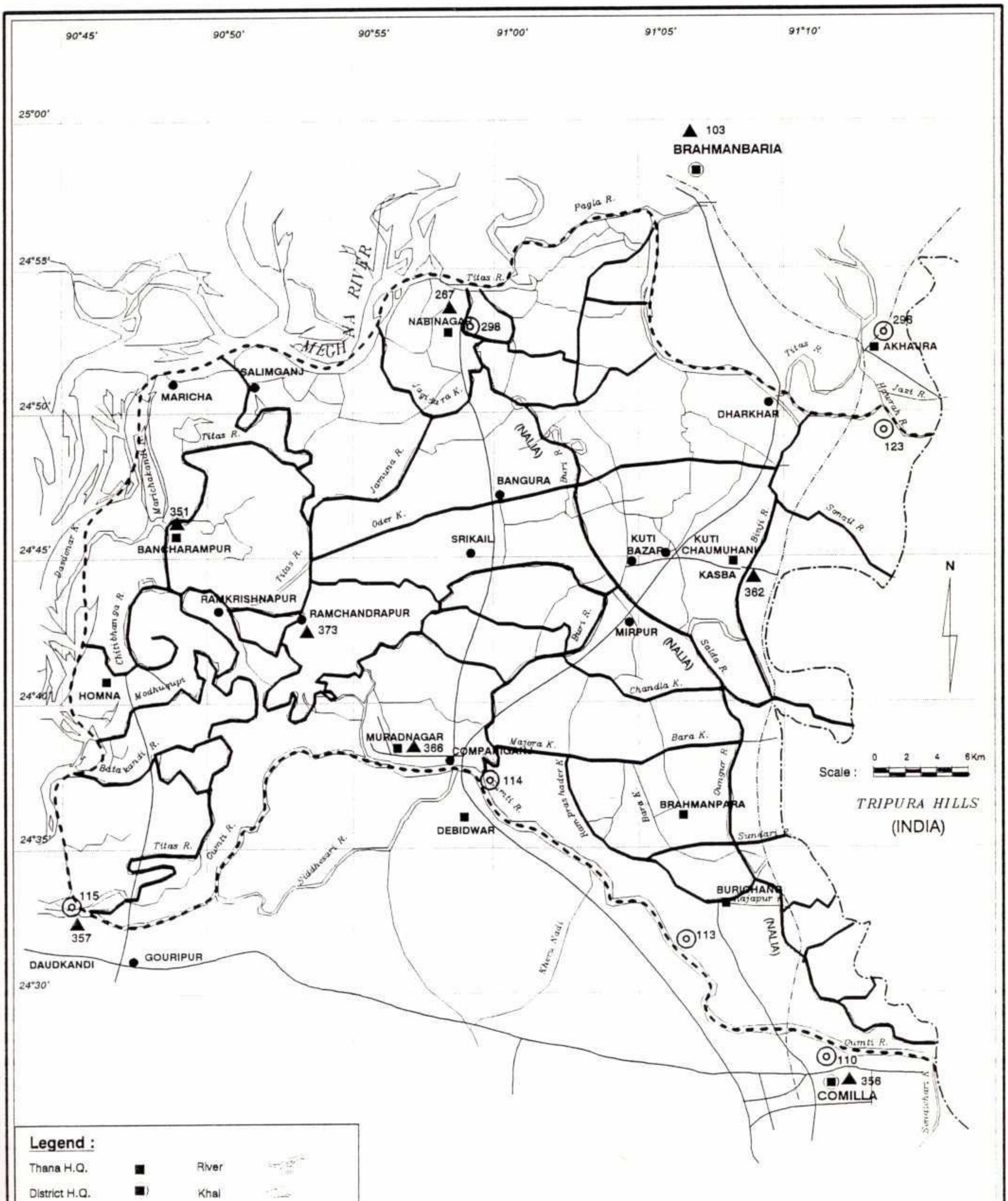


Figure 2.2
Relationship Between Crops, Rainfall and Floods

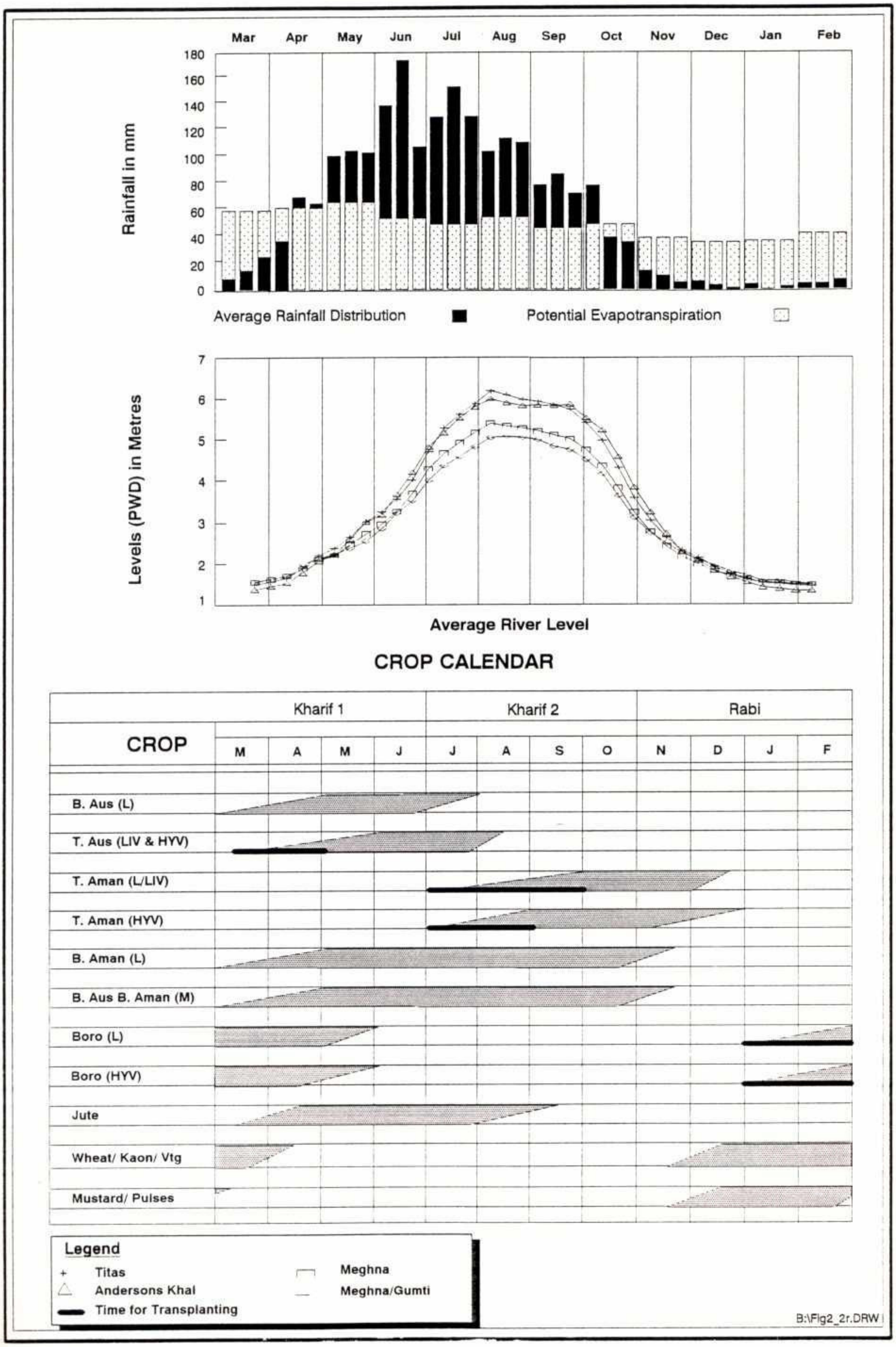
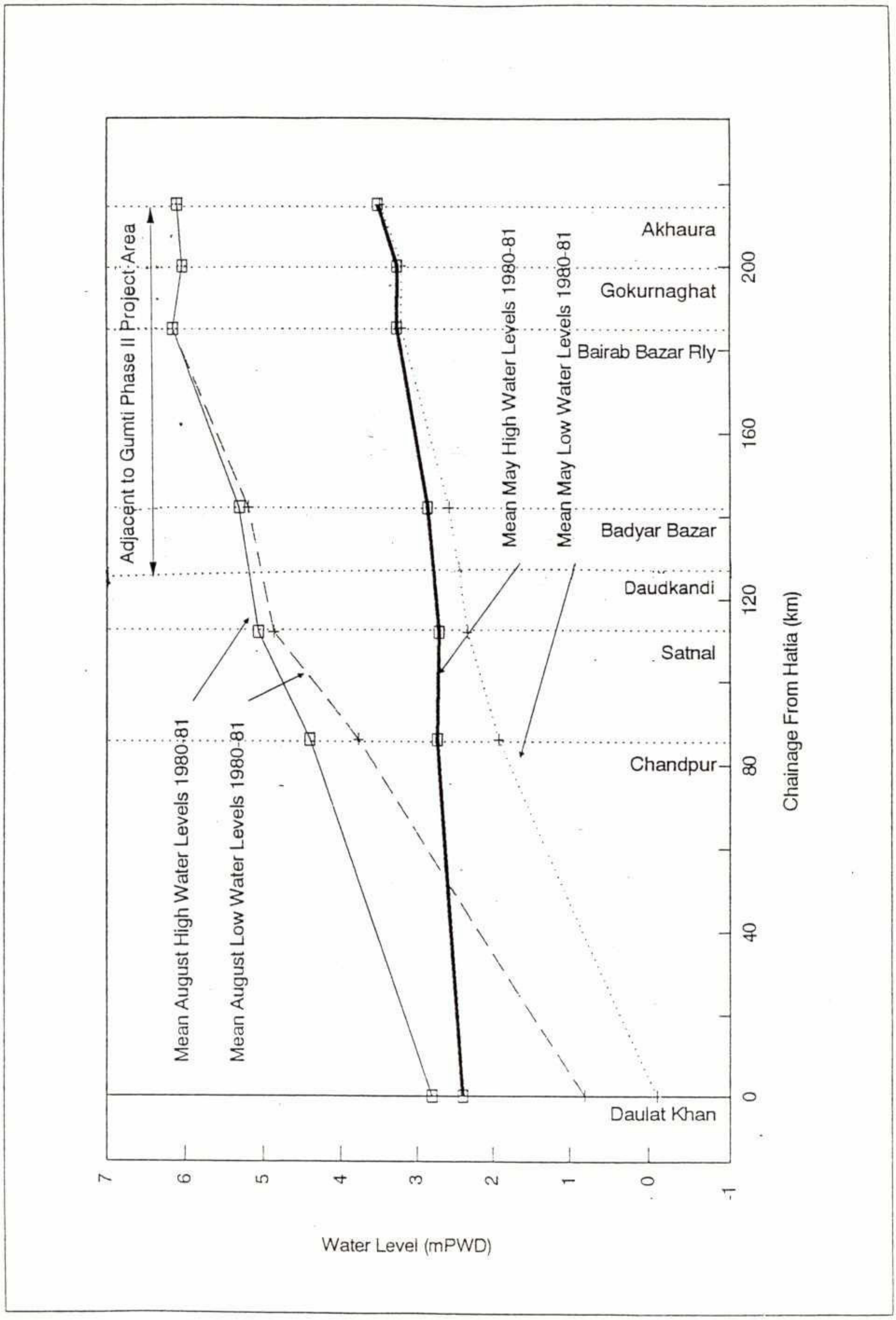


Figure 2.3
Meghna Water Surface Profiles



There are areas of relatively deep flooding in the project area close to the Meghna. Drainage in these areas is complex, with a series of interconnected channels and remnants of former main river courses. It is difficult to identify any singularly important main rivers, other than perhaps the Hawrah which flows into the Buri and Titas Rivers, and the Salda River. Some of the channels in the area had formerly been fed by spills from the Gumti River, prior to completion of embankments and the construction of a regulator at the head of the Buri Nadi River. The area does receive inflows from a number of rivers draining the western slopes of the Tripura Hills. The total area of these estimated catchments is 1252 km^2.

The area, within the borders of Bangladesh, between the Bhairab to Comilla railway and the Gumti River is about 1400 km^2. Thus about 50% of the drainage through the project area is generated in external catchments. Flash floods in these rivers can cause serious damage.

The Gumti River forms the southern boundary of the project area. It is embanked along most of its length in Bangladesh but can contribute to flooding in the south western part of the project area. The annual maximum mean daily flood in the Meghna at Comilla is 500 m^3/s. During times of flood, water levels in the Gumti are significantly higher than the surrounding land. Historically, the Gumti did spill through the project area through the Buri Nadi River. This is now controlled with gated inlets from the Gumti, which are normally kept closed during the monsoon.

2.1.4 Flooding Characteristics

On the basis of the MPO flood phase classification system, only 15% of the area is flood free. The timing, rate of rise, and duration of flooding are, in addition to the flood peak attained, very important factors influencing agricultural damage and cropping patterns, fisheries, and indeed the general disruption caused. Seasonality of flooding is therefore a key variable.

In terms of seasonality, the flood problems are:

pre-monsoon	: April-June	rapid rise in water level before boro crops are harvested, and kharif I crops planted; loss of young crops and seedlings; and loss of maturing boro.
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 runoff; duration of flood inundation is important, and whether flood water is clear or sediment laden;
post-monsoon	: Sept-Oct	drainage at too slow a rate to permit timely planting of certain crops;

In addition to the above flood periods, the general categories under which flooding in the project area can be considered are:

- monsoon floods from the River Meghna and Lower Meghna;
- flash floods from those rivers rising in the Tripura Hills to the east of the project area;

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- localised flooding as a result of heavy and intense rainfall.

The project area is well defined from a flood characteristic point of view, being bounded by the River Titas in the north, the Gumti River in the south, and the Meghna in the west. The areas close to the Meghna are particularly susceptible to deep flooding. During the main monsoon season, the Meghna dominates flood extent in the area, and in the northern part of the area, there is very little east to west gradient. From the elevation area characteristics published for MPO planning areas 29 and 31, and water level records, it is apparent that the Meghna is the primary source of prolonged monsoon flooding.

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 Section 10.

2.1.5 Water Level, Flow and Sediment 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 including the main river stations is summarised 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. No additional hydrometric field data were collected as part of this investigation.

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 any frequency analysis.

There are very few relevant discharge measurement stations in the project area. Only the Gumti, Buri Nadi and Hawrah Rivers are gauged. Flows into the Buri Nadi are controlled and the records at Jibanpur are thus of limited value. The station at Bhairab Bazar (273) on the Meghna is a strategic station in the national hydrometric network, but other than assisting in defining boundary flow conditions in the Meghna, gives little insight to conditions within the area itself. The station at Ganga Sagar Railway Bridge (123) is affected by backwater from the Meghna and has no stable rating. At Brahmanbaria Railway Bridge (3A), flow measurement has now been abandoned.

A short term station was established by the SWMC on the Salda River at the Salda railway bridge, and this is also affected by backwater from the Meghna.

Sediment deposition from rivers rising in the Tripura Hills is a problem in several areas, as is deposition close to the Meghna. There are, however, very few sediment data available for either the project area or the South East Region. There is no routine sediment or water quality sampling at any location in the project area.

TABLE 2.1

Mean Daily Discharge Availabilty for Gumti Phase II

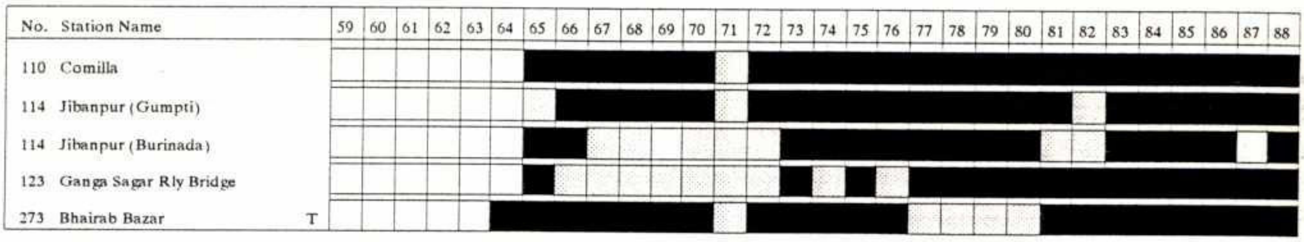
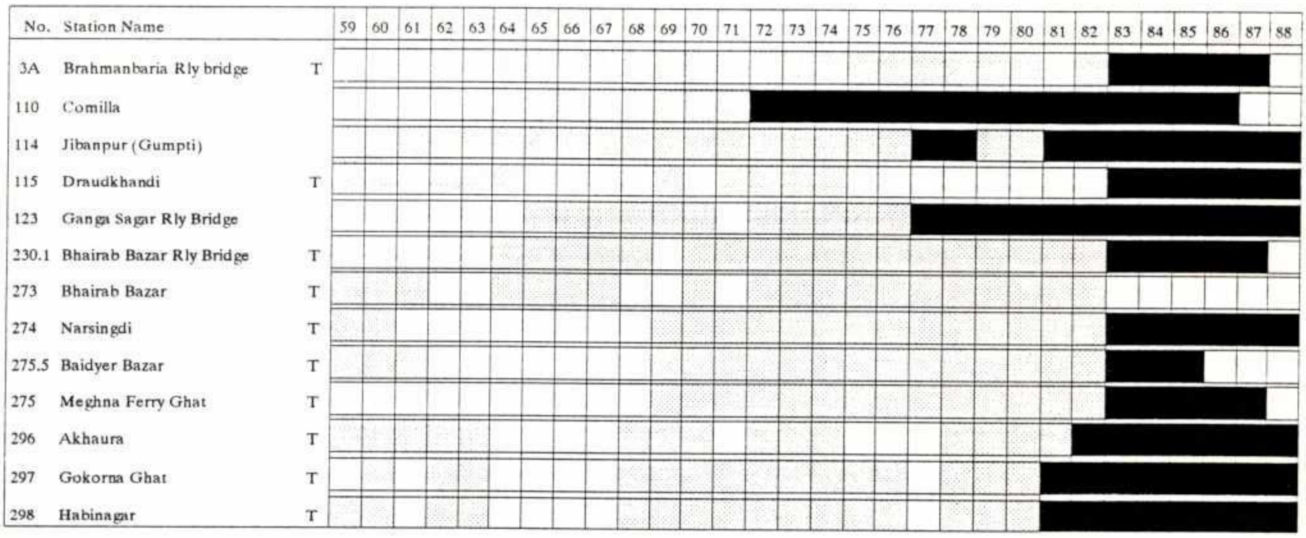


TABLE 2.2

Average Daily Water Level Availability for Gumti Phase II



Legend: ■ – full record ☐ – incomplete record

2.2 Flood Control

2.2.1 River Morphology

Upper Meghna Erosion

Any development of the Gumti Phase II project area must take account of possible shifting of the existing bank line of the Upper Meghna, particularly in determining the appropriate set-back for embankments.

FAP 9B (Meghna Left Bank Protection) and BWDB reports relating to erosion problems along the Upper Meghna at the boundary of the project area were reviewed, and field visits undertaken along the Meghna-Titas left bank from Nabinagar to Bancharampur and the nature and extent of erosion along the bank line studied. Available aerial photography, SPOT satellite imagery and maps from 1952 to 1990 were also studied. Subsequently a series of LANDSAT images (December 1973 - January 1993) covering part of the area also became available.

From all these sources it was observed that the Meghna is gradually shifting from a braided to a meandering form, apparently as a result of the diversion of the Brahmaputra flow through the present Jamuna channel in 1776. This shift is mainly due to the reduction of flow and the process is still continuing. Location-specific observations are given in Section 3 of Annex I.

It is concluded that there is significant erosion along the northern project boundary downstream of where the Meghna meets the Titas River. However, no major infrastructure is presently situated in this reach, and the cost of effective protective works is unlikely to be justified.

The recommended strategy is therefore to provide an adequate set back to any embankment, so that it is unlikely to be threatened within a project lifetime of, say, 30 years. An erosion rate of 20 m per year therefore suggests a set back distance of 600 m in this reach. Allowing a safety margin, the figure of 700 m proposed by FAP 9B seems entirely reasonable, and the set back of 500 m to 800 m already adopted by the 1990 feasibility study is consistent with this.

In the reach from Shantinagar to Daudkandi (forming the western boundary to the project area), a set back distance of 300 m has been adopted by the 1990 study, and this figure is considered adequate.

The above recommendations on set back distances do of course assume that present trends continue (or are not exceeded). Major interventions in the North East Region (FAP 6), for instance, could have significant effects upon the morphology of the downstream channel, although these would be very difficult to predict. At the time this report was written the FAP 6 "With Project" computer model runs had not been done.

Gumti Right Embankment

The right bank of the Gumti River, adjacent to the project area, is now embanked from the Indian border as far as the village of Daskandi, about 65 km downstream, following completion of the Gumti Phase I Project in 1992. This river has a substantial catchment in the Tripura Hills of India, and is subject to flash flooding. The Gumti Phase I project was merely the latest in a series of works to try and contain it. Embankment protection works have been provided on the outer banks at several bends, but erosion is still serious in some reaches, which need additional protection. The locations of these reaches are given in Appendix I, Section 3. The cost of carrying out these works, which are strictly speaking outside the project area, has not been included in the project proposals, and they should be regarded as part of the maintenance requirements of the Gumti embankment. Nevertheless, failure of the embankment arising from their neglect would cause serious damage to the project area, whether or not the proposals arising from the present study are implemented.

Howard Humphreys and Partners (Hydrological and Morphological Studies of the Gumti, Titas and Atrai Basins, April 1990) performed a hydrodynamic and morphological model analysis of the behaviour of the river with its embankments, substantially as now implemented. According to both the Howard Humphreys study and the 1983 confinement study by NEDECO the embankment as initially proposed is liable to overtop under 1 in 20 year conditions even in the middle reaches. The design was therefore modified during the Construction Stage and is now secure against overtopping. The overtopping at the downstream end under conditions of high Meghna water levels is not of major concern, since in the absence of a Meghna embankment, protection from main river floods is in any case not available. Indeed the right embankment has not actually been constructed beyond about chainage 60 km (although extension as a low submersible embankment is recommended in the Zone D proposals under the present study).

Previously, up to about 30% of the discharge at Comilla used to escape into the Buri Nadi at kilometre 41 (Feasibility Report on the Gumti South Project, Annex C, NEDECO, 1984). This escape has effectively been closed as part of the Gumti Phase I works, which arguably was as major an intervention morphologically as construction of the embankments themselves. Floodplain levels are not available from the Howard Humphreys study, but comparisons have been made between floodplain (and bed) levels extracted from the South East Regional Model (surveyed in 1986 approx) with those obtained from the 1993 surveys, within the embankments. This shows that there is a distinct rise between the two surveys, more or less mirroring the drop in bed level. In the reaches which have been embanked for many years, the land within the embankments is distinctly higher than that outside (viewed either in the field or from the Water Development Maps), confirming this tendency. The one-dimensional morphology model used by Howard Humphreys may therefore have been correct in finding no net erosion or accretion within the channel, but was not able to show the redistribution from bed to flood plain. In any case it is understood that the Howard Humphreys study did not allow for closure of the Buri Nadi offtake.

The removal of the hump in the bed downstream of the Buri Nadi offtake would have a major positive impact upon the availability of water for irrigation within the Gumti River, since it would then be possible to draw a backflow from the Meghna River during the dry season for perhaps up to 50 km upstream. The mean February/March low water level at Daudkandi is about 1 m above PWD, so under static conditions the water depth at the Buri Nadi offtake could be nearly 2 m, but a water surface slope of 3 or 4 cm/km would reduce this to zero. It is recommended that the channel be surveyed every year or two to check whether the trend is continuing. It may be worthwhile to dredge the channel artificially in order to achieve the benefits earlier, but it is unlikely that the channel could be economically maintained at a size in excess of its natural equilibrium.

The amount of irrigation water which could be drawn depends upon the eventual dimensions of the channel, which are difficult to predict with any confidence. However, it may become possible to pump water into the western portion of the Gumti Phase I area, which suffers from a severe shortage of surface water in the dry season.

2.2.2 Existing Schemes

JICA Work

Zone D has a number of proposed and ongoing new work in it. The work proposed by JICA in the Rural Development Studies of Bancharampur, Homna and Nabinagar are of relevance to the overall water regime and resources of the area. The pertinent works proposed include:

- khal re-excavation for irrigation development based on LLP usage;
- khal re-excavation for improved drainage;
- feeder road improvements (type 'A' and 'B');
- rural road improvements.

Floating pumps were at one time considered by JICA but have since been removed from their programme.

The khals are relatively small and a constant (indicative) excavation depth of 1.0 m is proposed. The re-excavation of the khals would allow more irrigation to be practised through the deployment of LLPs. The JICA programme also allows for the capital cost of a number of LLPs in the development budget. The present rationale is that next year 22.8 km of Khal would be re-excavated and 70 sets of 2 cusec LLPs will be provided. In the following year, a further 32.1 km of khal would be excavated and a further 70 sets of LLPs provided.

The improvement of the feeder roads in the area is an important development since communications in the monsoon are very problematic. The upgraded road between Gouripur and Bancharampur and beyond will be the major improvement. The line of the new roads was considered in locating our initially proposed submersible embankment schemes.

Satdona and Chandal Beel Projects

The Chandal beel project has a gross area of 813 ha and a NCA of 615 ha and includes a 3 vent 1.5 x 1.8 m regulator. The Satdona beel project has a gross area of 5153 ha and a NCA of 3350 ha and includes 2 nr 2 vent 1.5 x 1.8 m regulators. These are submersible embankment projects which were under implementation during the course of the study. Very little peripheral embankment work has been undertaken as the surrounding ground level of the beel was considered sufficiently high to protect the boro crop.

From the topographic maps (FINNMAP) and the flood hydrographs of relevant water level gauges in the area the land inside the Satdona Beel and Chandal Beel project areas could be subjected to problems of damage to a HYV boro crop in the pre-monsoon period.

The schemes as presently envisaged could have a serious detrimental affect on the fish who use the beel. This is because the gates are not fish friendly and they will be closed during the pre-monsoon period, when it is critical for the fish to move between river and beel. Since the construction is now complete, the effect of the fisheries should be carefully monitored in relation to the agricultural improvements obtained from protection of the boro crop.

2.2.3 Impacts of Floods

Discussion with people during surveys and people's participation meetings concluded that the normal annual floods were not a problem to people in the project area.

The flood of 1988 was the highest recorded flood in the Gumti Phase II project area. Along with most of the rest of the country, significant damage was done to both aman crops and infrastructure. This is discussed in more detail in Annexes I and J.

The major impact of floods in the area is caused by flash floods which come from the Indian border. From our surveys, significant damage is caused in Zones A and B on a regular basis to crops, generally the boro crop. Flash floods also caused damage to the area downstream of the existing Gumti north embankment in Daudkandi thana.

It should be noted that the 1993 pre-monsoon period has been especially prone to flash floods. Heavy rainfall from 17 to 19 February 1993 affected rabi crops on about 1200 ha downstream of the completed embankment.

On 10 May 1993 approximately 200 ha of boro in Kasba and 60 ha in Akhaura went under water. A few days after that, approximately 7000 ha north of Brahmanpara went under water for several days. Project staff witnessed farmers trying to harvest the boro crop from boats but it would have to be assumed that most of this crop would have been completely destroyed.

Although 1993 was an unusually bad year, it can be concluded that protection should be targeted against flash floods and the damage they cause. This is because the costs of protection against the major floods of 1988 would be enormous and difficult to justify, while protection against annual Meghna related floods would produce little benefit, as they cause little hardship.

2.3 Groundwater

2.3.1 Geology and Geomorphology

The surface geology and geomorphology of the project area have been described by Morgan and McIntire (1959), Bakr (1977) and Alam et al (1990). They are also discussed in detail in Annex C. The hills and terraces are of Lower or Middle Pleistocene age, while the floodplains are Holocene. The principal landform is the Old Meghna Estuarine Floodplain which is about 1.5 - 2 metres higher than the adjacent Middle Meghna and Surma - Kushiyara River Floodplains, and is characterised by an almost level landscape of smooth broad ridges and basins.

The Dupi Tila (Plio-Pleistocene) and younger strata are exposed at the surface. The deposits underlying the Old Meghna Estuarine Floodplain have been given the name Chandina Formation. The deposition of the late Quaternary sediments was controlled by global sea level fluctuations, in particular during the last glacial maximum of the Pleistocene, when sea level fell to about 130 metres below its present level approximately 18,000 years before present (BP). This led to the formation of incised channels along the Meghna and Old Brahmaputra valleys.

2.3.2 Hydrogeology

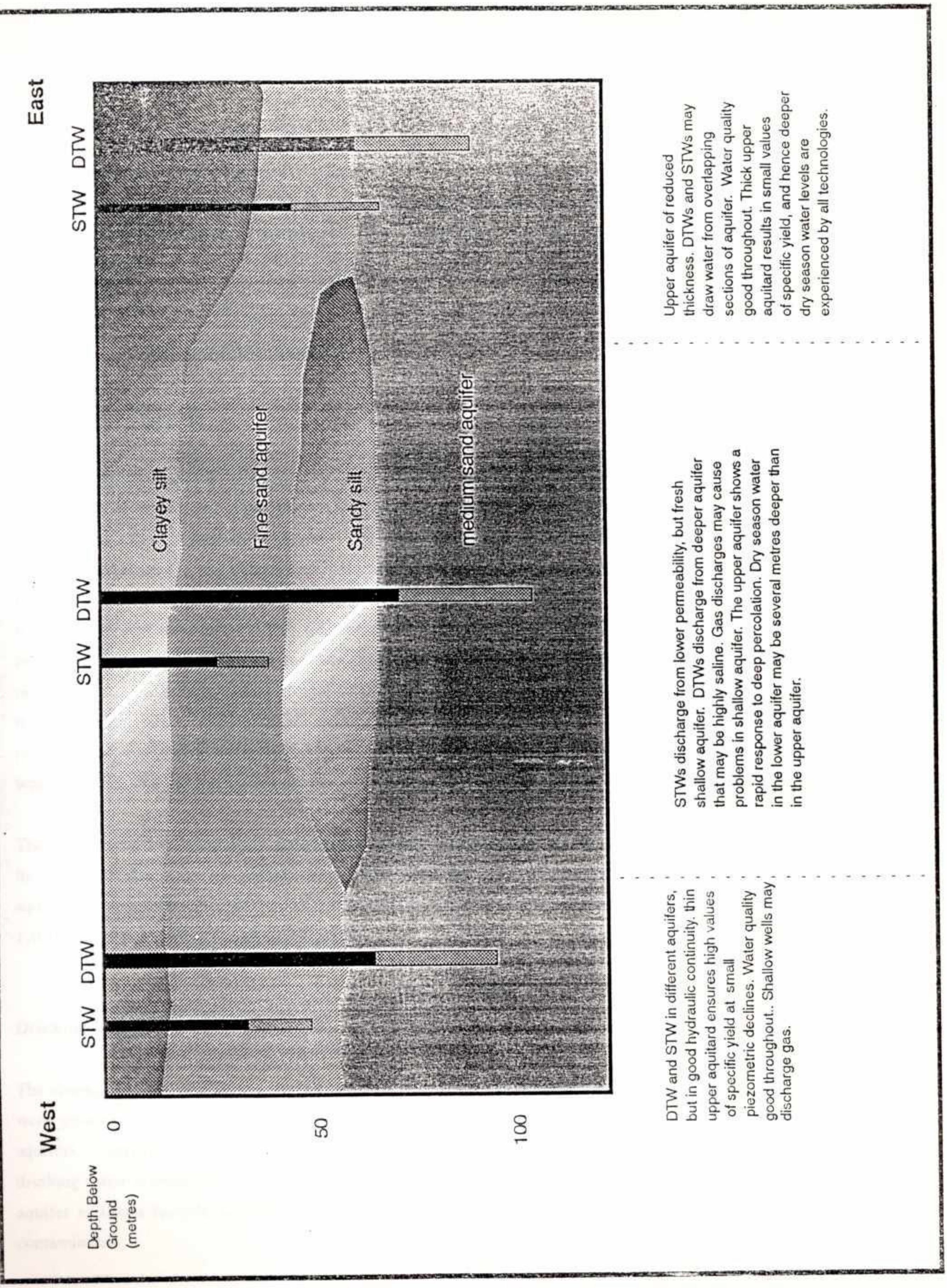
Groundwater is developed for irrigation principally from the Dupi Tila sands, and to a lesser extent the Chandina Formation. For drinking water the proportions are reversed. Despite its importance for public health the volume of groundwater withdrawn for domestic purposes is insignificant compared to that for irrigation. There are significant abstractions of groundwater by both deep and shallow tubewells (STWs) in most thanas, while abstraction by manual methods is quantitatively insignificant. The groundwater reservoir is recharged annually by infiltration of rainfall and floodwater. The potential recharge estimates are based on infiltration through the top aquitard only. However, it has been shown that groundwater abstraction often occurs from at least two aquifers in partial hydraulic separation. The semi-confining layer that separates the aquifers is sufficient to maintain different piezometric levels during the dry season while fully recharging both aquifers in the monsoon. Figure 2.4 shows a schematic (east - west) hydrogeological section through the study area.

Transmissivity determinations from pumping tests in the Greater Comilla area average 724 m^2/d with a standard deviation of 408 m^2/d. Thana average permeabilities range between 21 and 30 m/d. These permeabilities nearly all represent the Dupi Tila Formation, and are comparable with determinations in other areas, however, some wells are almost certainly screened partly in the Chandina Formation. Despite the smaller average grain size, it is expected that the Chandina Formation will have higher permeabilities because it is largely unweathered.

Groundwater levels are monitored by both BWDB and BADC. Groundwater flow occurs dominantly from east to west, although there are reversed gradients in the Homna and Bancharampur areas, which appear to correlate with a region of internal drainage. Generally the hydraulic gradients are low and lateral groundwater flow must be quite slow. Groundwater hydrographs show that the aquifers are fully recharged every year, and the broad monsoonal peaks of the hydrographs indicate that there are usually several months of 'rejected recharge'. Most

Figure 2.4

Schematic Hydrogeological Cross Section Through the Project Area



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of the hydrographs show little response to pumping because only in Comilla, Burichang, Kasba and Brahmanpara is net groundwater abstraction significantly greater than deep percolation losses from surface water irrigation. Natural recession of groundwater continues into March or April, but any modification of the hydrograph due to pumping can only occur between February and April. Hence it can be seen that in all parts of the study area, the effect of pumping is a minor part of the annual fluctuation.

The water level monitoring networks established by BWDB and BADC are generally adequate for keeping a check on the impact of groundwater development. However, there is a requirement to install an automatic water level recorder in both aquifers in Muradnagar and a second recorder in Debidwar, so that both shallow and deep aquifers may be monitored. Installation of an automatic water level recorder in Brahmanpara is also recommended.

2.3.3 Groundwater Quality

Distribution of Salinity

Detailed surveys of the electrolytic conductivity (EC) of operating DTWs were carried out in 1991 and 1992 by the DTW II Project and supplemented by a smaller survey by the South East Regional Study. These results represent the salinity of the main aquifer. The distribution of EC in tubewells pumping from the main aquifer is shown in Figure 2.5. It is seen that there are major variations of groundwater quality in the project area. In the east (roughly corresponding to Zones A and B) the groundwater is extremely fresh (<250 μS/cm). Brackish (defined here as $>$ 2,000 μS/cm) groundwater occurs mainly in an elongate belt in the west of Muradnagar thana, approximately following the boundary between Zones C and D, and also in small pockets in Zone D. It is emphasised that groundwater in excess of 2,000 μS/cm occurs only in a small proportion of the study area. Areas of intermediate salinity are conspicuously elongate, being drawn out towards the north or north-east, apparently mirroring the shape of the estuary in which the lower part of the Chandina Formation was deposited, and suggesting the presence of two embayments, in the Nabinagar and Brahmanpara areas.

The SERS and DTW II surveys measured the salinity of adjacent DTWs and HTWs at six sites. In every case the salinity of the DTW was similar to, or higher than, the HTW. The distribution of salinity in the shallow aquifer (as measured in HTWs and STWs) is similar to that in the main aquifer but the salinity rarely exceeds 1,000 μS/cm and never exceeds 2,000 μS/cm.

Drinking Water

The chemical quality of groundwater for drinking was compared with the Bangladesh Standards. The analyses were grouped to draw attention to the differences between the shallow and deep (and for irrigation, main) aquifers. Currently, the vast majority of drinking water is drawn from the shallow aquifer, but in some areas drinking water is drawn from DTWs during the dry season where suction pumps fail temporarily. This deeper aquifer is also a feasible alternative source of drinking water in the event of the shallow aquifer becoming contaminated.

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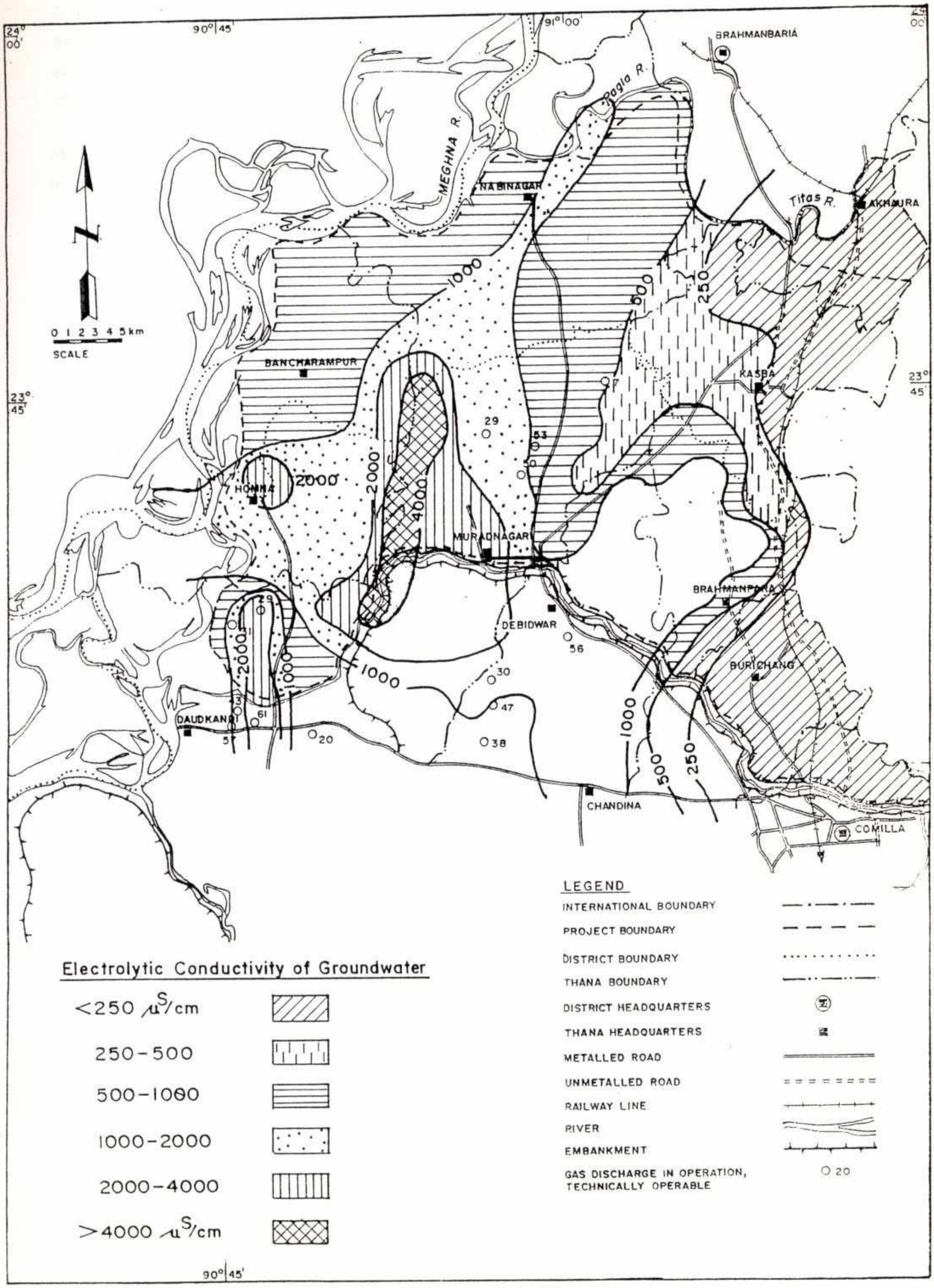
Figure 2.5
Distribution of Salinity (EC) in the Main Aquifer



The most pervasive groundwater quality problems are iron and manganese. Manganese is less of a problem in the shallow than the deep aquifer. Almost all samples from both aquifers exceed the recommended limits for iron. According to the WHO Guidelines for Drinking Water (1984) both iron and manganese are essential nutrients, but are objected to for reasons other than health (such as taste and the tendency to form oxidised precipitates).

Most of the water from the shallow aquifer exceeds the desirable limit for magnesium. The concern over magnesium in water is not clear, but, it is often considered that the sulphates of magnesium, calcium and sodium may cause problems (WHO, 1984). However, since sulphate does not exceed 2 mg/l, magnesium is not likely to be a problem. Sodium (which at high intake levels is linked to heart disease), exceeds the maximum permissible limits in two samples from the main aquifer. In both cases, high sodium is associated with high chloride and a generally high salinity.

Nitrate was determined[1] from samples collected from deep tubewells, piezometers and hand tubewells for drinking water. Nitrate analyses ranged from below detection limits to 10.8 mg/l NO_3-N. The Bangladesh Standard[2] for nitrate in drinking water is 10 mg/l. The highest concentrations are found in (domestic) hand tubewells in the shallow aquifer, and conversely all samples below detection limits were obtained from the main aquifer. Nitrate concentrations in excess of 10 mg/l in the shallow aquifer are clearly a concern for public health. Less obviously, but perhaps of equal or greater concern, is that water with nitrate concentrations of 3-7 mg/l has penetrated the aquifer to depths of 50-80 metres. This suggests the possibility of progressive contamination of the aquifer. The likely sources of nitrate in the aquifer system are:

(i) faecal sources (human and animal wastes)
(ii) oxidation and leading of organic - N compounds in the soil
(iii) leaching of artificial fertilisers.

In practice, it is often difficult to differentiate between (ii) and (iii) since they are mixed and the same processes control their fate in the soil zone. It is important to differentiate between these sources because the policy implications for reducing the risks to health are quite different. Further investigations and research should be undertaken to determine the extent of the problem, establish a baseline, identify the relative importance of different sources of nitrate, predict long term trends and hence establish a general, but coordinated, strategy to minimise the long term health risks.

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1 Samples were collected and analysed by the British Geological Survey's regional hydrochemical study (Davies and Exley, 1992).

2 The WHO European Standards of 1970 established a 'recommended' limit of 11.3 mg/l (NO_3-N) and a 'maximum acceptable' limit of 22.6 mg/l. The WHO International Standards of 1971 took account of higher water intake and bacterial levels in some non-european countries and made 10 mg/l the limit. The US EPA also adopted 10 mg/l. The EEC directive (1980, effective from 1985) makes 11.3 mg/l the maximum admissible level, and 5.6 mg/l the guide level.

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2.3.4 Minor Irrigation Development

Most data on minor irrigation are collected through either BADC and/or DAE. Until the mid-1980's almost all minor irrigation equipment was distributed through BADC. However, since the privatisation of the LLP and STW sub-sectors, data collection has become inherently more difficult. The 1990 Study carried out its own surveys for the project area for the years 1986 to 1989. In recent years, rigorous surveys of minor irrigation were organised by CIDA funded Agriculture Sector Team (AST). Their March 1991 Survey is widely considered the best available data, and has been accepted as the baseline for the present resource evaluation. Table 2.3 compares the AST data with those of the 1990 Study for the design year of 1987 and the final surveyed year of 1989.

TABLE 2.3
Comparison of Minor Irrigation Estimates

Irrigation Mode	1987 (1990 study)	1989 (1990 study)	1991 (AST)
LLP	15,725	24,519	30,384
STW & DSSTW	5,888	12,517	16,219
DTW	5,414	7,625	10,899
Total	**27,027**	**44,661**	**57,502**

Note : All numbers in the table are total irrigated areas in hectares.

There has apparently been a rapid growth in irrigation coverage, by both groundwater and surface water, during the last six years, and thus the use of 1987 statistics gives a misleading picture of the present resource use. There is a further complication in that the 1987 and 1989 surveys did not count the areas irrigated by manual tubewells and traditional methods, which bring the total irrigation coverage in 1991 up to about 63,000 hectares. This may be compared with an 'irrigable' area which is probably of the order of 110,000 hectares, but might conceivably be as high as 130,000 hectares.

2.3.5 Groundwater Development Constraints

Salinity

For irrigation purposes, no impact on the yields of either rice or wheat is expected if the electrolytic conductivity of the irrigation water does not exceed 2,000 μS/cm, although yield reductions might be expected with certain vegetables if irrigated with water of more than 1,000 μS/cm. Long term historical precedent indicates that irrigation will continue to be dominated by rice and/or wheat. Therefore, for resource planning it is assumed that groundwater may be recommended for irrigation wherever the salinity does not, or will not, exceed 2,000 μS/cm. The shallow aquifer zones, down to about 40 metres, may be exploited throughout the area. In effect, it may be said that salinity is not a constraint on suction mode tubewell development in the area.

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Where it is necessary to exploit the deeper aquifers the 2,000 μS/cm contour in Figure 2.5 should serve as a reliable guide, although some caution (or optimism) should be shown when drilling within a kilometre or two of the boundary of this zone. The 2,000 μS/cm contour was used to define the area of salinity constraints in Figure 2.6.

Natural Gas Constraints

Discharges of natural gas to tubewells are very common, especially in Zone C. Although it is widely recognised by farmers to be a constraint on irrigation, apparently none of the studies conducted before 1992 identified the problem (here, or apparently in other areas). Further, the conventional MPO style assessments of groundwater potential do not recognise gas as a constraint. Consequently the project has conducted a special survey of the occurrence of gas in irrigation wells, which is described in full in Annex C.

Gas discharges have been noted from DTWs, STWs and hand tubewells for drinking water. Gas is observed coming out of solution during the operation of wells. Often the gas may be ignited, indicating the presence of methane. Drilling contractors report striking large pockets of gas during drilling, which sometimes lead to abandonment of the hole, and are a potential danger to the workers. Drillers report that gas problems occur predominantly in the shallow aquifer. There are no records of gas discharges being an actual safety hazard at operating tubewells.

DTWs producing gas are largely restricted to Zone C. In the majority of cases gas is a nuisance for DTWs, and may reduce the working life of pumpsets by promoting corrosion, but only a very small proportion of 'problem wells' cannot be operated usefully.

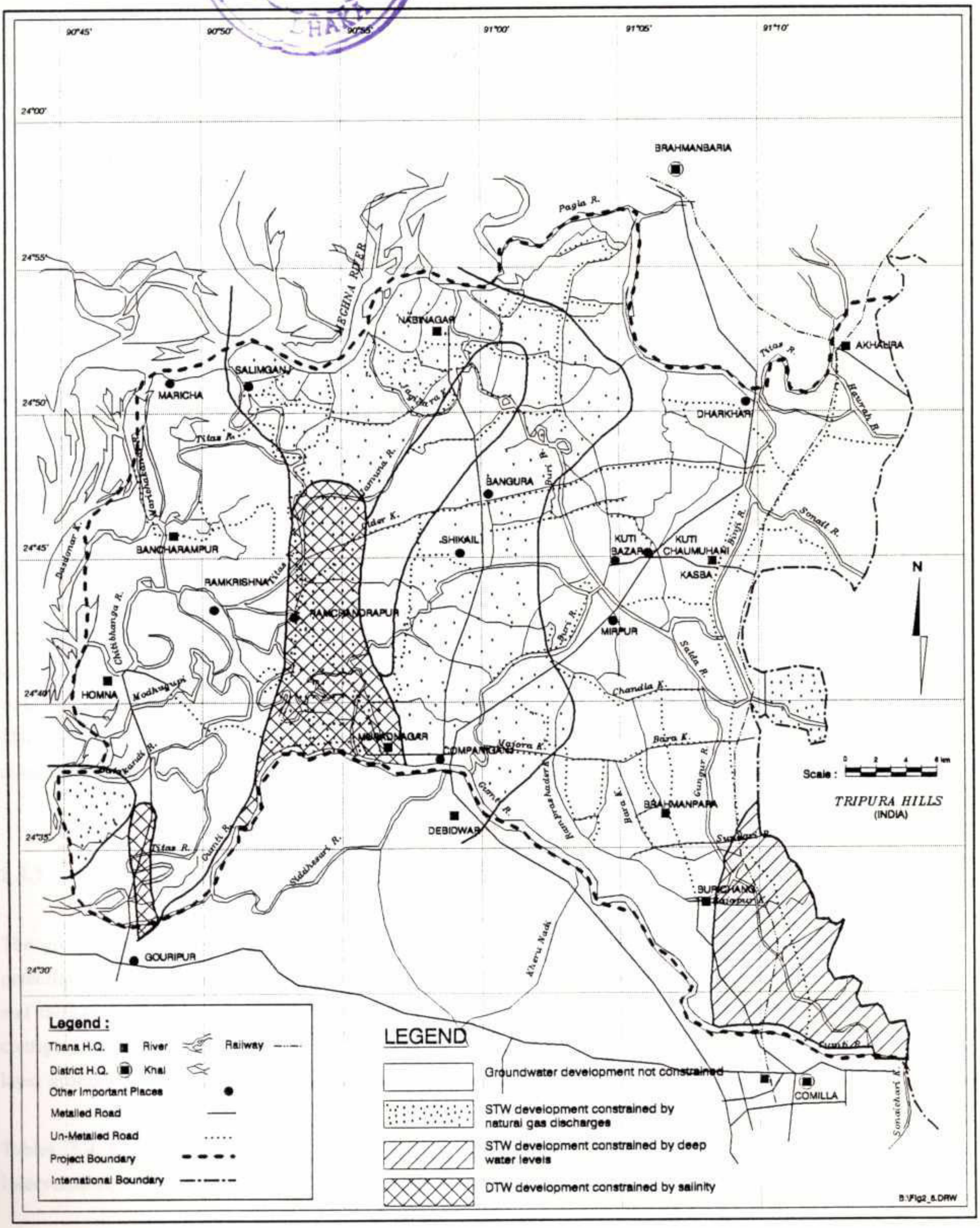
It is more difficult to quantify the constraint on STWs. However, there is no doubt that high speed, surface mounted suction pumps are inherently more susceptible to interference from gas discharges, which cause loss of suction. Interviews with BADC, BRDB and DAE officials, STW drillers, pump mechanics and farmers indicate serious problems in some areas. Indirect evidence is provided by the intensity of STW irrigation. The areas where STW development is constrained are shown in Figure 2.6. It is seen that suction mode wells are severely constrained in Zone C, and parts of other zones.

Gas in HTWs is extremely common, supporting the shallow origin of the gas, and as with DTWs is a nuisance but does not prevent the operation of wells.

2.3.6 Choice of Tubewell Technology

Groundwater abstraction technologies in Bangladesh may be classified into four groups on the basis of two criteria - whether the pumps are suction mode (surface mounted) or force mode (down the well), and whether they are mechanically or manually powered. Manual pumps are of little importance for irrigation in the study area, but probably account for well over 90% of safe drinking water supplies. The operation of suction mode wells with surface mounted pumps is limited to water level depths of between 5 and 7 metres, depending on discharge and aquifer conditions. Where they work, suction mode wells are always cheaper to construct that their force mode equivalent, and are therefore widely preferred.

Figure 2.6
Groundwater Development Constraints



Where water levels exceed suction limits, either force mode wells must be developed or the suction pump must be placed in an excavation. Practically, the deep setting option only applies to mechanically powered irrigation pumps; for drinking water supplies, more expensive piston pumps (the 'Tara') replace the popular UNICEF Nr 6 pump. For irrigation purposes, force mode tubewells have been virtually synonymous with the BADC 2 cusec deep tubewell. However, with the current plans for privatisation there is likely to be a major shift towards lower capacity wells, the use of cheaper well components, shorter screen lengths, and lower quality but cheaper pumps and engines. A particular uncertainty in areas such as the Comilla region is whether force mode wells would continue to be screened in the deeper medium to coarse sand aquifer, or whether they will be screened in the shallow fine to medium sand aquifer normally exploited by shallow wells. This would reduce capital costs, but would probably increase drawdown and, in some areas, gas problems and clogging of screens by fines. The range of force mode tubewell design options is shown in Figure 2.7.

Where gas discharges occur, either the efficiency of shallow tubewell pumps is severely impaired or they do not work at all. The best solution in these areas would be to use force mode wells, either in the deeper parts of the aquifer where there is less gas, or to construct shallow, low capacity force mode tubewells in the same aquifer that would otherwise normally be exploited by STWs.

Where salinity problems occur, the best option for groundwater irrigation should be to exploit the shallow aquifer, and preferably the upper part of it (if this option is not viable, the alternative would be to investigate a probable fresh water aquifer below about 120 metres). Most of the saline areas are also constrained by gas in the upper aquifer, and hence shallow force mode tubewells (SFMTWs) or manual tubewells will be required.

The SFMTW has not yet been demonstrated in the gas constrained areas. Gas and salinity may both promote corrosion of well and pump components and hence the use of resistant materials such as PVC or fibre glass (or stainless steel) is recommended. In any case, plastics would almost certainly be preferred on economic grounds. The typical design (SFMTW-2) would probably include a single diameter (either 150 or 200 mm) string of casing and screen. The pump could be either a vertical turbine or an electric submersible.

2.3.7 Groundwater Development Potential

The groundwater potential for each abstraction mode was basically estimated using a combination of the potential recharge estimates of FAP 5 and new determinations of the depth - storage curves, to which the gas and salinity constraints were applied. For the areas with complications due to salinity and multiple aquifer configurations, these results were further investigated using the SUTRA solute transport model, and a multi-layer groundwater model (SCTM). These results are described fully in Annex C.

Tables 2.4 to 2.6 describe the probable impact of increased groundwater irrigation, **without project intervention**, which has been assessed on the assumption that it would occur in three phases:

- additional STWs up to suction limits (without deep setting)
- additional STWs and DSSTWs up to suction limits
- development by suction mode wells first, followed by force mode wells where land resources remain un-irrigated

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Figure 2.7

Force Mode Tubewell Design Options

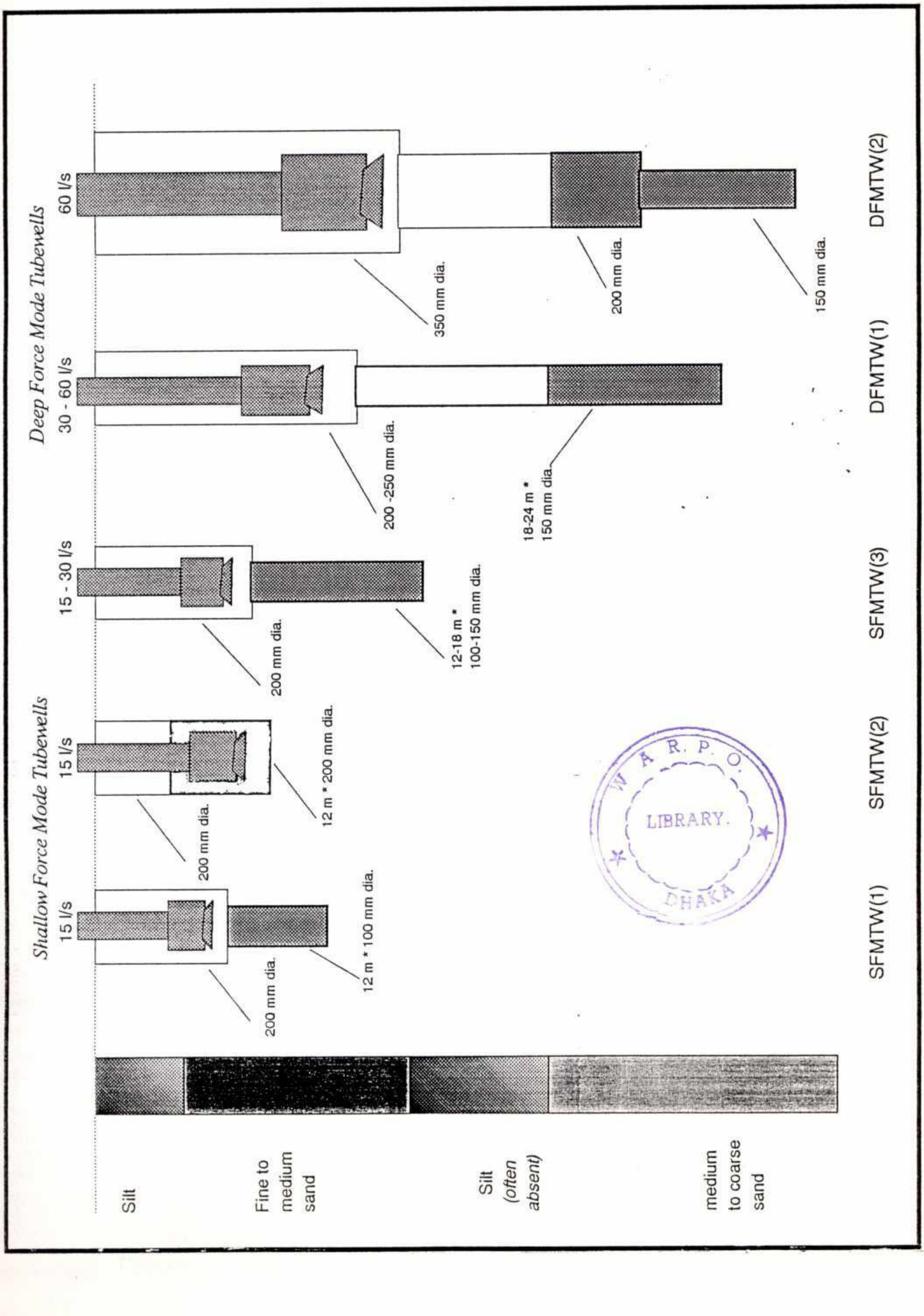

TABLE 2.4

Analysis of Future Groundwater Development by STWs Only

Thana	Total Area Irrigated ha	Cultivable Area Irrigated %	Suction Mode ha	Force Mode ha	Net GW Abstn. mm	% of Constrained Potential Recharge	*Water table at full development* Est. SWL m	Int. Specific Yield	Vol. Released mm
Akhaura	5,753	90%	1,668	567	120	14%		–	–
Kasba	11,914	65%	5,143	2,240	183	28%	5.0	0.028	184
Nabinagar	16,855	60%	7,168	535	120	16%	2.4	0.020	124
Bancharampur	17,492	90%	12,272	230	272	58%	5.1	0.053	272
Homna	13,468	88%	10,136	20	266	46%	5.3	0.046	263
Daudkandi	9,307	90%	4,008	235	166	28%	1.9	0.041	169
Muradnagar(2)	6,055	28%	857	1,385	44	8%	2.0	0.024	44
Debidwar	2,632	40%	1,567	141	111	19%	3.0	0.020	108
Brahmanpara	5,148	56%	2,389	1,808	167	32%	5.5	0.028	164
Burichang	4,519	62%	828	2,840	190	37%	7.2	0.028	188
Comilla	2,483	69%	729	898	179	33%		–	–
Total / Average	**95,625**	**67%**	**46,764**	**10,899**	**165**	**29%**	**4.2**	**0.026**	**138**

TABLE 2.5

Analysis of Future Groundwater Development by STWs and DSSTWs

Thana	Total Area Irrigated ha	Cultivable Area Irrigated %	Suction Mode ha	Force Mode ha	Net GW Abstn. mm	% of Constrained Potential Recharge	*Water table at full development* Est. SWL m	Int. Specific Yield	Vol. Released mm
Akhaura	5,753	90%	1,668	567	–	–		–	–
Kasba	14,947	82%	8,176	2,240	259	39%	6.9	0.031	258
Nabinagar	20,487	73%	10,800	535	177	24%	3.9	0.026	177
Bancharampur	17,492	90%	12,272	230	–	–		–	–
Homna	13,746	90%	10,414	20	273	48%	5.4	0.047	273
Daudkandi	9,307	90%	4,008	235	–	–		–	–
Muradnagar(2)	7,343	34%	2,145	1,385	69	13%	3.0	0.024	68
Debidwar	3,163	48%	2,098	141	146	25%	4.0	0.024	144
Brahmanpara	7,459	81%	4,701	1,808	258	50%	7.6	0.032	254
Burichang	4,794	66%	1,103	2,840	204	39%	7.9	0.028	208
Comilla	2,773	77%	1,019	898	210	38%			53
Total / Average	**107,264**	**75%**	**58,403**	**10,899**	**145**	**25%**	**5.5**	**0.021**	**131**

TABLE 2.6

Analysis of Future Groundwater Development by Suction and Force Mode Wells

Thana	Total Area Irrigated ha	Cultivable Area Irrigated %	Suction Mode ha	Force Mode ha	Net GW Abstn. mm	% of Constrained Potential Recharge	Water table at full development Est. SWL m	Int. Specific Yield	Vol. Released mm
Akhaura	5,753	90%	1,668	567	567	–		–	–
Kasba	16,420	90%	8,176	3,713	295	44%	7.9	0.032	297
Nabinagar	25,349	90%	10,800	5,397	253	34%	5.5	0.032	252
Bancharampur	17,492	90%	12,272	230	230	–			–
Homna	13,746	90%	10,414	20	20	–		–	–
Daudkandi	9,307	90%	4,008	235	235	–		–	–
Muradnagar(2)	19,215	90%	2,145	13,257	301	55%	7.8	0.039	300
Debidwar	5,955	90%	2,098	2,933	328	55%	10.0	0.028	328
Brahmanpara	8,324	90%	4,701	2,673	293	57%	8.3	0.034	293
Burichang	6,514	90%	1,103	4,561	293	56%	9.5	0.032	291
Comilla	3,238	90%	1,019	1,363	261	48%		–	–
Total / Average	**131,314**	**90%**	**58,403**	**34,950**	**280**	**32%**	**8.2**	**0.020**	**160**

The main conclusion of this analysis is that in all thanas **it is possible to irrigate all remaining land from groundwater** without exceeding a maximum of 58% of the groundwater resource. However, this assumes the area with both salinity and gas constraints can be irrigated by shallow force mode tubewells, which are untested in the area. Akhaura, Bancharampur and Daudkandi thanas could be brought under full irrigation with the installation of STWs only. Homna is in a similar position but would require some deep setting. However, at certain locations in these four thanas, force mode wells might be required to overcome gas problems, or might be preferred economically, and therefore should not be excluded. In the other thanas force mode wells will be required for 90% of the cultivable area to be brought under irrigation[3]. The technologies required for full groundwater development in different areas are shown in Figure 2.8.

Implications of Modelling for Resource Potentials

The multi-layer groundwater model (SCTM) demonstrated the probability of a head differential developing between the upper and lower aquifers in Muradnagar and Debidwar. In Muradnagar, drawdown in both aquifers may be moderate but in Debidwar it has been shown that, under the present state of knowledge, it is possible that it may not be practical to fully develop groundwater for irrigation. Careful monitoring of water levels and abstraction in both aquifers through one complete irrigation season and the following recovery period is recommended to resolve this issue.

The analytical and numerical models of salt water upcoming indicate that, provided well depths are kept as shallow as possible, short term (100 days) annual pumping of groundwater from the shallow aquifer poses very little risk of saline contamination. Hence, provided that shallow force mode tubewells (SFMTWs) can successfully overcome the problems of gas discharges, groundwater may be developed for irrigation even in the saline zones. However, some caution is still recommended, and the wells should be promoted on a pilot basis at first, and then monitored annually for any sign of progressively deteriorating water quality.

Impact of Possible of FCD and FCD/I Interventions

Other things being equal, any reduction in the depth and duration of flooding must reduce the maximum quantity of water that might infiltrate into an infinite reservoir beneath the soil zone. However, the available groundwater resource exceeds the probable demand for irrigation and potable supply, and hence a reduction of potential groundwater recharge is not necessarily a negative impact on groundwater irrigation. The highest anticipated use of available groundwater to achieve irrigation on 90% of cultivable land is 58% in Bancharampur. Groundwater hydrographs show the additional recharge that occurs during events such as the 1988 flood is of no practical value to groundwater users in the following dry season. Years with moderate flood depths have similarly little effect on the following dry season. It is probable that reducing the duration of flooding has a greater effect than reducing its depth. It appears from the hydrographs that the aquifer is 'rejecting recharge' for at least two months.

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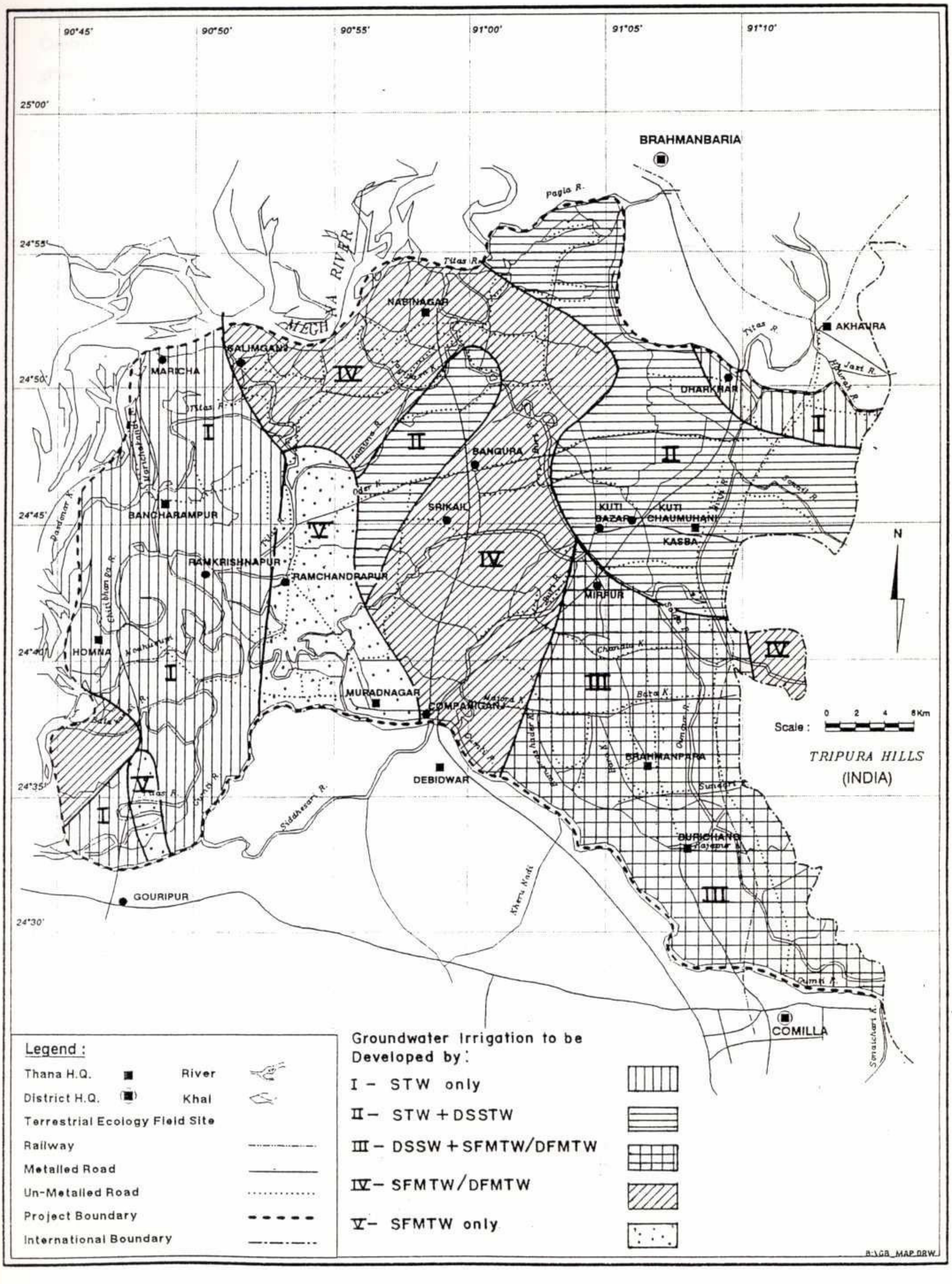
3 Economically and socially it might be better to irrigate less than 90% of the land if the increment of land is small, and it would require replacing fewer shallow tubewells to bring this land under irrigation.

Figure 2.8

Groundwater Development Zones



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The impact of full flood protection on potential recharge and hence usable recharge was investigated under SERS by re-running the MPO Potential Recharge Model with a synthetic flood hydrograph in which flooding is completely removed from all flood phases. This serves as a worst case analysis for the impact of the Flood Control options proposed under the 1990 Study. In Nabinagar, Homna, Daudkandi and Muradnagar the groundwater potential is not reduced at all. The greatest reduction of potential recharge would be in Akhaura, however, this thana already has about 80% of its cultivable area under irrigation, and dominantly from surface water. Therefore no adverse effect is anticipated in Akhaura unless the same flood control and drainage measures also seriously reduce the availability of surface water. For the thanas where a reduction in usable recharge is predicted, Table 2.7 also shows the abstraction that would be required if irrigation were developed to its practical limit using groundwater. With the same proviso, that existing surface irrigation is not reduced, it appears that flood control and drainage schemes do not pose a serious threat to groundwater development for irrigation.

TABLE 2.7

Effect of Full Flood Protection on Usable Recharge

Thana	MPO Groundwater Potential NFP mm	MPO Groundwater Potential FFP mm	Reduction due to Flood Protection	Abstraction Required for Full Development (mm)
Akhaura	738	327	56%	120
Kasba	506	405	20%	295
Nabinagar	288	288	0%	
Bancharampur	*Not assessed under MPO Phase II*			
Homna	507	507	0%	
Daudkandi	364	364	0%	
Muradnagar	425	425	0%	
Debidwar	566	457	19%	328
Brahmanpara	599	506	16%	293
Burichang	482	458	5%	293
Comilla	669	599	10%	261

Source : National Water Plan Phase II, and Southeast Regional Study (1991)

Note : NFP - no flood protection, FFP - full flood protection

Impact of Reduced Surface Water Irrigation on Groundwater Resources

Surface water irrigation is complementary to groundwater development because it provides a source of recharge during the dry season, both increasing the total availability of groundwater and reducing the lowering of the water table (and reducing pumping costs). In the preceding analysis it has been assumed that surface water

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irrigation would at least be maintained at its present level. However, it is understood that a new irrigation scheme will shortly be commissioned in India which will drastically reduce the dry season flows in the Gumti River. This will mainly affect Comilla, Burichang, Brahmanpara, Debidwar and Muradnagar. The magnitude of this reduction is not known, and will presumably be progressive, but there can be little doubt that this will result in reduced LLP irrigation in Zone A and parts of Zone C.

To estimate the impact of this development on minor irrigation the analysis carried out for existing conditions was repeated for reduced existing surface water irrigation. The reduction was simulated by setting to zero all surface water irrigation in all DAE Blocks that border the Gumti River. The results are shown in Tables 2.8 and 2.9. In those parts of Comilla, Burichang and Debidwar which lie in the Gumti Phase II area the effect on existing surface water irrigation would be dramatic, for almost all of the LLP and traditional irrigation lies within a band perhaps 1.0 to 1.5 km wide along the banks of the Gumti River, and in which there is negligible groundwater irrigation. The reverse applies further away from the river.

TABLE 2.8

Impact of Non-Availability of Gumti River Water on the Surface Water Irrigation

Thana	Irrigated Area Lost ha	Reduction in Surface Irrigation
Muradnagar	1519	40%
Debidwar	583	63%
Brahmanpara	200	21%
Burichang	727	85%
Comilla	643	75%

If the present source of irrigation water is lost, farmers will switch to groundwater. As shown in Table 2.9, there is sufficient groundwater to support the increased demand, however, there will be negative impacts on the existing users. Without the beneficial effects of dry season recharge from LLP irrigation, the groundwater potentials for all technologies would be reduced. The estimated drop in static water levels at full development would be increased by about two metres in Parts of Zone A. In Burichang and Comilla, current abstraction would exceed both the STW and DSSTW potentials, requiring widespread conversion of STWs to DSSTWs, and DSSTWs to force mode wells. New wells would mainly use force mode technology.

Impact of Groundwater Irrigation on Drinking Water Supplies

Hand tubewells in Burichang and Comilla already experience problems during the late dry season because of the depth to water, and force mode hand tubewells are required to provide a reliable supply. In other thanas, such problems are likely to be restricted to pockets of very high land. These problems would be exacerbated by any reduction in flows in the Gumti River.

Full development of the STW potential, being itself limited by suction, cannot cause a major deterioration of dry season water supplies, such effects will be restricted to pockets of higher land. With full development of the DSSTW potential, Brahmanpara and Kasba would also require the installation of force mode hand tubewells. If the groundwater resource is developed to its maximum potential using force mode tubewells (only after the suction mode potential is exhausted) there would actually be relatively little additional impact on drinking water supplies. The greatest impact on irrigated area would be in Burichang, Debidwar and Muradnagar. Water levels in Burichang already fall beyond suction limits in the dry season, but more wells would be affected, while in Debidwar and Muradnagar it is likely that the hand tubewells will continue to operate effectively from the shallow aquifer, despite deeper water levels in the main aquifer.

TABLE 2.9

Impact of Non-Availability of Gumti River Water on Groundwater Resources

Thana	Current Groundwater Abstraction mm	*With Irrigation from Gumti River* Constrained Potentials: STW mm	DSSTW mm	*Without Irrigation from Gumti River* STW mm	DSSTW mm	Increased Drop in SWL at Full Development
Muradnagar	44	43	69	40	65	0.7 m
Debidwar	62	111	146	88	123	2.2 m
Brahmanpara	166	165	258	161	254	0.4 m
Burichang	190	122	204	101	183	1.3 m
Comilla	179	170	210	130	170	-

2.3.8 Costs of Groundwater Development

Table 2.10 gives a summary of the expected capital and operating costs of suction and force mode tubewells. The designs quoted are arbitrary selections from what should be seen as a continuum of design options, selected to show some typical examples of the possible range. The force mode designs are basically those shown in Figure 2.7. Many of these designs may be economically sub-optimum, because they are biased towards low capital cost, but most economic studies of tubewell design have shown that parameters such as screen length may be varied greatly with little shift in the net present value of total costs (and yet a large shift in the relative proportion of capital and operating costs. The final option in Table 2.10 (SFMTW 3) will probably not be required, unless it is found that the salinity and shallow gas problems cannot be overcome and it is necessary explore and develop aquifers below the saline zone (as is already being done in Noakhali and Lakshmipur districts).

TABLE 2.10

Indicative Capital and Operating Costs of Possible Tubewell Technologies

Mode	STW	DSSTW	SFMTW(1)	SFMTW(2)	SFMTW(3)	DFMTW(1)	DFMTW(2)	DFMTW(3)
Discharge (l/s)	7	10	15	15	23	30	60	30
Expected Command Area (ha)	3.8	5.4	7.4	7.4	11.1	13.4	23.8	13.4
Pump chamber length (m)	0	0	18	12	18	21	24	27
Screen length (m)	12	12	12	12	18	18	24	18
Expected well depth (m)	30	30	30	24	36	60	70	150
Blank casing (m)	18	18	0	0	0	21	22	105
Cost of pump chamber (Tk/m)	0	0	330	330	340	1250	1608	1250
Well screen diameter (mm)	100	100	100	200	150	150	150	150
Cost of well screen (Tk/m)	240	240	240	1280	656	656	656	656
Cost of blank casing (Tk/m)	230	230	330	330	340	623	623	623
Unit cost of installation (Tk/m)	100	100	300	300	400	500	780	900
Other costs	1,700	1,700	10,000	10,000	12,000	15,000	25,000	15,000
Total cost of installation	3,600	5,600	10,800	9,000	16,800	33,000	59,280	140,400
Cost of well components	8,720	8,720	18,820	29,320	29,928	66,141	93,042	125,973
Cost of engine and pump	26,500	26,500	51,500	51,500	63,000	74,500	200,000	74,500
Total Capital Cost (Tk)	38,820	40,820	81,120	89,820	109,728	173,641	352,322	340,873
Capital Cost per hectare (Tk)	**10,216**	**7,559**	**10,925**	**12,097**	**9,852**	**12,992**	**14,803**	**25,505**
Fuel and Lubricants (Tk/ha/yr)	2,550	2,402	2,300	2,300	2,300	2,300	2,300	2,300
Operator & managers salaries etc.	3,011	4,279	5,884	5,884	8,826	10,591	18,860	10,591
Operating Cost per hectare (Tk	**3,342**	**3,194**	**3,092**	**3,092**	**3,092**	**3,092**	**3,092**	**3,092**

General Conditions:

1. Aquifer permeability 20 m/d
2. Average static water level 4 metres
3 Irrigation requirement 800 mm
4. Assumes diesel power, at Tk 14/l
5. All costs assume private sector construction and opertion.

Notes:

1. For derivation of costs see Appendix C.VII, and MMI (1992, v2.2/4)
2. See Figure 2.7 for typical designs
3. SFMTW – shallow force mode tubewell
4. DFMTW – deep force mode tubewell

Applications

STW – conventional shallow tubewell
DSSTW – conventional deep set shallow tubewell
SMFTW(1) – For shallow aquifers constrained by gas, or a competitor to the STW.
SMFTW(2) – as above, but with shallow salinity.
SMFTW(3) – Higher capacity version of SFMTW(1)
DFMTW(1) – For deeper aquifer conditions
DFMTW(2) – Private sector version of traditional BADC 2 cusec design
DFMTW(3) – For very deep aquifers

Suction and force mode tubewells each have their optimum roles in irrigation (see Annex C). The primary determinant is the depth to water. Under more difficult aquifer conditions, where gas constraints apply or at more advanced stages of irrigation development, there will be a natural transition from suction mode to force mode pumping. An economic comparison of STW and (private sector) DTW irrigation shows that except with very shallow water tables, DTWs are economically preferred when irrigation is examined as an isolated activity. Most of the advantages of STWs lie in their easier financing, smaller group sizes and the possibility of alternative uses for the prime mover. Full details of this analysis are given in Annex C.

2.4 Minor Irrigation

2.4.1 Existing Situation

All existing irrigation within the project area comes under the category of minor irrigation; that is to say that there are no schemes involving major pump stations and/or extensive gravity distribution. The CIDA funded Agriculture Sector Team (AST), in its Census of Lift Irrigation, categorises minor irrigation modes as follows:

- Low Lift Pumps (LLP)
- Deep Tubewells (DTW)
- Shallow Tubewells (STW)
- Deep Set Shallow Tubewells (DSSTW)
- Hand Tubewells (HTW)
- Traditional Methods

A discussion of the development trends of all these modes over the years, based upon AST and other data sources, is presented in Section C.5 of Annex C (Groundwater Investigations), which also include the 1991 irrigated areas by mode according to AST, tabulated by Department of Agricultural Extension (DAE) block. This section therefore concentrates on the spatial distribution of existing irrigation by mode within the project area.

A database of gross (GA) and net cultivable arable (NCA) areas by one minute square is available as part of the land level database discussed in Section I.1.3 of Annex I. The AST data were used to estimate the percentage of the NCA within each block which is presently (1991) irrigated by various modes. Details of results obtained for all modes of irrigation are given in Annex I. Features which become apparent are:

- the relative sparseness of irrigation in the centre of the project area, which the Zone C irrigation proposal seeks to address,
- the concentration of DTW in the east and especially the south-east,
- the concentration of LLP along the major rivers and surprisingly along the Salda River mid-way up the eastern boundary. In the latter case there is probably a severe risk of water shortage as the Salda flow dwindles late in the season.
- the sparsity of STW in the central areas, presumably due to the problems of gaseous aquifers, and
- the significant contribution of traditional methods over most of the area.

2.4.2 Irrigation Water Requirements

Irrigation water requirements have been assessed in accordance with the methodologies developed for the CROPWAT computer programme (Manual and Guidelines for CROPWAT, FAO, Rome 1991). The basic assumptions made are as follows:

(i) Irrigated boro dominates all other crops, and the water requirements have therefore been calculated for this crop alone. The crop growth stages, their lengths (rounded to whole decade periods) and the values of the crop coefficients associated with each are derived from the Deep Tubewell II Project Final Report (Supporting Volume 2.1 - Natural Resources, Mott MacDonald/ODA, 1992).

(ii) Reference evapotranspiration values have been taken for Comilla, since this is the nearest climatic station collecting sufficient data for application of the modified Penman formula.

(iii) Since the irrigation water requirements are being calculated primarily for the Zone C irrigation proposal, the rainfall station used for the calculations is Muradnagar, with records available since 1968.

A range of options is available for converting the result to effective rainfall. For the present analysis the CROPWAT Option 1 has been taken, with 80% being assumed effective, falling to 70% for monthly rainfall values in excess of 100 mm.

(iv) Deep percolation rates estimated from DTW operating records are given as 5 mm/day for Comilla and 3 mm/day for Brahmanbaria in the Deep Tubewell II Project Final Report quoted above. A figure of 4.5 mm/day has been adopted for the present study.

(v) An overall transmission efficiency of 70% has been adopted in determining the water duty for the primary pump station. This is a fairly high figure because existing khals are used as the main distribution channels, and water levels will be well below ground level. Furthermore, a substantial degree of re-use is anticipated, since any surplus runoff will find its way back into the distribution system.

The peak water duty for 18 hours per day pumping at the primary pump station was found to be nearly 2.3 l/s/ha, in the first decade of February.

2.4.3 Typical Command Areas

Assumed irrigation command areas for the various types of irrigation equipment at present in use are given in Table 2.11. Additional details including the capital and operating costs associated with the pumping and distribution systems are presented in Annex J (Financial and Economic Analysis). Annex C (Groundwater Investigations) also gives details of several modified groundwater technologies, using small force mode pumps to overcome the problems of gas and underlying salinity in shallow aquifers. Cheaper versions of the existing DTW, including one having a 1 cusec (28 l/s) capacity are also proposed.

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TABLE 2.11

Capacities and Command Areas of Pumping Equipment

Description	Capacity (l/s)	Command Area (ha)
Low Lift Pump (LLP 1)	20	10.0
Low Lift Pump (LLP 2)	56	20.0
Shallow Tubewell (STW)	7	3.8
Deep Set Shallow Tubewell (DSSTW)	10	5.4
Deep Tubewell (DTW)	60	23.8

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, shown in Figure 9.1, 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 384 farmers, with more detailed case studies of 51 of these farmers.
2. A survey of 240 fields in the four 2 km square topo/hydrological survey areas (60 fields x 4 squares).
3. A questionnaire survey of 96 fish pond operators.
4. A questionnaire survey of 160 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 4 sample squares.

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 topography in the Gumti Phase II Sub-Project area has irregular micro reliefs on the different physiographic condition. The physiographic condition is broadly divided into floodplains, piedmont plains, hills and terraces. Floodplains cover most of the area and include ridges and inter-ridge depressions along the Meghna and smoothed-out plains of very low relief, with low broad ridges and extensive shallow basins in the central part of the area. The remaining minor area is situated on the piedmont plains, hills and terraces along the eastern edge of the area to the Tripura Hills.

Soils are mostly fine to medium texture of Silty Clay, Silty Clay Loam and Silty Loam, except for coarse textured soils existing in a limited area along the Meghna. There are 42 soil associations situated in the area according to the 1990 report. The principal determinants of agricultural development are the flooding regime and availability of irrigation, rather than any intrinsic soil properties. Most of the area falls primarily into land capability classes II and III. The east falls into class II and the west into classes III and IV. A small area of class I land occurs in the centre. According to the crop suitability classification of the 1990 report, most of the soil associations are rated as suitable for crops under the condition of flood control and drainage improvement.

3.2.2 Soils

Existing Soil Conditions

The available soil information for the Gumti Phase II study area includes the SRDI data collected as part of a systematic programme for the whole country during the 1960's and 1970's. Since then work has been carried out for the previous 1990 Report Gumti Phase II Study, which used the SRDI work along with additional field data collection. Also available is the Land Resources Appraisal of Bangladesh for Agricultural Development carried out by FAO and published in 1988. This produced agro-ecological mapping of the country which has been used to produce a map of these zones for the study area and is shown in Figure 3.1. All this data would seem to suggest that seasonal flooding, the lack of irrigation facilities and low dry season rainfall are the main constraints holding back more intensive land use and optimum crop production, rather than those of problematic soil quality. The conclusion is that some 78% of the study area is rated as good to moderate agricultural land and crop production could be intensified from this. Soil type mapping is summarized in Figure 3.2 and derived land capability in Figure 3.3.

The SRDI data collection programme included surface soil chemistry information, mapped and published by thana. Unfortunately only one very small part of the study area, in the very untypical extreme south west, is covered by the presently published work and the study was unable to obtain access to the unpublished data. It is important for any future studies that this work is made available, so its usefulness in providing baseline information for monitoring can be assessed and wasteful duplication of data collection avoided.

Whilst no major soil constraints to agricultural use were observed in the existing SRDI and BWDB soils survey data, it was noted that, after centuries of cultivation, the natural fertility of most of the land seems to be rather moderate. It would thus seem that soil management is the key issue if medium and long term problems of soil degradation are to be avoided. The balanced use of suitable fertilizers on almost all the soils would appear to be a requirement in order to maintain high yields, particularly from new varieties. This is part of the complex interlinked chain by which the traditional availability and use of organic fertilizer is changing as animal dung is diverted for use as domestic fuel due to wood becoming scarcer. This is compounded by the increasing difficulties in keeping livestock, as common access grazing land reduces due to agricultural intensification. Fodder availability for stall fed animals also declines as it competes with use as a domestic fuel and building material source and less is produced from nutritionally poorer short stalk HYV crops. This indicates that there is scope for the increased use of chemical fertilizers. However, care needs to be taken to ensure that this does not cause water quality problems due to high nitrate levels in enclosed drainage areas producing algal blooms, some of which could be toxic. There is also the risk of nitrate pollution in groundwater which is discussed in Section 2.3.3 and Annex C.

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Figure 3.1

Agroecological Regions in Project Area

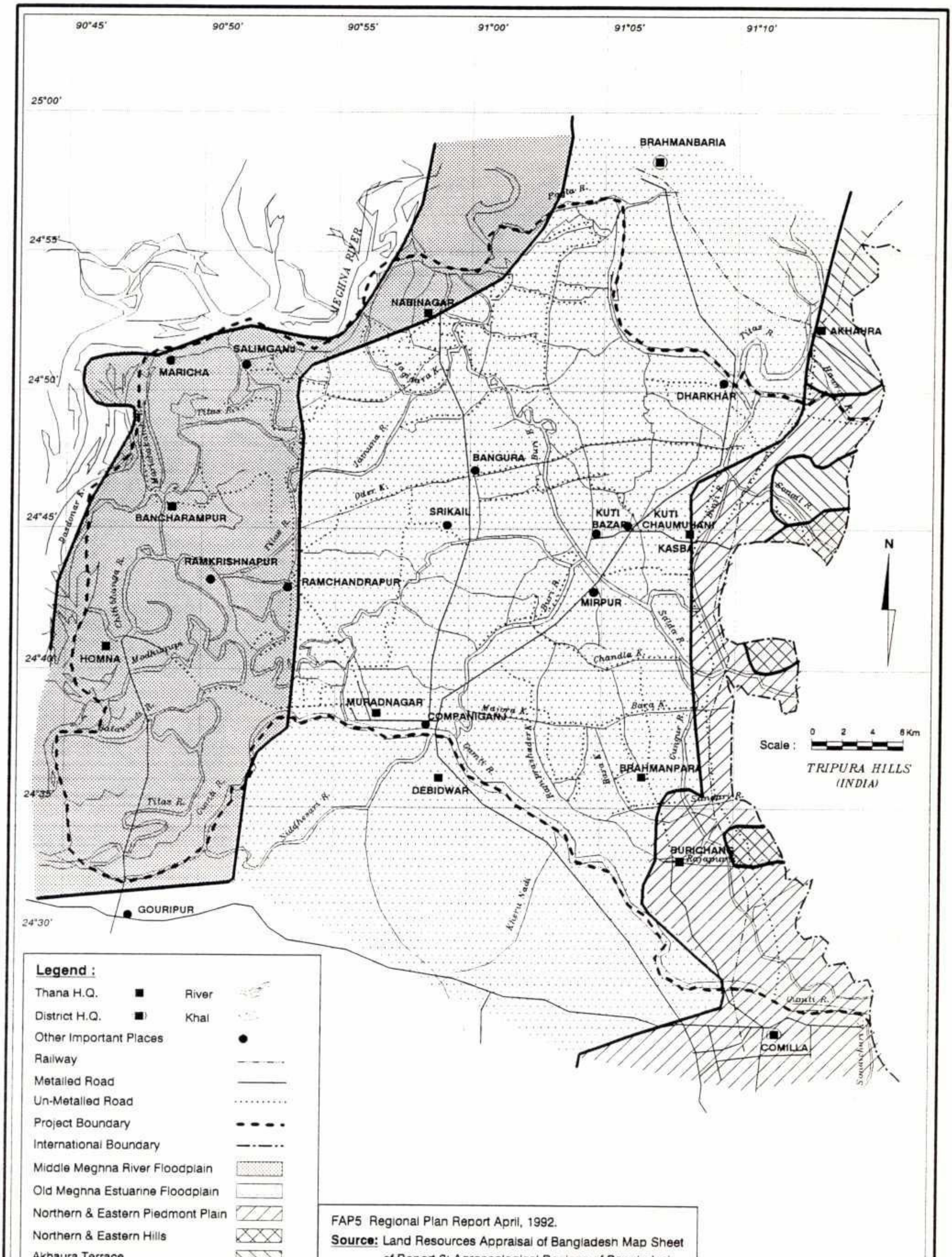


Figure 3.2
Soil Types

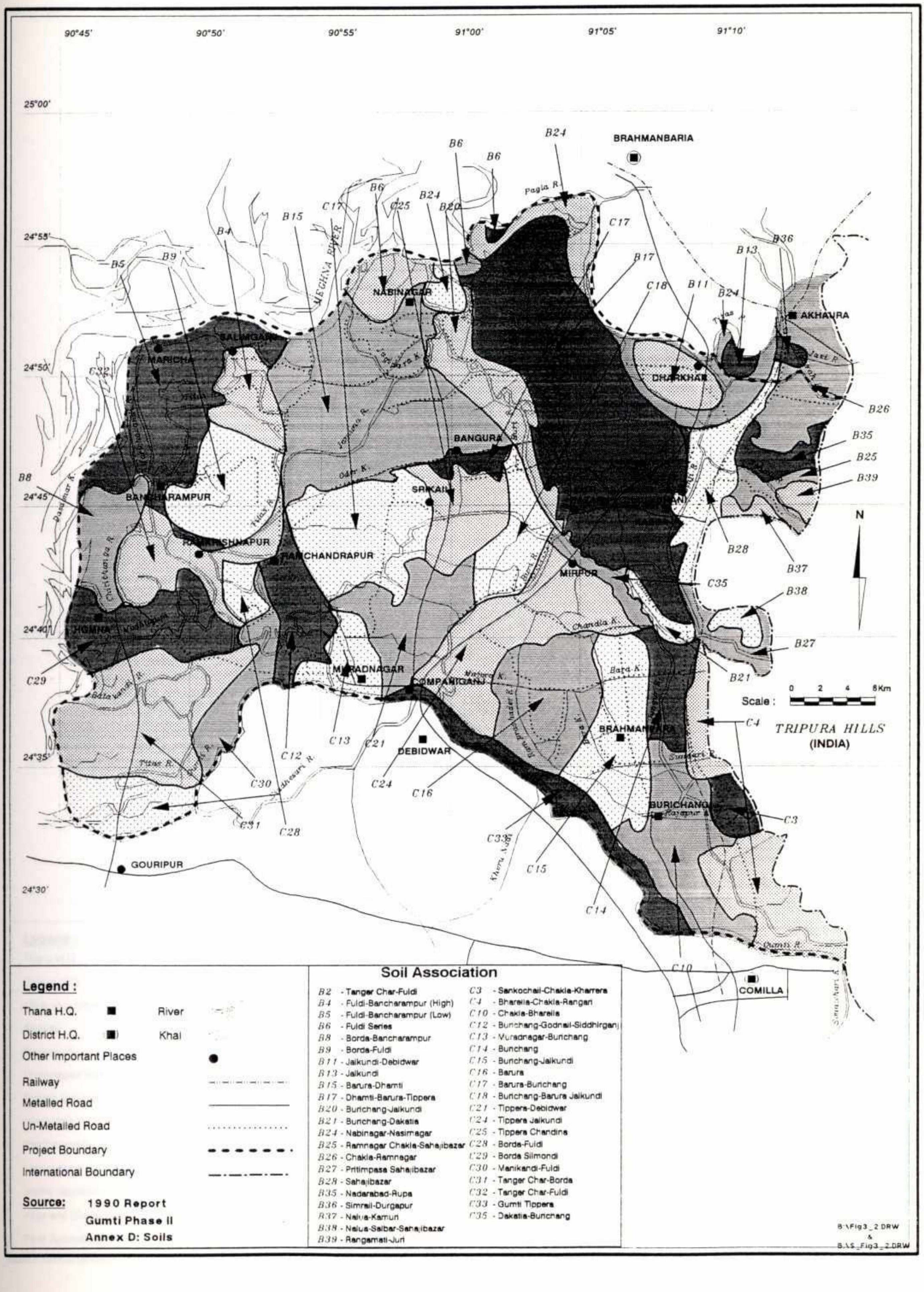
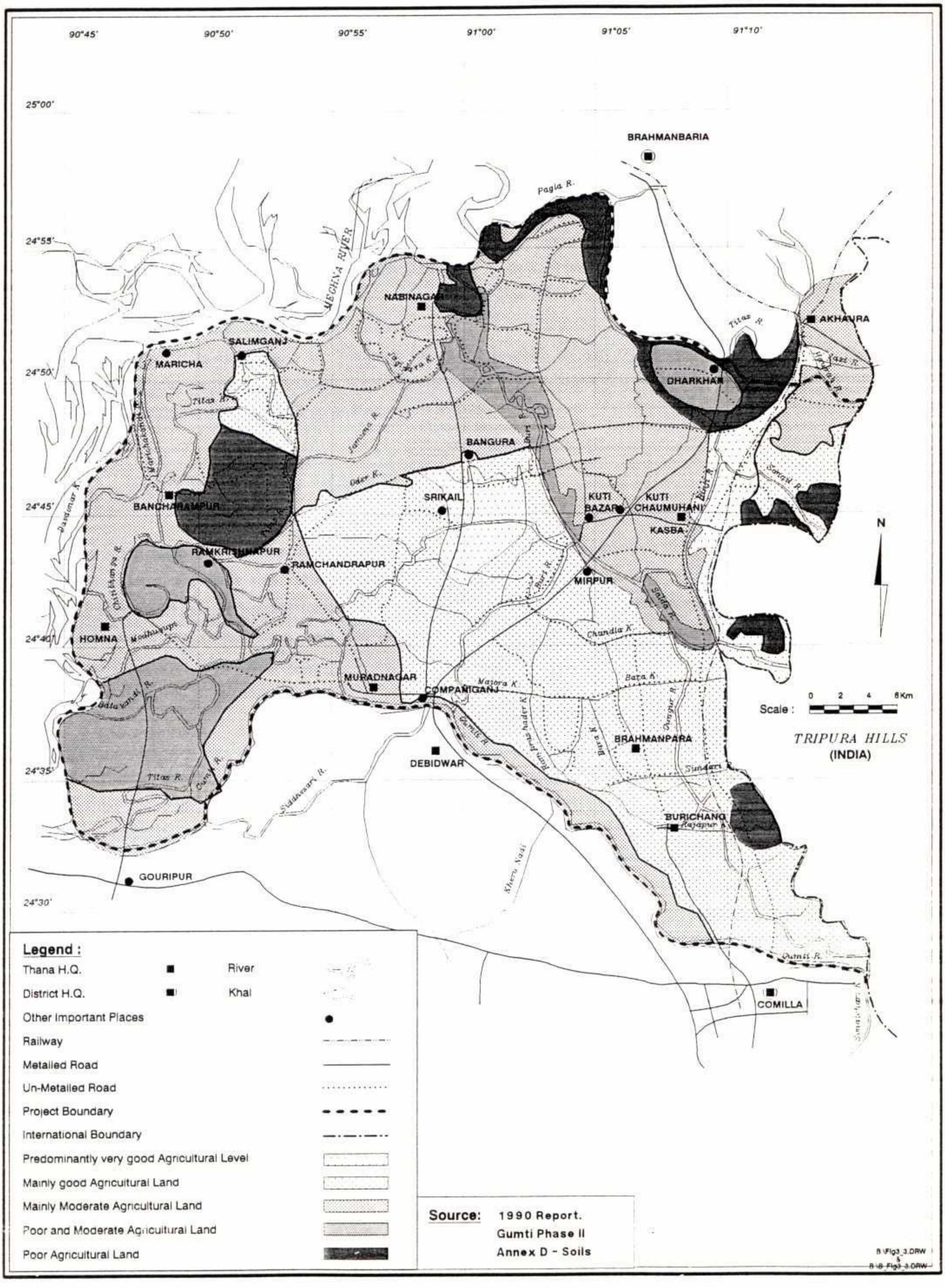


Figure 3.3
Land Capability



Source: 1990 Report.
Gumti Phase II
Annex D - Soils

B:\Fig3_3.DRW

After fertilizer application, irrigation would seem to be the most economic method of increasing overall crop production. By adopting irrigation, most of the land could be made to produce good dry-land or rice crops in the dry season. With controlled flooding, wetland monsoon crops such as aus and jute could be sown earlier and yields of transplanted aman would be more certain on some lands. Overall, the soils would benefit if agricultural production in most of the land included a greater diversity of crops than at present.

The main constraint to the expansion of irrigated agriculture appears to be the availability of water rather than soil conditions and there has recently been a significant up-take of groundwater irrigation, particularly in the south east of the study area. However the chemical composition of irrigation water is important, as it may have significant impacts on the future development of soil chemistry and structure. This is particularly the case where soils that were previously dry in the dry season are to be kept wet using irrigation and conversely those which were previously waterlogged in the wet season and will in future be drained. There are also soil fertility depletion risks linked to the continuous mono-cropping of rice that the availability of irrigation water will permit. These issues are likely to constitute the major impacts on soil resources of any water and land management intervention in the area. They are mentioned briefly below and are dealt with in more detail in Section 12 of this volume as well as in Annexes E and H.

Likely Soil Fertility Issues

In the south eastern part of the study area, groundwater abstraction for irrigation is already extensive. In the western part of the study area sufficient surface water exists in the Meghna River system to irrigate the area using deepened khals for gravity distribution. Gravity fed surface irrigation is not presently technically possible in the central part of the study area and in addition there are salinity and gas constraints to groundwater abstraction there. Alternative sources and/or technologies would be needed to overcome these problems and they are proposed in the interventions.

Saline groundwater has been encountered locally in the south west corner and southern central part of the study area. Further details are given in Annex C on Groundwater Investigations, which has considered the possibility of saline upcoming in relation to geological conditions. This work would seem to indicate that groundwater quality needs to be monitored to check whether its increased use for irrigation in these or adjoining areas will cause problems with soil chemistry and also result in saline water being drawn into aquifers that are presently non-saline.

In considering large scale flood control and drainage schemes it should be noted that, particularly in the western part of the study area where the soils are more silty, there is low infiltration and slow permeability. This results in the development of plough pan formations and low aeration conditions when soils are wet. Such soils have a high capillary potential which keeps them moist for most, if not all, of the dry season except in slightly higher areas where soils are puddled for transplanted aman cultivation. For this reason drainage is considered a higher priority than irrigation for dry land Rabi crop cultivation, with irrigation only being necessary for boro paddy cultivation in these areas.

Another implication of any intervention is the possible change in siltation patterns that may occur and how these effect soil quality and use. Evidence from other recent studies (FAP 16 Soil Fertility Study, unpublished preliminary results) indicates that silt in the south east part of the country is not particularly high in nutrients and in terms of water and land management is a serious dis-benefit, as it clogs drainage and smothers cultivable land. As it has also been noted that surface water is low in minerals and nutrients, it has been suggested that the intensity of biological processes is the major reason for the land being able to sustain such high levels of use. Any interventions which directly or indirectly effect the efficiency of these processes are thus likely to cause changes in the ability of the soil to sustain agriculture.

The links between organic fertilizer, fuelwood, fodder and crop residuals and grazing land availability along with demand for the use of chemical fertilizers have already been explained above. In addition, agricultural intensification can result in increased use of agro-chemicals, particularly herbicides and pesticides, as HYV's are far more responsive to their use than traditional varieties. The use of these can also cause surface water quality problems and have implications for soil chemistry. However whilst there is some evidence of DDT residuals in enclosed basin areas in the Noakhali area the one sample taken in the Gumti Phase II area showed no signs of this. This is explained further in the water quality Section 6.3.

Irrespective of any planned water development intervention, there is considerable scope for improving existing rain-fed agriculture, particularly by using appropriate and environmentally sound soil and land management practices. These include the expansion and intensification of cultivation of a wide range of Rabi crops on loamy ridge soils, especially wheat, chili, potato, groundnut, mustard, pulses and other vegetables. These will have benefits to soil chemistry as well as providing greater diversity to human nutrition. Other steps include the increased and more efficient use of fertilizers and organic matter along with construction of field drains or raised beds on basin margin soils so that dry land rabi crops can be planted on time.

There is a requirement to establish a regular soil fertility monitoring system as an essential component of agriculturally based programmes and projects, particularly those that encourage irrigation. Such a monitoring programme could be best carried out as part of an agricultural extension service proposed for the area, linked with a monitoring and evaluation unit for any proposed project.

Any monitoring system must be constantly on alert to recognize and identify symptoms of declining soil productivity, ecological hazards and changes in soil physical and chemical properties. To be useful, these need to be recognised in time to enable practical solutions to be implemented to tackle the identified decline. Recommendations as to the necessary changes in land management practices that may be required to forestall soil quality decline will need to be directed at policy planners as well as to farmers. An appropriate institutional structure is required that is able to deal with these issues and is perhaps best tackled as part of a multi-disciplinary planning, management and monitoring facility that requires to be set up by the implementing agency of any proposed project.

3.3 Current Land Use

The Gumti Phase II Sub-Project area covers approximately 141,000 ha in gross, extending over 4 thanas in Brahmanbaria District and 7 thanas in Comilla. The gross area includes 16% of non-cultivable land consisting of perennial water bodies, infrastructure and settlement area. The net cultivable area (NCA) is estimated at about 118,000 ha which corresponds to 84% of the gross area. Table 3.1 shows distribution of the area by planning Zones A, B, C and D.

TABLE 3.1

Gross Area and NCA by Planning Zones

(Unit: ha)

Item	Planning Zone								Total	
	A		B		C		D			
Gross Area	32000	(23%)	26800	(19%)	41400	(29%)	40700	(29%)	140900	(100%)
NCA	24500	(21%)	22400	(19%)	35000	(30%)	36100	(31%)	118000	(100%)
Ratio to Gross		77%		84%		85%		89%		84%

In terms of the flood phase, 14% of the area is Highland:F0 (flood depth of 0 to 30 cm), 23% Medium highland:F1 (30 to 90 cm), and 63% medium lowland and lowland:F2&F3 (over 90 cm). Floods are caused by the flash flood from the eastern Tripura Hills in the pre-monsoon season and the monsoon flood due to poor drainage and spillage from the Meghna and its tributaries. The planning zones show the different flooding and inundation conditions according to the flood phase characteristics.

In Zone A, which is located in south-eastern section of the project area, more than 81% of NCA is F0 and F1, and F2&F3 land occupies only 19% of NCA. Zone A is affected by flash flooding from the eastern Tripura Hills in the pre-monsoon season and the monsoon flood with longer duration due to poor drainage of rainfall. Zone B extends in the north-eastern portion of the area, and almost half of the land is situated in F2&F3 (56%). Zone B is also affected by flash flooding from the Tripura Hills, however, flood caused by poor drainage is related to the water level of the Meghna. In Zone C, which occupies the central part of the project area, 74% of the area is over 90 cm of flood depth (F2&F3). This zone is subjected to flooding during the monsoon. Zone D is located in the western part of the area and 87% of the land is situation in F2&F3. This zone is mainly affected by the monsoon flooding. Area by flood phase in the planning zones is summarized in Table 3.2.

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TABLE 3.2

Net Cultivable Area by Flood Phase in Planning Zones

(Unit: ha)

Flood Phase	Planning Zone A		B		C		D		Total	
Highland F0 < 30 cm	9300	(38%)	4500	(20%)	1700	(5%)	1100	(3%)	16600	(14%)
Medium Highland F1 30 to 90 cm	10500	(43%)	5400	(24%)	7400	(21%)	3600	(10%)	26900	(23%)
Medium Lowland and Lowland F2 & F3 > 90 cm	4700	(19%)	12500	(56%)	25900	(74%)	31400	(87%)	74500	(63%)
Total	24500	(100%)	22400	(100%)	35000	(100%)	36100	(31%)	118000	(100%)

Source: Estimation by Farmers Survey and AST data

Irrigation conditions have been changing every year depending on the rainfall and flooding as well as distribution of equipment. It is considered that irrigation coverage has expanded recently through development of STWs, DTWs and LLPs. Irrigation conditions of the area are estimated using data obtained through farm survey and AST data. Irrigation water is applied mainly for boro crops, although supplemental irrigation was made for rabi, aus and aman crops. Application of irrigation is high, approximately 63,000 ha or 53% of the total NCA. Irrigation conditions vary depending on the planning zones and flood phases. Zones A, B and D are irrigated to more than 50%, however, Zone C is presently irrigated to about 40%. Irrigation condition by flood phase generally indicates that the irrigation rate is higher on lower land levels.

Zones A and B have different characteristics from Zones C and D in irrigation conditions by flood phase. Medium highland and medium lowland in Zones A and B is irrigated to a maximum of 70% and even Highland is about 50% under irrigation. This may be because the irrigation water source in Zones A and B includes both groundwater and surface water. On the other hand, highland in Zones C and D are cultivated under rainfed conditions, and medium highland and medium lowland have a low coverage of irrigation. Irrigation sources in Zones C and D mainly include surface water, using LLPs. Irrigated area by planning zone and flood phase is shown in Annex E and is summarized in Table 3.3.

The Crop Diversification Programme (CDP) is active in the Comilla region. The programme is attempting to promote crop diversification by the use of research trials and demonstration plots. At present, CDP has set up demonstration plots for soya, potato, sunflower and mustard near Comilla. Although these crops have been considered, they are unlikely to have a particularly significant impact on the project, when compared to rice.

TABLE 3.3

Irrigated Area by Planning Zones

(Unit: ha)

Condition	Planning Zone								Total	
	A		B		C		D			
Irrigated	15200	(62%)	15200	(68%)	14100	(40%)	18200	(50%)	62700	(53%)
Rainfed	9300	(38%)	7200	(32%)	20900	(60%)	17900	(50%)	55300	(47%)
Total	24500	(100%)	22400	(100%)	35000	(100%)	36100	(100%)	118000	(100%)
Mode of Irrigation										
LLP		14		13		22		31		
STW		17		27		6		11		14
DTW		27		22		6		4		13
Traditional		4		6		6		4		5
		—		—		—		—		—
		62		68		40		50		53

Source: Estimation by Farmers Survey and AST data

Irrigation by Flood Phase

(Unit: ha)

Condition	Planning Zone						Total	
	Highland		Medium Lowland		Lowland			
Irrigated	6700	(41%)	13400	(50%)	42500	(57%)	63700	(53%)
Rainfed	9800	(59%)	13500	(50%)	32000	(43%)	55300	(47%)
Total	16500	(100%)	26900	(100%)	74500	(100%)	118000	(100%)

Source: Estimation by Farmers Survey and AST data

Ownership of irrigation equipment is positively related to farm size but access to irrigation is generally evenly spread between farm sizes.

3.4 Farm Size Fragmentation and Land Tenure

Farm sizes have been classified as follows :

Category	Farm Size (ha)
Marginal	0.02 to 0.2
Small	0.21 to 1.0
Medium	1.01 to 3.0
Large	3.01 +

The study area is dominated by small farmers. According to the farmer survey, nearly 80 per cent of farmers fall within the small or marginal categories, yet between them own only 40% of the land.

		Area owned (%)				Overall %	
Category	**Zones**	**A**	**B**	**C**	**D**	**Area**	**Number**
Marginal		5.3	8.1	4.3	5.7	6.2	25.2
Small		44.2	32.6	34.5	34.4	33.8	53.2
Medium		35.5	36.6	39.1	32.6	38.1	17.6
Large		15.0	22.7	22.1	29.3	21.9	4.0

Overall, the pattern of land ownership has not changed significantly since the 1983/84 Agricultural Census.

	Small farms 0.02 - 1.00 ha		Medium farms 1.01 - 3.0 ha		Large farms 3.01 ha +	
District	**number**	**area**	**number**	**area**	**number**	**area**
Comilla	84.5%	54.3%	14.5%	38.4%	0.9%	7.3%
Brahmanbaria	80.5%	46.0%	17.7%	41.6%	1.8%	12.3%

The survey records average farm size as 0.8 ha which compares with 0.91 ha for the whole country. If the landless are added, the comparison between the survey data and the agricultural census is as follows:

	Gumti Survey	Census
Landless	30.2%	11.5%
Marginal	17.4%	31.5%
Small	36.5%	44.6%
Medium	12.7%	11.5%
Large	3.1%	0.9%

In general, the two sets of data are remarkably similar. The major difference is the division between landless and marginal, where the survey suggests there are more landless households than marginal farmers. While it is possible that many people with very small plots of land have been forced to sell in recent years, it is also possible that errors were made in reporting people as landless when in fact they have small plots of land, but are not known in the village as farmers, primarily earning a living in some other occupation.

Table 3.4 shows land tenure arrangements on the 384 holdings covered in the farmer survey. Results have been weighted to take account of farm size distribution in the tax list analysis. Compared with the census data, rather fewer farms rent in land in the project area (22% against 37%) and the overall amount of land rented in is quite small, although sample farms rented out form quite a substantial area. Larger areas are rented out than are rented in, obviously to more to than one client.

Small farmers account for 76% of all rented in land with medium (sized) farmers accounting for ready all the remainder. Rented out land is more evenly spread between all farm sizes.

Arrangements for renting land are nearly always based on sharecropping whereby the owner receives 50% of the yield and contributes nothing to the cost of cultivation. Within the group of small farmers who rent land, the area contracted constitutes about half of the area farmed by these farmers.

TABLE 3.4

Farm Size and Land Tenure - Results of Farmer Survey
Gumti Phase II Area

	farm size (cultivated land) - ha				
	marginal 0.02-0.2 ha	small 0.21 - 1.0 ha	medium 1.01 - 3.0 ha	large over 3.0 ha	All farms
Proportion of all farms	25.0%	52.3%	18.3%	4.4%	100.0%
Proportion of farms in class that: own land	100.0%	100.0%	100.0%	100.0%	100.0%
rent out land	9.1%	24.2%	65.8%	45.1%	28.9%
rent in land	7.6%	31.8%	18.5%	0.0%	21.9%
Average area for all farms: land owned	0.19	0.69	2.29	4.87	1.04
not cultivable	0.04	0.08	0.22	0.29	0.10
cultivable owned	0.15	0.61	2.07	4.57	0.94
land rented out	0.02	0.14	0.51	0.43	0.19
land rented in	0.01	0.08	0.07	0.00	0.06
net area cultivated	0.14	0.55	1.63	4.14	0.80
Average for farms that rent land					
- land rented out	0.22	0.57	0.79	0.92	0.54
- land rented in	0.08	0.26	0.33	0.00	0.21
Proportion of land					
owned	4.5%	34.6%	40.2%	20.6%	100.0%
not cultivated	9.4%	39.4%	38.7%	12.5%	100.0%
rented out	2.3%	38.4%	49.2%	10.1%	100.0%
rented in	2.5%	75.6%	21.9%	0.0%	100.0%
cultivated	4.3%	35.9%	37.1%	22.7%	100.0%

Fragmentation of land holdings observed is 6.4 fragments per hectare which is slightly higher than the national average. The dispersion of land holdings across different flood phases is rather low, and nearly one half of farmers own land on only one flood phase and most of the remainder on two. Dispersion of land across flood phases is, as might be expected, positively related to farm size.

Farm size	% of farmers with plots on number of flood phases			
	1	2	3	4
Marginal	80	19	1	0
Small	44	46	10	0
Medium	19	60	18	3
Large	14	58	23	5

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. They are presented in schematic form in Figure 3.4. Comparison with DAE and BBS cropping patterns revealed some discrepancies between the three sources of data, although in two out of four zones there was a better fit between the survey results and DAE data than there was between DAE and BBS data. A more serious discrepancy occurred with estimated access to irrigation between the survey and the Agricultural Sector Team's (AST) 1991 assessment of irrigation areas.

Compared with the AST data, the survey consistently overestimated the amount of irrigation and as it is not known whether the survey or AST is correct, a midway point between the two was adopted, and cropping patterns altered accordingly (by reducing areas of boro). Future cropping patterns reflect increases in irrigation which are expected to occur whether or not the project is implemented. There are no technical restrictions on the use of groundwater in the study area and in most places it is assumed that irrigation will be developed over 75 per cent of the NCA (except in Zone D where it is restricted to 60 per cent by some very low lying and poorly drained land). Thus "future without" cropping patterns were derived from an expected increase in boro cultivation over the present situation. In general this tends to reduce cropping intensities as boro conflicts with both rabi and early sown aus and aman crops. As no changes in flooding regimes are anticipated, areas of transplanted HYV and LV aman remain unchanged.

"Future with" cropping patterns are derived on the basis of increased irrigation (as for Future Without) and from changes in the flooding regime which permit increased areas of T aman to be cultivated. They are presented in schematic form in Figure 3.5. The extent to which an increase in T aman reduces areas of broadcast, transplanted or mixed aus and aman crops depends on the intensities currently achieved. Areas of T aman which can be safely grown in a 1 in 5 wet year have been calculated by comparing water levels produced by the hydro dynamic model which are converted into flooding depths with the land level database. FPCO guidelines (as yet unpublished) on submergence tolerance of rice crops and calculated maximum cropped areas were used accordingly. Overall, the model predicts present conditions sufficiently well to justify its use in predicting future areas, although in those zones where it proved less reliable only 80% of its predictions were incorporated.

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Figure 3.4

Schematic Cropping Pattern under Present Condition

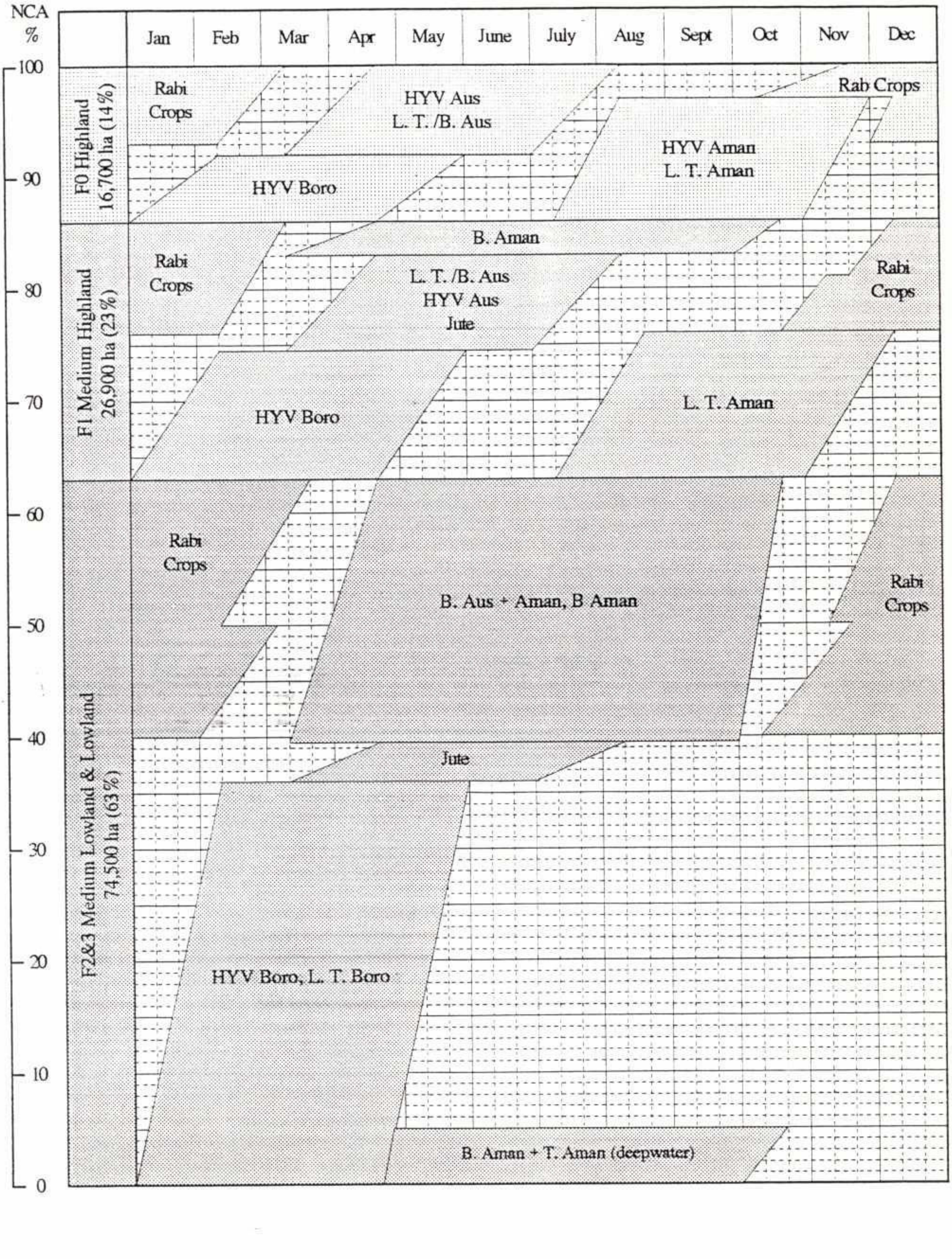

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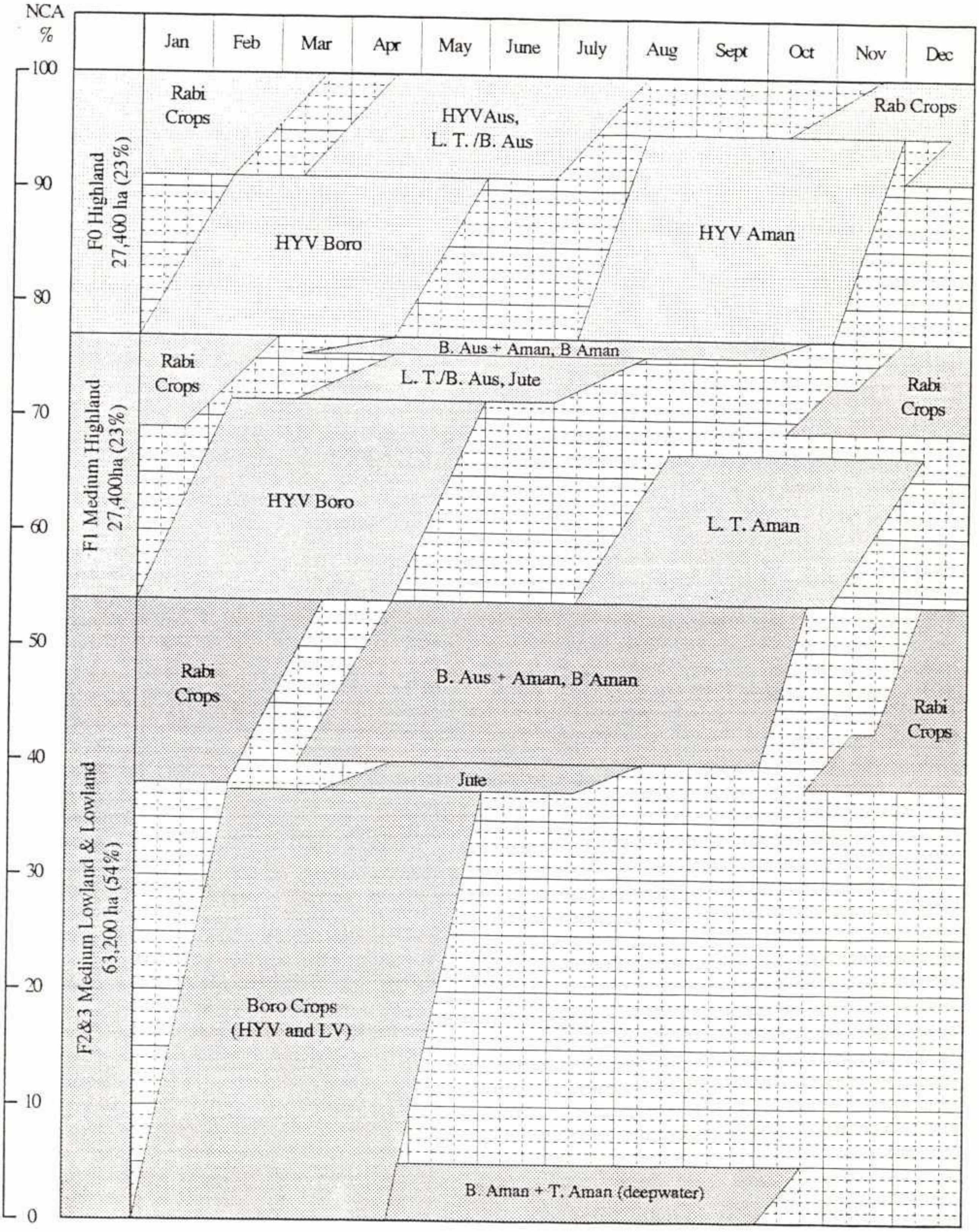
Figure 3.5

Schematic Cropping Pattern under Future With Project Condition



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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.

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 move productive types of paddy when hydrological conditions change sufficiently to permit this". Yield assumptions adopted in this study are presented in Table 3.5.

TABLE 3.5

Crop Yields Used in Economic Models

Gumti II

	Farmer Survey	DAE	BBS	Used in Budgets
B Aus, local	2.30	1.87	1.43	2.00
B Aus, HYV	2.95		1.53	2.50
T Aus, local	2.51		2.81	2.50
T Aus, HYV irri				3.6
T Aus, HYV n-ir	3.58	3.27	2.69	3.20
Mixed aus/aman	3.13			2.30
B Aman local dw	1.80	1.73	2.19	1.88
T Aman local dw	2.62			2.40
T Aman, local	2.70	2.25	2.48	2.60
T Aman HYV irr				3.85
T Aman HYV n-ir	3.79	3.83	3.02	3.65
Boro, local	3.71	2.65	2.34	3.00
Boro, HYV irrig	5.60	4.79	4.19	5.40
Wheat irrig.	2.30	1.70	1.65	2.25
Wheat unirrig.	1.99			1.80
Potato irrig.	11.86	15.07	12.61	15.00
Potato unirrig.	11.42	6.63	7.65	10.00
Jute	1.94	1.61	1.72	1.90
Pulses: keshari	0.89		0.66	0.70
mung				0.60
masur	0.45		0.61	0.50
mash	0.72			0.70
Mustard	0.75	0.90	0.84	0.75
Sugarcane	38.41			38.41
Spices (chilli)	2.6*		2.7*	4.00
Veg. (brinjal)	10.59		7.19	8.00

* assumed dry weight

Production figures based on these yields and the cropping patterns discussed in 3.5 are presented in Section 15 (Economics).

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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 3.6.

TABLE 3.6

Physical Input Quantities and Production per Hectare

Crop	Labour days	Draft Animals pair day	Seed (kg)	Fertilizer (kg)			Animal manure (kg)	Pesticide (kg)	Production (t/ha)	
				Urea	**TSP**	**MP**			**Main Crop**	**By-product**
B Aus. local	142	45	85	100	50	0	1000	0.25	2.00	4.00
B Aus. HYV	145	45	85	100	50	0	1000	0.25	2.50	2.50
T Aus. local	154	47	30	80	40	0	1000	0.25	2.40	4.80
T Aus. HYV irri	181	47	30	140	110	35	1000	0.50	3.60	3.60
T Aus. HYV n-ir	177	47	30	140	110	35	1000	0.50	3.20	3.20
Mixed aus/aman	165	44	83	80	40	0	0	0.13	2.30	2.30
B Aman local dw	111	44	83	50	0	0	0	0.13	1.88	1.88
T Aman local dw	134	40	44	90	25	0	0	0.13	2.40	2.40
T Aman. local	146	40	44	100	50	20	0	0.25	2.60	5.20
T Aman HYV irri	171	43	30	133	95	38	700	1.16	3.85	3.85
T Aman HYV n-ir	167	43	30	133	95	38	700	1.16	3.65	3.65
Boro. local	120	25	40	128	0	0	0	0.00	3.00	6.00
Boro. HYV irrig	214	45	30	193	160	45	1000	1.00	5.40	5.40
Boro HYV p-irr.	160	45	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
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	0.64	0.64
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 fertilizer 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. Fertilizer 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

Delays in farming operations caused by lack of labour were registered by 22% of marginal farmers, 40% of small farmers 66% of medium farmers and 55% of large farmers in the farm survey. Nevertheless most of the work on smaller farms is done by the farmer and his family.

Women do most of the post harvest work, especially grain drying and cleaning but almost all now use a machine for milling par-boiled paddy. About 80% of farmers hire some labour. A surprisingly high proportion of farms (20% of the case studies) hire women as well as men although women are paid considerably less than men. Should the trend towards hiring women continue, it is likely that much of the delay currently reported would disappear.

3.8.3 Draught Power

Some form of draught power, either animal or mechanical, is almost always used for land preparation. Animal power is also used for threshing (as are machines), weed control and transport.

The survey in Gumti showed that 58% of farmers owned their own animals. Ownership of animals is strongly related to farm size with relatively few smaller farmers owning their own animals. Some 11% of farmers use power tillers (2 wheel tractors with rotary cultivators) which can cover at least six times more land per day than a pair of animals for at least part of their land preparation requirements. About 52% of farmers claim that shortages in draught power cause delays, usually resulting in late planting and consequent yield reductions rather than reduced crop areas. Boro is the principal crop effected by these shortages, although B aman is also delayed.

3.8.4 Credit

The number of farmers who obtain credit from banks, moneylenders, input dealers and other sources excluding relatives is so small that no seasonal credit change has been included in the crop budgets. Over 90% of finance, required to fund growing crops, is retained profits from previous crops or from other family owned enterprises.

3.8.5 Markets

The marketing system in the project area is largely traditional and in the hands of small traders, many of whom are also farmers. Products are channelled from the growers 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 share 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.

(c) Secondary Markets

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

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.

3.8.6 Marketing Margins

Price differentials between primary markets and the farmgate are generally between 3 and 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 for 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, the staff include 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 Gumti Phase II Project 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 strewed HYVs and means there is a significant risk of crop damage. In the dry season, lack of irrigation may also be a constraint, although rapid growth of minor irrigation means that over 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 use the improved agricultural environment.

There are a number of significant 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 have 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 fertilizer 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, fertilizer 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 deep water 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 deep water 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. With increasing population pressure, and if the risk of abnormal flooding can be reduced, farmers may in time increase cultivation of boro - deep water aman in more deeply flooded areas.

Perhaps a more serious constraint in the use 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. This is most likely to effect use of groundwater where the aquifer is deeper, requiring the more expensive force-mode technology or where STWs operate less efficiently. 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.

4 Fisheries

4.1 Introduction

Freshwater fish are an important source of income and cheap protein for a large proportion of the human population in Bangladesh, and capture and culture fisheries are the two main forms of fishing that are present in the country.

The Gumti Phase II project area is a significant and productive wetland, having an extensive network of seasonal and perennial rivers with khals cris-crossing it, making it very important for capture fisheries. Most of the study area lies within the annual flooding area of the country and as such, it is believed to play an important role as a fish habitat, especially in those areas isolated during the dry season which often merge into one vast expanse of water during the floods. This extensive flooding enhances the fisheries every year by carrying those species which migrate from the main rivers into the floodplain aquatic habitats for breeding, feeding or dispersal purposes. In addition, the man-made khals and other type of artificial depressions (estuaries, road-side borrow pits and canals) also found in the area, act as fisheries production sites and are good settings for the cultivation of commercially important species. However, ecological and biological data regarding fish and their use is lacking, especially for the smaller species.

It is therefore essential to carry out an evaluation of the existing fish diversity and fisheries in the area and the potential ecological impacts that any flood control project might have on their life cycles and on the natural environment. However, it must be emphasized that to carry out such an evaluation properly, a detailed ecological assessment of the interactions between the ecosystem and the use of these resources by the local human population is indispensable. It is therefore beyond the scope of this project to attempt to assess the existing environmental situation in detail, given the short period of time available.

The main objective of the fisheries component of the Gumti Phase II Feasibility Study was to carry out an evaluation of the fisheries resources of the area and make an assessment of the impact of FCD and FCDI projects on capture and culture fisheries under a set of different strategies. Comparative assessments have been made on the likely effects of these interventions on the fisheries resources.

Given the importance of open water floodplain fisheries, the focus was placed on these activities and it is hoped that information gathered in this study will form a much needed baseline for any future analyses, especially at the design level.

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 grossly under resourced to comply with the basic requirements for ecological and/or biological cycles to be taken into account. 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 Gumti Phase II area has been estimated from information received from the Thana Fisheries Office survey. This indicates the number of fishermen per thana and the number of households in the area as per the 1981 census (BBS, 1981). It would be valuable to verify these data from the 1991 BBS census when this becomes available. Table 4.1 shows details of these results per zone.

TABLE 4.1

Number of Fishing Households in the Gumti Phase II Study Area

	Number of Fishing Households								
	Number of Households	Full - Time	%	Part - Time	%	Occasional	%	Total	%
Zone A	61.140	1.207	2	1.888	3	11,034	18	14.129	23
Zone B	53.193	2.173	4	3.374	6	19.807	37	25.354	47.7
Zone C	82.281	7.650	9	11.270	13	21.092	26	40.012	48.6
Zone D	96.653	5.428	6	18.363	18	63.876	66	87.667	90
Total	293.267	16.458	5.6	34.895	11.9	115.809	39.5	167.162	57

Source: BBS 1981 Census for Number of Households.
Gumti Phase II Thana Fisheries Office Survey for Number of Fishermen

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 the complex system which exists in the Gumti Phase II area.

This study was carried out during the period from September 1992 to February 1993, and field data were collected during mid-October to 1 December 1992. Fishing patterns, gear used and operators were addressed for each type of capture fishery system.

Unfortunately, the results from this short field study cannot be cross- checked with existing data from the DOF (1983-84 to 1989-90) as their data for the last 3 years is not available as yet. Furthermore, given that this catch assessment survey was carried out in collaboration with the local fishermen, most likely to be full time and part time fishermen, the recorded catches are assumed to be commercial catches, whereas those reported by DOF are for subsistence household fisheries. Subsistence fishing is defined in this report as being carried out by people who directly catch and consume "common good" fish resources for a large proportion of the animal protein in their diet and who are mostly landless and poor.

The surveys carried out were as follows:

Catch Assessment Survey

The emphasis of the catch assessment survey was placed on the capture floodplain fisheries. Data were therefore collected for some beels, khals and sections of rivers within the project area. The FRSS catch assessment forms were used to record leasing arrangements and fish catches in the area.

Fish Market Survey

Eleven fish markets in Planning Zones B, C and D were surveyed during the same field visit as the catch assessment, the locations are shown on 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

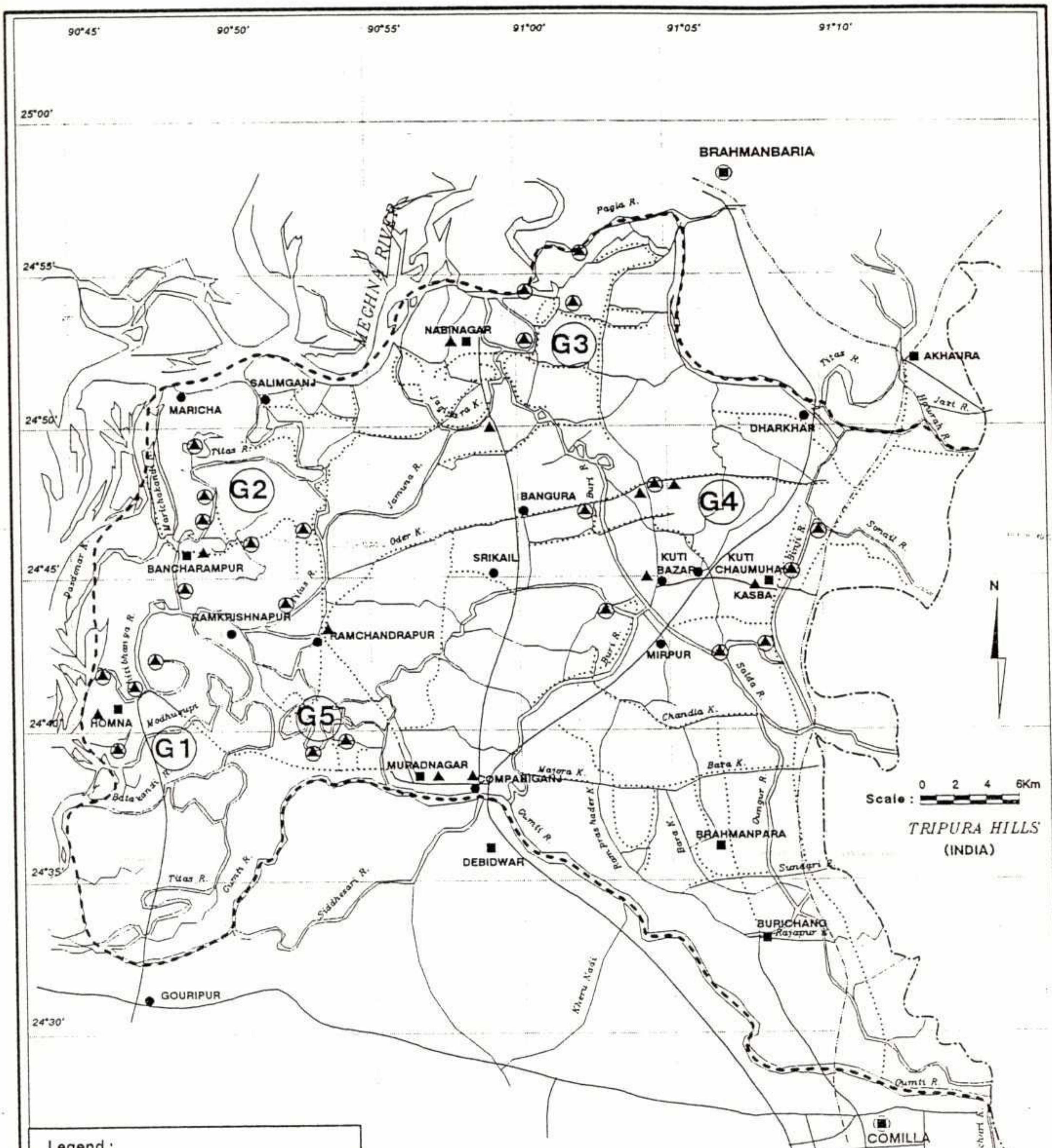
This survey was carried out by the agro-socio-economic team, to establish the type of fishing operators. Three surveys relevant to fisheries included a) fish pond, b) fishermen and c) farmers' questionnaires. Details of the surveys are presented in Annex G, Sociology and Poeple's Participation.

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.

Figure 4.1

Fish Catch Assessment and Market Sampling Sites



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People's Participation Meetings

People's participation meetings were also held at 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

Five sampling sites (G1 to G5) were selected in the main floodplain area (Figure 4.1) of the Gumti Phase II project area, which includes Zones B, C and D. Zone A was not sampled for capture fisheries due to the lack of suitable habitats, e.g. beels and floodplain, resulting from the unusually dry conditions that year. Field visits had a duration of 4 days during which information on fish catch was collected. The zone boundaries can be seen in Figure 9.1, in the People's Participation Section.

4.3 Methodology

4.3.1 Analysis for Estimating Impacts on Fish Production

The analysis of the potential impacts on the fisheries of the Gumti Phase II project area relied heavily on the results provided by the MIKE 11 hydraulic model. Thus provided a simulation of water levels and discharges at particular nodes in the schematisation of the river system, in response to a set of boundary conditions which effectively comprise upstream flows and downstream water level controls.

For the analysis of fisheries impacts, the minimum water level in three values per decade (10 day period) was used. As the focus of the fisheries component was placed strongly on open water capture fisheries, i.e. the floodplain, it was decided to aggregate all water levels greater that the MPO Flood Phase F0 (30cm). The hydraulic model results were mapped to provide a spatial distribution to changes in the extent and duration of the floods in the Gumti Phase II area. Model runs were carried out for a 1 in 2 year flood (a mean or 'normal' year) over a 25 year period. Results of the rising and falling 1 in 2 year flood patterns are shown in Figures 4.2 and 4.3.

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, khals and beels) was analyzed in relation to fishing gear for each zone. In an attempt to reduce the margin of error, information on the catch reported over a 4-day period was not used, as it included recall data over the previous three days. The mean number of days that a particular fishing gear was used in the Gumti Phase II area was calculated from the catch assessment questionnaires and was used for the analysis.

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Figure 4.2

Rising 1 in 2 Year Flood Pattern

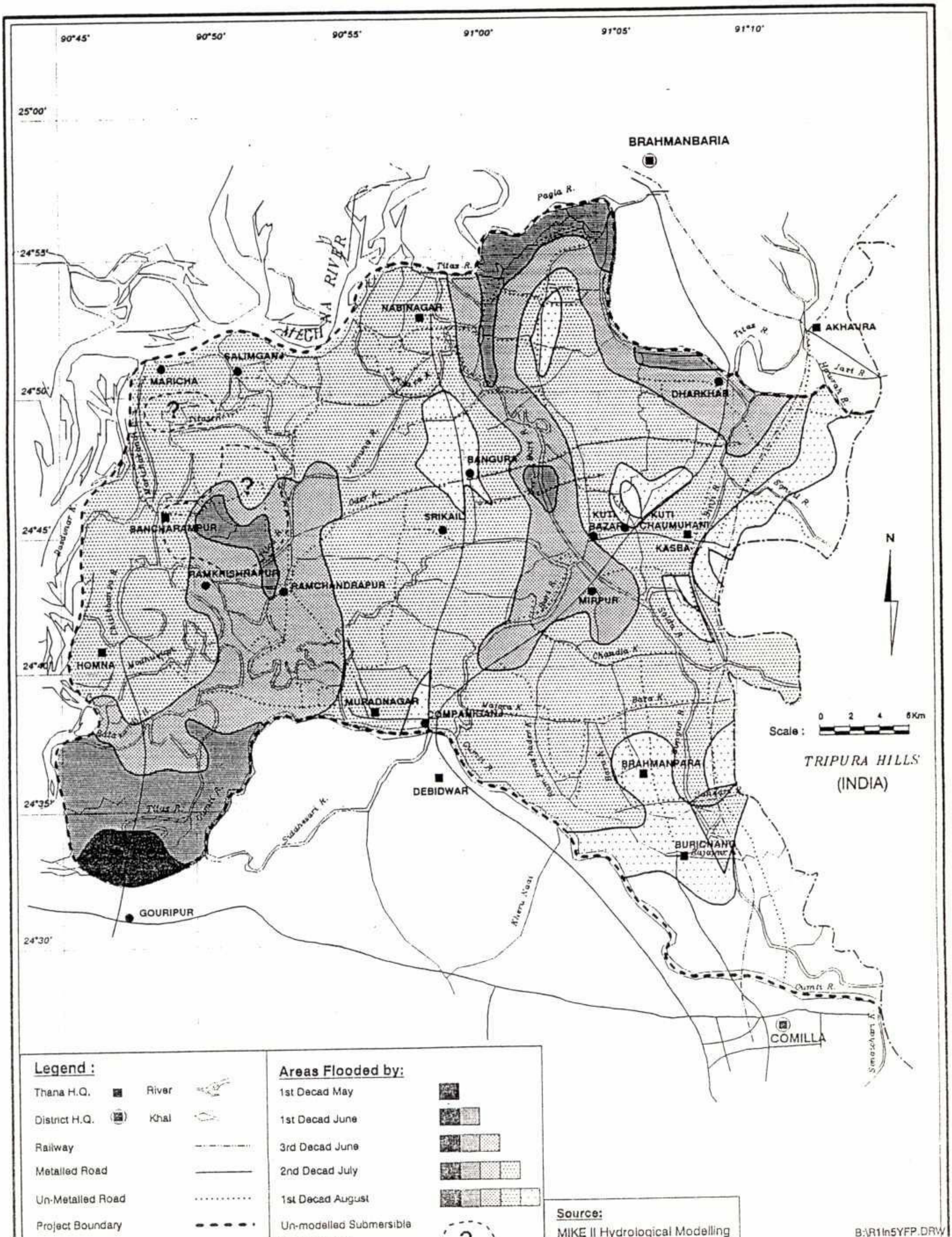
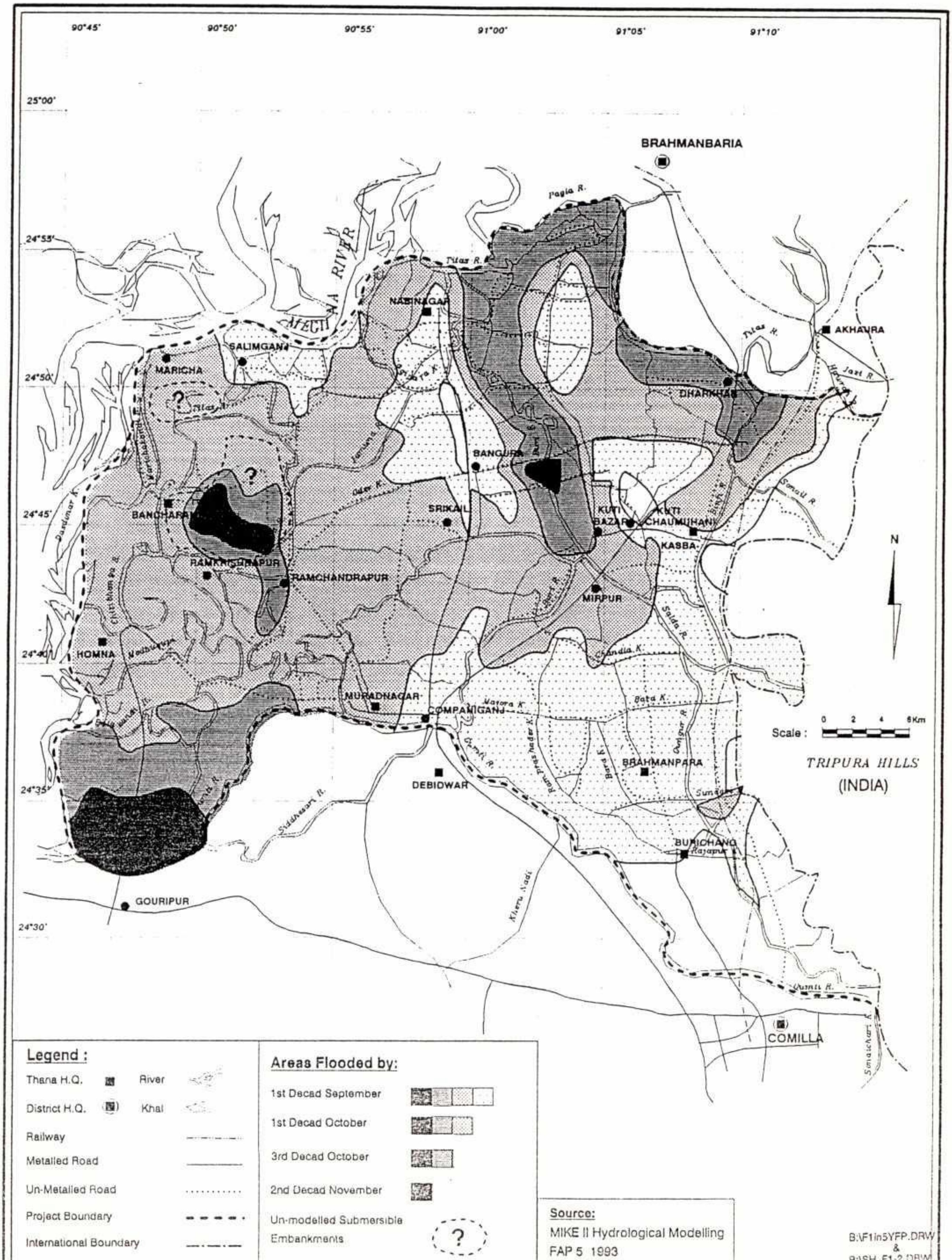


Figure 4.3

Falling 1 in 2 Year Flood Pattern



In addition, it was decided to analyze the katta catches separately as they were extremely high. Katta catches were only recorded in Zone D and were further isolated and analyzed for the relevant gear. Results were incorporated to the estimated total catch for each zone. Catch figures for khals were incorporated into river figures as there were only two samples from this type of system.

4.3.3 Estimated Fish Production in Gumti Phase II

Fish production in the project area was also calculated using national production levels (provided by FAP 17 based on DOF data, 1988-89) and compared with production levels calculated in this study.

Using national production levels, the estimated annual capture fisheries production in Gumti Phase II amounts to 10,179 MT; with an increasing production from Zone A towards Zone D. Pond production shows a different pattern with highest yields in Zone A (1,878 MT) and C (1,379), followed by Zone B (779 MT) and lastly, Zone D (398 MT). Overall estimated production including ponds amounts to 14,612 MT, which results in a production level of 115 Kg/ha (hectors of wet land).

Using the production levels estimated during this study for internal rivers/khals and beels, FAP 17's estimated production levels for floodplains (152 Kg/ha) (FAP 17, 1993), which include the commercial catch, and the average pond production levels reported by the TFO (1 760 Kg/ha), the results are quite different. The estimated total catch for the Gumti Phase II project area, including ponds, was 31,499 MT, in a total area of water bodies of 127,173 ha (including a portion of the Meghna River), resulting in a production level of 248 Kg/ha. (This is shown in Table 4.2 and Figures 4.4 and 4.5). However, if only the capture fisheries are considered, the resulting estimated total production in open waters is just over 24,100, with a production level of 196 Kg/ha, over an area of 122,971 ha. Both these production levels are comparable to fish production reported for other tropical countries (Lowe-McConnell, 1987).

4.3.4 Catch Species Composition in Gumti Phase II

Of the 260 species of freshwater fish reported for Bangladesh, approximately 47 (18%) were recorded in the study area. However, a preliminary list of species occurring in the area compiled from the catch surveys and fishermen's reports amounted to 90 species which represent 34.6% of the fish species reported for the country. Appendix F.IV in the Fisheries Annex shows the preliminary list of fish and prawn species occurring in the Gumti Phase II Project Area.

In general, the catch species composition in each of the fishing systems per zone showed a similar number of species. In Zone B, there were 17 species in rivers and 14 in beels, but only 4 species in the khals. However, this may be explained by the few samples taken from this type of system. In Zone C, the difference was also small with 22 species caught in rivers and 27 in beels. In Zone D, the species composition in the three systems was remarkably similar, although actual catches were very different. The similarity in species composition has been interpreted as an indication of the ability of the various species to freely move within the floodplain area to reach different habitats in the floodplain, and of the importance of this area for all types of fish.

Figure 4.4

Area of Fishery Systems per Zone in Gumti Phase II

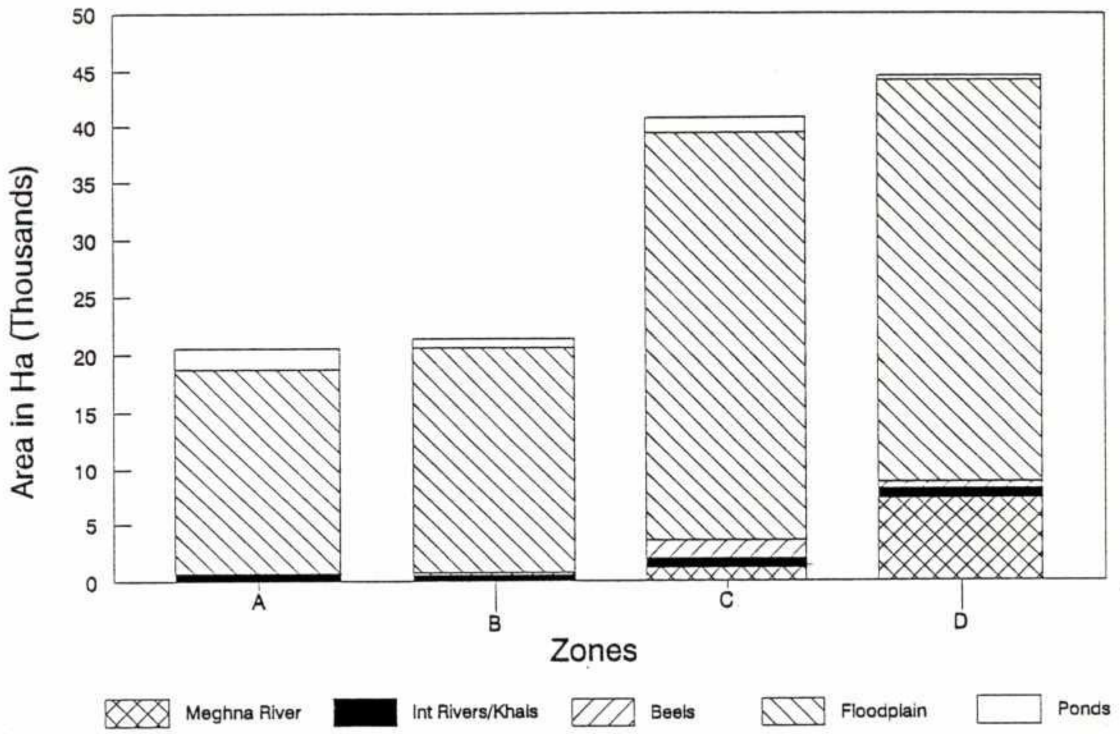


Figure 4.5

Estimated Fish Production per Zone in Gumti Phase II

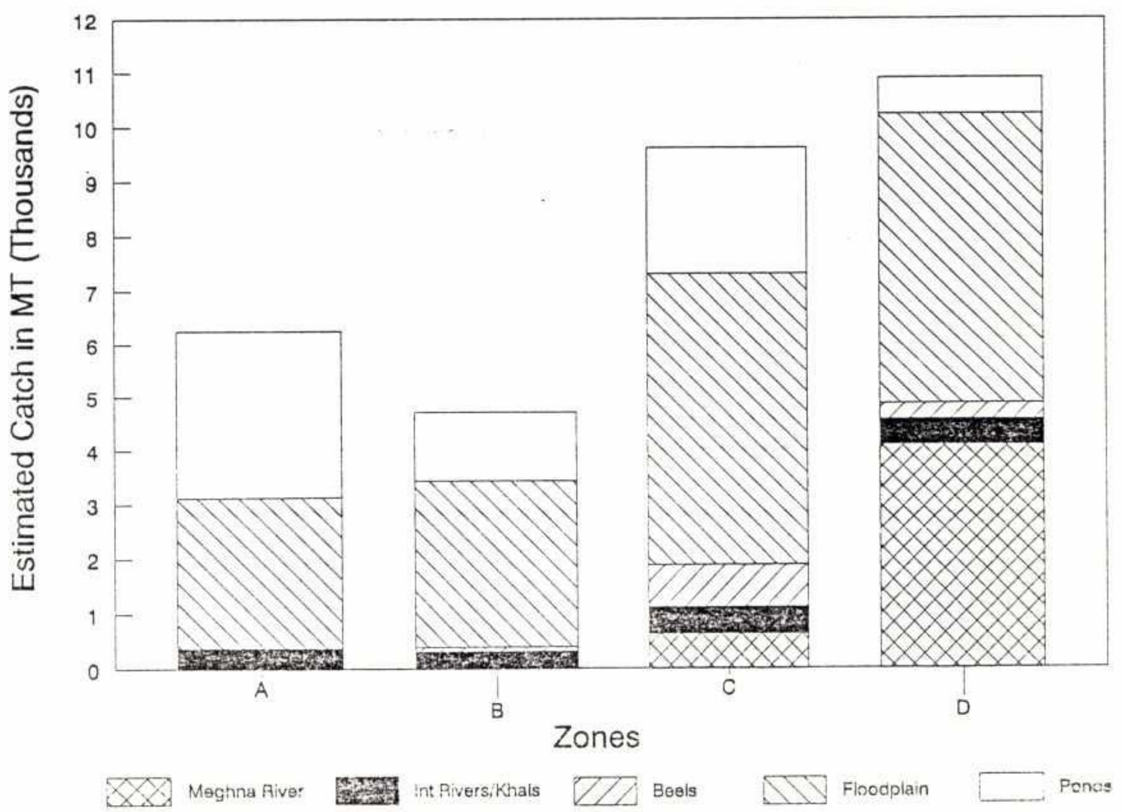


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TABLE 4.2

Fish Production in MT per Zone in Gumti Phase II Using Production Levels Estimated During this Study

Fishery System	Zones				Production		
	A	B	C	D	Total	Level (Kg/ha)	
Meghna River	0	0	627	4,091	4,717	557	*
Int Rivers & Khals	378	314	477	477	1,646	557	*
Beels	0	85	758	296	1,139	489	*
Floodplains	2,750	3,021	5,458	5,372	16,601	152	**
Sub Total	3,128	3,420	7,319	10,236	24,103	196	
Ponds@	3,133	1,299	2,300	664	7,396	1,760	@
GRAND TOTAL	6,261	4,719	9,619	10,900	31,499	248	

* Average Production levels estimated from this study's catch assessment survey

** FAP 17's new estimate for floodplain production from DOF data including commercial catch

@ Average Pond Production for 'Cultured' Ponds from Thana Fisheries Office Survey

Zone A : Brahmanpara, Burichang, Debidwar, Comilla Sadar.

Zone B : Kasba, Akhaura.

Zone C : Nabinagar, Muradnagar.

Zone D : Homna, Bancharampur, Daudkandi.

Source : Gumti Phase II Study 1993.

A full study on migration and displacement of fish throughout the Gumti Phase II Project area as well as on the Meghna River basin is needed before definite assumptions are made in this regard.

Around 30 different types of fishing gear were found to be in use in the project area (see summary in Fisheries annex F, Appendix F.V). Thus, in order to analyse the catch in relation to gear type, gears were grouped under seven main categories. The catch species composition per zone and habitat type was summarized. These results have been used to estimate the proportion of migratory species (long-distance migrants) in relation to the total catch for the fisheries impacts. However, it should be noted that this survey did not cover any seasonal changes in species composition or abundance.

4.3.5 Fish Marketing

A total of 11 markets were sampled in the eight week period. Figure 4.1 shows the location of the sampled markets. The eleven Bazaars (markets) sampled per zone were:

Zone B: Kuti, Kasba and Dely
Zone C: Nabinagar, Muradnagar, Bholachong, Companiganj and Ramchandrapur
Zone D: Homna and Bancharampur

There were approximately 50 different species being sold as fresh produce. The number of species traded per zone varied and there was an apparent increase in these from Zone B (26 species) to Zone C (35 species) and Zone D (48 species). Species found for sale in Zone D only, included Air, Sar Punti, Pabda, Chela, Hilora, Baspata, Batta, Cutcutia, Gangania, Kazali, Ghawra, Napti, Gachua and Patka. Big Shrimps were also for sale in this area only. Chewa/Chering and Fasha were only found for sale in Zone B.

Results of the survey show that there were 34 species sold as dry fish in the eight week period. The number of traded species was higher in Zone C (25 species), followed by Zone D with 21 species, and lastly, Zone B with 16 species. The higher variety of dry fish species in Zone C is not surprising as the area is a good market territory, especially in the Nabinagar area, where a large number of small fish were observed being dried during field visits.

4.3.6 Estimated Economic Value of the Fish Catch in Gumti Phase II

To obtain an estimate of the market value of the catch in the project 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: 58 Tk/Kg, medium value: 39 Tk/Kg and low value: 27 Tk/Kg.

The current market value of the capture fisheries production (24,103 MT, including Zone A) in the project area is estimated to be Tk 855 million, of which Tk 263 million was contributed by the high value species, Tk 206 million by the medium value species and Tk 386 million by the low value species.

It should be remembered that these estimates refer only to the commercial catch, as far as it is known. Therefore the subsistence catch (i.e. that consumed directly which does not pass through the market) has not been taken into account in this analysis. Therefore the total value of the catch would be expected to be even higher than this estimate, although it is not known by how much.

It is clear that any proposed engineering intervention will need to take into account the loss of income to the members of the intricate local economic web such as the fishermen, market dealers, Jalmahal leaseholders, boat builders, net and trap makers, as well as those who benefit by supplying transport, ice and other services. It is granted that many fishermen would already have been performing several of these tasks themselves. However, any disruption to the fishing system, hence to its dependent community, will have serious consequences for the local and regional economy.

4.4 Estimation of Impact of Proposed Projects

4.4.1 Project Interventions

The definition and description of the intervention strategies are dealt with in more detail in Section 11. The relevant strategies that were considered for fisheries impact analysis have been summarised as follows:

Strategy (c): Intermediate Flood Response and Development

A mixed strategy including controlled flooding using submersible embankments, non-submersible embankments, small flood water exclusion polders and improved drainage.

The elements of this mixed strategy include the rehabilitation and rationalisation of existing embankments (particularly road embankments) and construction of new ones, possibly including submersibles, to allow flooding to be controlled and managed. In some cases, this will entail the complete exclusion of river flood water. In addition, a khal re-excavation programme will be carried out, aimed at improving drainage of flooding caused by local rainfall. There is also provision for a surface water source for irrigation in those areas where groundwater use is constrained by water quality. This is to be achieved by both pumping water into a deepened khal network and also by gravity flow into deepened khals from the Meghna River in the dry season. These are shown in Figure 4.6.

Strategy (d): Full Flood Control and Drainage

This strategy was suggested in the 1990 Report for the area. It excludes all external river flooding into the protected area by construction of full embankments and is shown in Figure 4.7. In addition, there was provision for improved drainage by khal excavation and a targeted programme to promote uptake of irrigation using groundwater sources.

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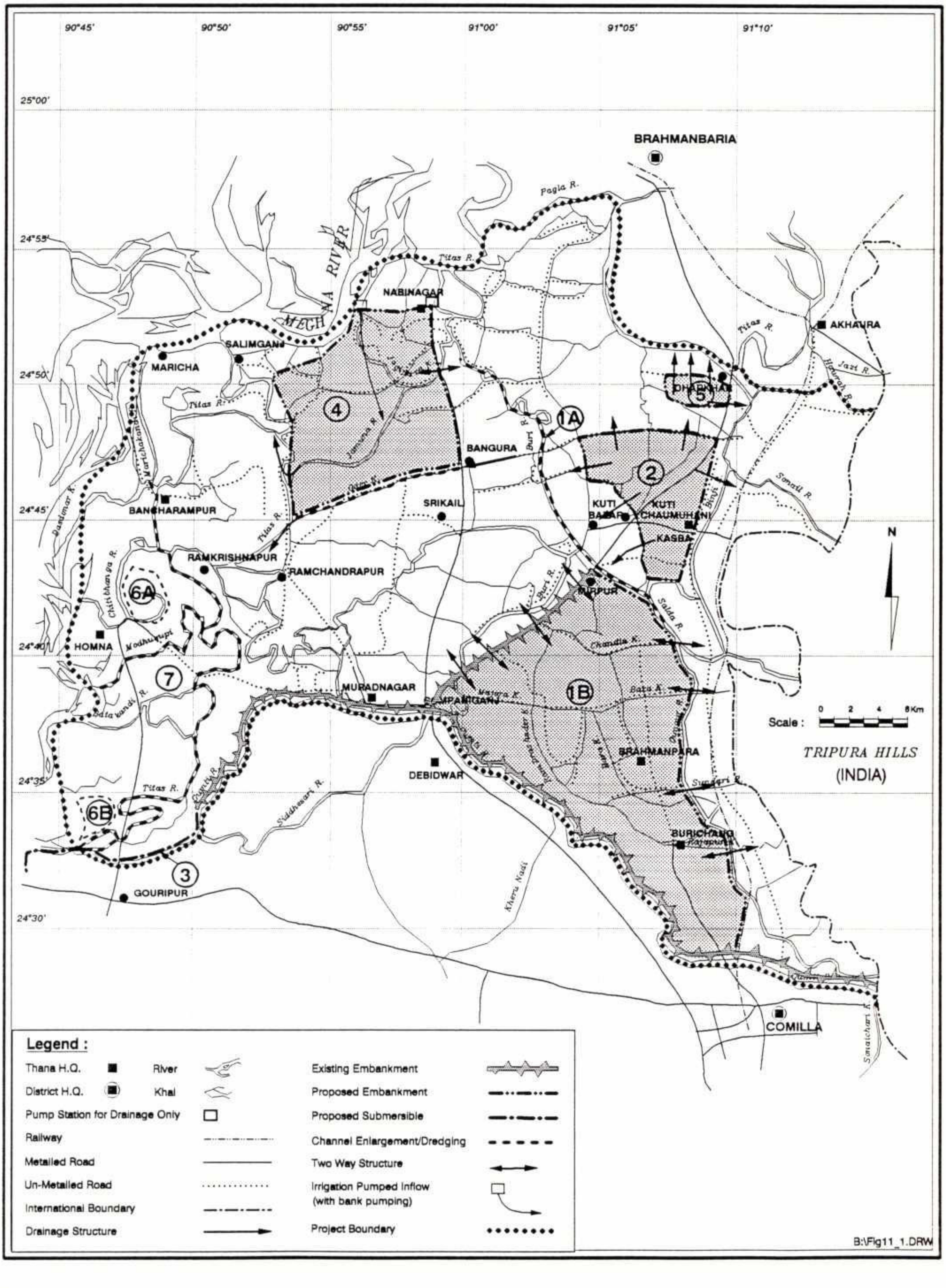
Figure 4.6

Layout of Interventions



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Strategy (e): Full Flood Control, Drainage and Surface Water Irrigation

This strategy was also suggested in the 1990 Report and has the full embankment provision of strategy (d) aimed at excluding all external surface inflow into the area. The same khal re-excavation programme was proposed which would have been linked to promotion of surface irrigation by pumping water back into the drainage system during the dry season, rather than a promotion of groundwater irrigation provision. These pumps would also be used for polder drainage in the monsoon season. Figure 4.8 shows details of this proposed scheme.

4.4.2 Rationale for Estimating Impacts on Fisheries

Attempting to estimate fisheries losses due to FCD and FCDI schemes in a complex area such as Gumti Phase II in the period of time and with the funding available for this project is extremely difficult, especially since 1992, the year when the short field work was carried out, was a dry one. However, the major issues concerning these types of interventions in the area were identified and those concerned directly with the interventions under consideration are described below.

The analysis of the impacts has been carried out for a six year period starting after the end of the construction period. The results of the assessment of all the interventions are presented in Table 4.3.

Intervention 1A - Channel Enlargement and Dredging Parts of the Buri Nadi and Salda Rivers

Re-excavation of this section is an intrinsic part of intervention 1B, which is controlled flooding to prevent flash flooding in Zone A. It is required so as to prevent induced increased flooding of the unprotected areas in Zone A. Difficulties in estimating changes in fish production in this intervention arise from not having enough information on the ecology and biology of the various species which inhabit this type of system. However, it has been assumed that in general, the expected increase in water volume in this intervention will be beneficial to fish, and thus increase production.

In order to calculate the change in depth of water due to khal excavation, existing bed and water levels, and thus mean water depths, were looked at for each month during a 'normal' 1 in 2 year at suitable intersections. Further analyses were carried out using the modelled output, and the new bed, water levels and water depths were calculated. The overall difference in the mean water depths for a without (WO) and a with project (WI) situation in all deepened khals showed a 50% increase in water depths. Thus, this factor was taken into account for estimating benefits to fish production, assuming a direct relationship between water depth and fish production.

Intervention 1B - Flood Protection in Zone A.

Water within the embanked area will be drained from it during the wet season and water inflow to this zone will be controlled by eight gated structures, four in the east and four in the north-west. At present, there are at least 20 ungated structures in the north-west side road embankment between Companiganj and Mirpur and although the water exchange is not very good, it does take place through the embankment.

Figure 4.7
Map of Strategy (d)

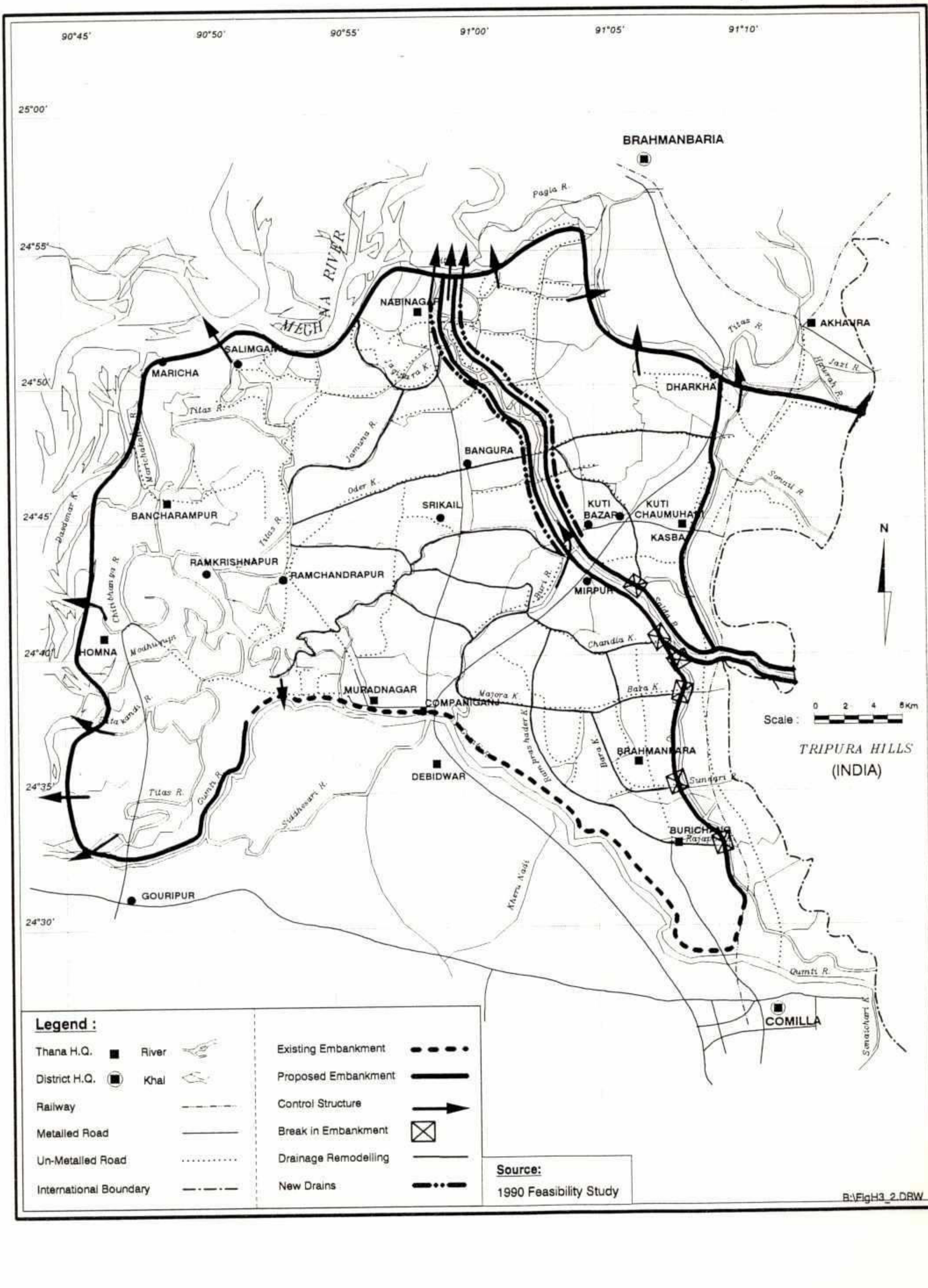


Figure 4.8
Map of Strategy (e)

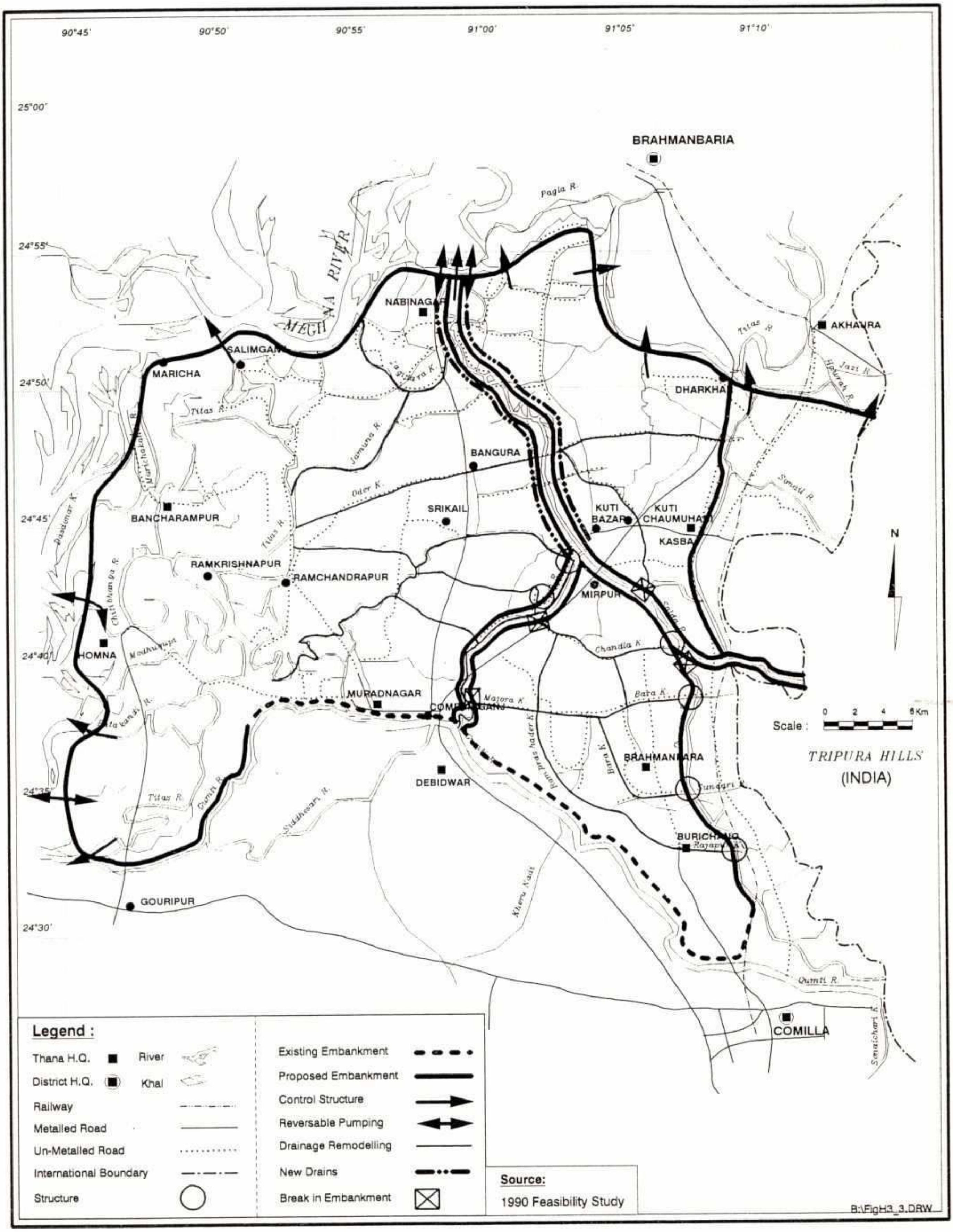


TABLE 4.3

Estimated Fisheries Impacts Due to Interventions Without Mitigation

	Intervention	1	2	3	4	5	6A	6B	7	
	Gross Area (ha)	23,400	5,000		10,459	823	1,560	1,060		
Systems										
Int Rivers and khals	NOW	276	59		156	10	18	12	1,111	
	WO Yr 6	252	54	0	142	9	17	11	1,015	
	WI Yr 6	244	39		150	6	24	11	1,374	
	Change %	-3.3	-27	0	6	-27	41	-6	35.4	
Beels	NOW	0	9	0	67	3	33	12	0	
	WO Yr 6	0	8	0	61	3	30	11	0	
	WI Yr 6	0	3	0	26	1	12	5	0	
	Change %	0	-58	0	-57	-58	-58	-58	0	
Floodplain	NOW	2,013	760	0	1,590	125	237	161	0	
	WO Yr 6	1,838	694	0	1,452	114	217	147	0	
	WI Yr 6	525	203	0	145	33	91	62	0	
	Change %	-71.4	-70.7	0	-90	-70.7	-58	-58	0	
Ponds	NOW	2,293	243	0	528	0	25	17	0	
	WO Yr 6	2,986	316	0	688	0	33	23	0	
	WI Yr 6	2,986	316	0	688	0	33	23	0	
	Change %	0	0	0	0	0	0	0	0	
										TOTAL
TOTAL	NOW	4,582	1,070	0	2,340	138	313	203	1,111	9,758
	WO Yr 6	5,077	1,072	0	2,343	126	296	192	1,015	10,120
	WI Yr 6	3,755	562	0	1,009	41	160	99	1,374	7,001
	Change %	-1,321	-510	0	-1,334	-85	-136	-92	359	-3119
	Change Tonnes	-26	-48	0	-57	-67	-46	-48	35	-31

Under this intervention it is planned to reduce the number of openings on the north-west side from 20 open structures to 4 gated channels. The allowance made for fish to re-enter the poldered area consists of fish-friendly gates which would be kept open until the middle of June, or until increased water levels threaten the agricultural crops in the area. Under this scheme a proportion of the migratory species is expected to be able to enter the area.

It has been estimated from the catches recorded during this short survey that approximately 16% of the species contributing to the total catch in Zone A are long-distance migrants, i.e. species that enter the Gumti Basin from the main rivers, mainly the Meghna and the Titas, in order to reproduce, grow or feed (e.g. Rui, Catla, Mrigala). The migration paths of these species, and many other short-distance migrants, such as most of the floodplain resident species, will be seriously obstructed and many species may not be able to return of their own accord to any of the aquatic habitats within Zone A, unless they are assisted. Therefore, it has been assumed that these long-distance migrants represent a direct loss of 16% of the total fisheries of the zone.

For the analysis of floodplain production, it has been assumed that there is a linear relationship between area of floodplain and production in the floodplain. It has therefore been estimated that under this intervention there would be a mean reduction of 32% in the area of floodplain within the embankment. However, it cannot be assumed that the remaining reduced floodplain will still be able to produce the previous catch levels after polderization, as most of the access for fish to the area would have been severely reduced. Hence, of the remaining floodplain resident species, a loss of 50% has been assumed to occur due to poldering.

Further to this post construction reduction, the fish production was projected over a six year period using the national trend of -1.5% for open water fisheries and +4.5 % for pond production. This value was incorporated in all calculations when trend data were used.

Interventions 2 and 5

These interventions are similar in nature, being full polderization of approximately 22% of Zone B, with some 19% corresponding to Intervention 2 and 3% to Intervention 5. This entails the exclusion of all external flood water from the area and reliance upon gravity for drainage through a limited number of structures. The percentage of the total catch in the intervention area, contributed by migratory species to the internal rivers and khals, has been calculated as 27% and that for beels as 11%. This gives a figure for the total intervention area, catch of nearly 14%, which can be considered a direct loss to the fisheries within the poldered areas within this zone. The reduction in the floodplain species has been based on similar considerations as in intervention 1B (50%) and losses to beel fisheries have been estimated to be 58%.

Intervention 3

This intervention involves extending the existing right bank embankment of the Gumti River all the way to Gouripur. The section of new embankment is submersible and will therefore only prevent pre-monsoon flash floods from entering the protected area. As such, the assumption made here is that the fisheries in the Gumti River are likely to remain the same.

Intervention 4

This intervention is an enclosed polder which covers 21% of Zone C and 4% of Zone D. This will also include a two-way water pumping system within the poldered area. The intention is to increase the area available for agricultural purposes by pumping it dry during the wet season. Khal re-excavation will also take place which aims to ensure wet season drainage flow to the pumps and dry season irrigation. The methodology for this is dealt with separately as Intervention 7, but it is included in the intervention 4 figures for the internal polder area.

Fish losses as a direct result of preventing the inflow of migratory species (through recruitment of eggs and fry, or by breeding adults) have been calculated to be as follows: Zone C: 32% for rivers and 12.5% for beels (combined loss of 16.8%) and Zone D: 12.3% for rivers, 13.3% for khals and 23.8% for beels (combined loss of 15%). Since the intention is to completely drain the poldered area (see Figures 4.9 and 4.10), losses to floodplain resident species have been assumed to be at least 90%.

Interventions 6A and 6B (Northern and Southern Submersible Embankment Schemes)

These interventions propose the construction of submersible embankments which together cover approximately 6.4% of the total area of Zone D. The experiences of the existing schemes in Satdona and Chandal Beels have been used for estimating fish losses regarding these interventions.

Intervention 7

Khal re-excavation in various parts of the Gumti Phase II Project Area.

In general, this will result in deeper and wider channels, designed to maintain interconnection between main rivers, internal rivers and khals. In Zone D, excavation will involve deepening small khals which are designed to be kept full of water in the dry season. It will also have the added function of assisting drainage during the flood season, which might result in faster current speeds.

Under the present intervention, nearly all khals being remodelled will have more water for a longer period of time. In most instances, re-excavated khals will hold water throughout the year when previously they did not. Thus, it has been assumed that khal re-excavation will result in increased refuge areas for fish during the dry season. However, this may also result in heavier fishing in these restricted areas.

Strategy (d): Full Flood Control and Drainage (Put Forward in the 1990 Report)

Figure 4.7 illustrates the concept. The area was to be divided into two main sections, with two further small portions on the eastern side isolated even further. There was also a khal re-excavation component, but this was for drainage assistance as there was no provision for retaining water in these locations during the dry season. It has thus been assumed that the long-distance migrants would be a straight loss to the area and the respective proportions of these migrants to each fishing system for each zone have been calculated.

Figure 4.9

Rising 1 in 2 Year Flood Pattern with Interventions

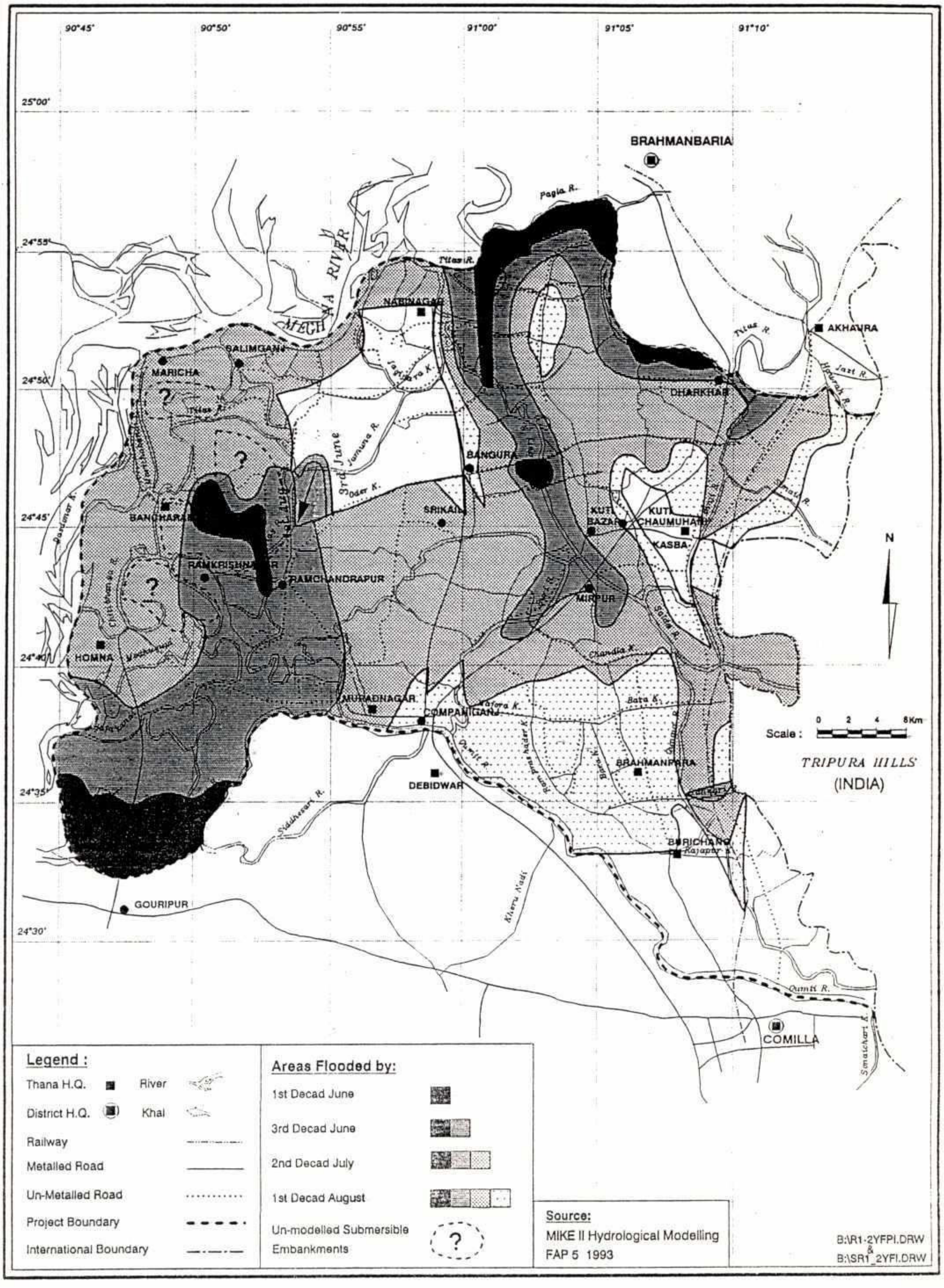
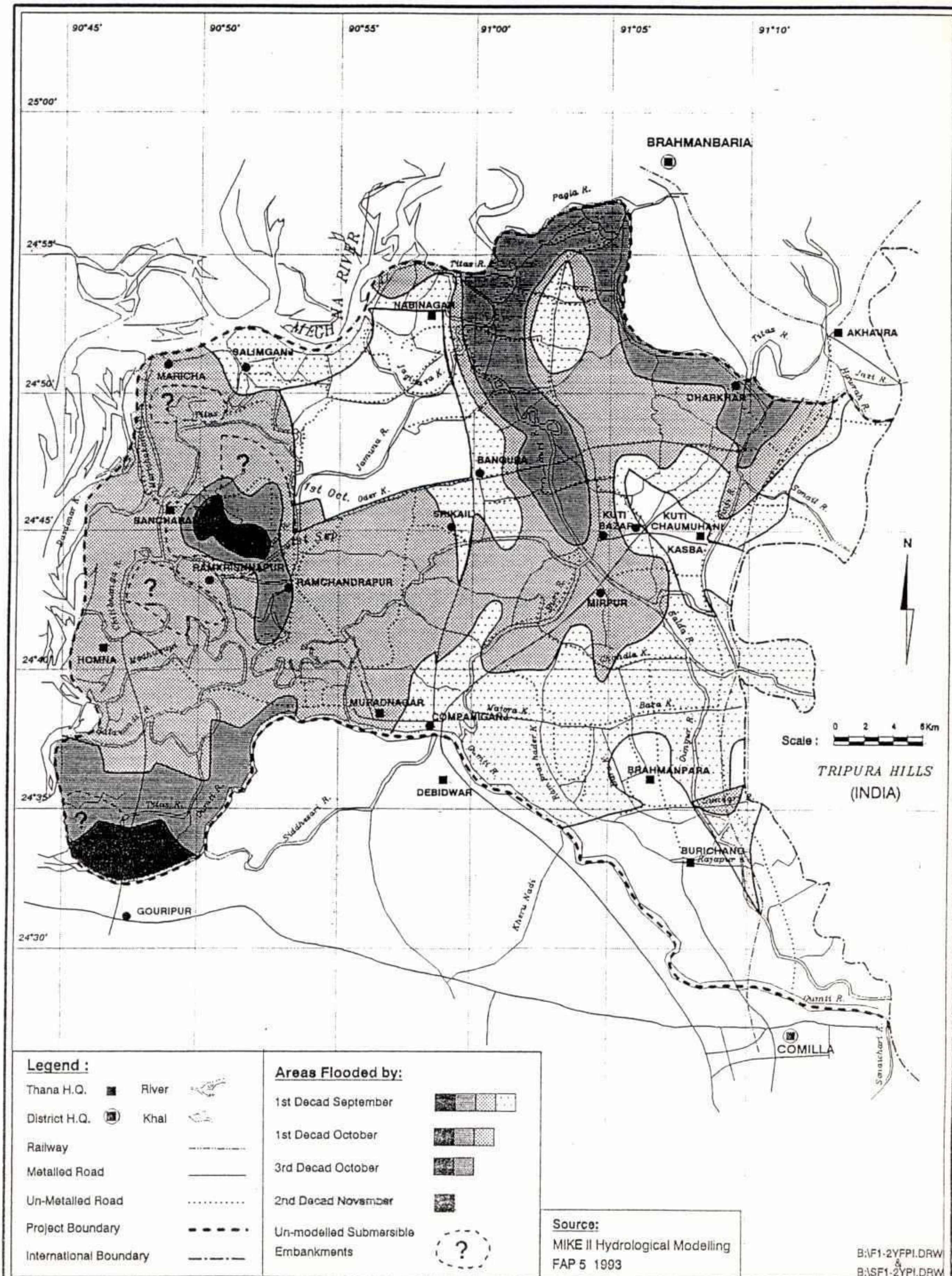


Figure 4.10

Falling 1 in 2 Year Flood Pattern with Interventions



To estimate the loss of the remaining floodplain resident species is extremely difficult, as it is related to the existing levels of catch activity and how this is likely to continue. However, lessons from the impacts reported in Chandpur and Meghna-Dhonagoda projects after polderization (35% loss directly after construction and a further 15% over the next few years) were used and based on these, proportional changes in fish production in the Gumti Phase II study area were estimated for this strategy. The basic criterion was that the smaller the polder, the greater the loss proportionally to the area. Thus, 90% loss figures were used for the systems within the small blocks on the eastern side (Bijni Block east of Kasba, and the one north of Comilla); a 50% loss in the north-eastern block and a 35% loss in the main block.

Strategy (e): Full Flood Control, Drainage and Surface Water Irrigation (Recommended in the 1990 Report)

This strategy is a development of Strategy (d) with a further polder in Zone A (Figure 4.8). Thus, changes in fish production were assumed to be similar to that under Strategy (d), except for the area in Zone A, where losses would have increased from 35% to 50% as it would have resulted in a much smaller polder. Khal re-excavation was also part of this intervention for Zones B, C and D and these were to be kept full of water from irrigation by pumping. A similar increase to that assumed under Strategy (c) in the estimated production was incorporated in their respective production figures.

4.4.3 Estimated Fisheries Benefits and Dis-benefits

Table 4.3 shows details of changes in estimated fish production for each intervention and for each system being considered under Strategy (c). The combined fish production loss for all interventions in the project area was of 3,119 MT representing a mean loss of 30.8% within direct intervention areas. Changes in estimated fish production for each intervention are detailed below.

Intervention 1B:

Under this intervention, there will be a reduction of 3.3% in the estimated fish production of internal rivers and khals within the polder area, from 252 to 244 MT by Year 6. Seasonal beels have been assumed to remain unchanged as they are situated outside the polder and will continue to be filled with water and hopefully fish. Unfortunately, no beels were reported by the relevant TFO in Zone A and thus, it was not possible to estimate their production. This will have to be taken into account if any interventions are going to go ahead in this area.

Floodplain fisheries production is estimated to be reduced by over 71%, from 1,838 MT to 525 MT by Year 6. However, very little is known regarding their sustainability, or their ability to recover. It has been assumed that pond production will follow the national trend of 4.5% increase per annum. Since pond production is high in this area, it provides some compensation for the losses to the natural systems but is unable to balance them as the production and consumption systems are essentially independent of each other. Overall, there was a loss of 26% within the intervention area representing an estimated 1,321 MT.

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Interventions 2 and 5:

The loss in fish production in the internal rivers and khals for both of these interventions was estimated to be 26.9%, declining from 54 to 39 MT for intervention 2, and from 9 to 6 MT for intervention 5. Beel production was difficult to estimate as there was no suitable wet period satellite imagery available to locate the areas of permanent beels within the project area. According to the information available, the polders did not appear to impinge too much on the known beel areas and thus losses were estimated to be 5 MT and 2 MT respectively. The loss to the floodplain fishery was severe in both cases, nearly 71%, with 491 MT loss in intervention 2 and 81 MT in intervention 5. Pond production was relatively low in the intervention 2 area. In addition, no production from ponds was allocated to intervention 5 as it would appear from the 1989 dry season SPOT satellite imagery that there were not many ponds within this small polder. The total loss resulting from intervention 2 was 47.5% (510 MT) and that for intervention 5 was 67.4% (85 MT).

Intervention 3

It was not possible to estimate changes in fish production under this intervention as there was insufficient information available, however, losses were thought to be negligible.

Intervention 4

Internal river and khal production was assumed to benefit from the khal re-excavation proposed on the southern part of the polder. Accordingly, fish production was estimated to increase by 5.6% over the six-year period from 142 to 150 MT. Beels are an important wetland ecosystem in the northern part of Zone C and thus estimated to be seriously affected by the polder and pumping scheme. Beel fisheries were calculated to decline from 61 MT to 26 MT, a decline of nearly 57%. However, the floodplain in this area is undoubtedly the system which will suffer most as a result of polderization and water extraction. Therefore, losses to floodplain fisheries were estimated to be severe, declining from 1,452 MT to 145 MT, a loss of 90% by Year 6. Pond production is very small in this area and its potential for increase will not compensate for the decline in capture fisheries.

The overall losses to the total production under this intervention were substantial and amounted to 1,334 MT, representing nearly 57% of the total production.

Interventions 6A and 6B

Internal river and khal production increased by 40.8% for intervention 6A but there was a decline of 6.1% for 6B. This difference is the result of khal re-excavation in the first scheme. Beel production declined by 58% in both interventions, from 30 to 12 MT for 6A and from 11 to 5 MT for 6B. Floodplain fisheries also declined by the same proportion from 217 to 91 in 6A and from 147 to 62 MT in 6B. Pond production was assumed to be proportional to the area of the intervention area within the zone and thus very small. Overall losses due to intervention 6A were 45.9% (136 MT), and for 6B they were 48.1% (92 MT).

Intervention 7

Changes in fish production as a result of this intervention have been amalgamated, although they have an influence throughout all zones. Overall, an increase of approximately 359 MT has been estimated to occur under this intervention, representing an increase of over 35%. However, fish production in this type of system only represents 5.5% of the total catch as a whole in the project area. It should be borne in mind that khal re-excavation has been assumed to be positive on the whole, but this assumption must be tested by a detailed study looking at resultant changes in current velocities, depths, extent and duration of the water in khals.

In addition, it should be pointed out that structures will also be placed at several khal intersections and that design, management and operation of these will be a crucial factor in determining future fish production. A post-construction monitoring programme should be implemented to look into the effects of khal re-excavation on fish biomass, species composition, and their biology and ecology.

Estimated Changes in Fisheries Production Under Strategy (d)

Under this strategy, overall losses were estimated to be around 34%, that is approximately 9,223 MT, having a market cash value of Tk 328 million. Because there was to be no khal re-excavation that could result in increased water availability, the heavy losses estimated as a direct result of the prevention of species' access to the areas within the polders could not be compensated for. In addition, all other fishing systems are seriously impacted, especially the floodplain catch in Zone A which suffers significant losses (nearly 71%) and Zone B (56%), and declines by a similar amount in Zones C and D. The decline in beel production is approximately the same for Zones B, C and D.

Estimated Changes in Fisheries Production Under Strategy (e)

Overall estimated losses were slightly lower than those of the previous strategy due to some benefits being accrued from khal re-excavation for gravity irrigation in the dry season. However, losses in floodplain production were increased in Zone A as a result of further sub-divided empolderment of this area. The rest of the fishing systems were assumed to be impacted to the same extent as under Strategy (d).

4.5 Possible Mitigation Measures

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

4.5.1 Water Management

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

Re-excavation of Khals

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

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.

4.5.2 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:

Restocking with Fry and/or Fingerlings

Restocking of suitable areas such as specific beels and khal sections with fry or fingerlings. However, this will need to take into account the ecology of the existing resident species in the area so that any introduction of species does not lead to a major environmental imbalance. Restocking programmes should therefore only be carried out using indigenous species which occur naturally in the selected areas.

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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 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 under way in Comilla, and 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 fisheries projects like these.

Enforcement of Existing Fisheries Regulations

The enforcement of existing regulations should particularly be carried out in relation to important areas such as Satdona and Chandal Beels, along with other known breeding, nursery and feeding areas for fish and other commercially important groups such as shrimps.

4.6 Conclusions and Recommendations

It is clear that there is serious conflict between agricultural development and existing capture fisheries in Bangladesh. The scope for developing these two activities 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 not only represent a decline in overall production in actual metric tonnes, but also affect 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 this may produce an imbalance in existing fishing systems with detrimental results to the ecology and the people of those systems.

It should be realised that some areas are suitable for agricultural growth whilst others 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 the future development of the country.

It should be noted that the estimated fisheries production in the project area during this study is based on a very short field survey which took place during an unusually dry year and is thus likely to represent an unusual situation. Even so, it is clear that the fisheries production and/or potential of the area is far higher than previously estimated. Results from this study certainly appear to confirm that the Gumti Phase II area is one of the most productive areas in the country. Therefore, further studies should be carried out on the capture fisheries production of the project area targeted to the proposed interventions as a matter of the highest priority and before any FCD and/or FCDI interventions actually take place. The fisheries impact analyses results and their financial valuation have been integrated into the overall economic analysis of each of the seven studied interventions. These have proved to be highly significant in four of the proposed interventions.

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

Fisheries Management Programme

A Fisheries Management Programme should be developed jointly with the leading fisheries organisations in the area. Such a programme should include provision 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 finalised 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.

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 groups.

Involvement of Local NGOs

In addition, the involvement of the various NGOs - such as the Comilla Rotary Club - 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.

Aquaculture

Regarding aquaculture activities, it is important to note that substantial benefits may be obtained by improving pond culture, especially since a large number of ponds are 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 for it.

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. However, it does not address the issue of displaced occasional fisher-persons (in many cases women and children) or the nutritional loss to the poor, an issue which should be given the highest priority by local and central government. Furthermore, aquaculture *per se* will never compensate for the loss of habitat and species diversity, which in the case of the floodplain in the Gumti Phase II area, stands to be severe.

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 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 expected to be currently under used in the Gumti Phase II area.

Rice-fish culture

The activities of the Comilla Rotary Club 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 (eg. Mymensingh) with promising results. The possible development of this activity in the Gumti Phase II 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. A 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.

Improved Knowledge of 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 projects in this country.

Sustainable Use of the Biodiversity of the Area

Despite the short period of time allowed for this study, it was possible to establish with certainty that the Gumti Phase II area is indeed a highly productive floodplain region, as well as being an extremely important wetland. This is not surprising given its proximity to the Meghna River, the most productive main river in the country (FAP 17, 1993).

It is apparent that the wetland yield of the Gumti Phase II study area is used in a variety of ways. The fish itself is both sold and used for personal consumption, crustaceans and molluscs are fed to poultry, and aquatic plants provide food and animal fodder and can be used as a source of construction materials for agricultural and other uses.

It is also clear that these natural resources are presently being used intensively by the human population in the region, as is the case throughout Bangladesh. Obviously, a considerable proportion of the people in the area rely on being able to use these free resources, especially fish, which are within easy reach for their everyday needs. Any intervention which may substantially alter this pattern will undoubtedly have serious consequences on 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 no longer 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, and it is a challenge that should be taken on by all concerned.

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 Gumti area are required. Unfortunately, this data has not yet been made available for Comilla or Brahmanbaria districts. Information is being released, but priority is being given to the coastal areas. Further attempts to obtain this data were made shortly before writing the Draft Final Report, but unfortunately they have been unsuccessful.

Therefore, the data presented in the following section are from 1981 BBS census 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, figures and maps. The crude union-wise data are presented in Annex G, Appendix G.1C.

5.2 Population Estimates

The Gumti Phase II project, which covers an area of 140,854 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 have an average of over 1,000 per square kilometre, the highest density being found in Zone D (close to 1,200) and the lowest in Zone B (931).

Nearly 1.5 million people were living in the project area in 1981, corresponding to almost 260,000 households. Assuming a 1.8% annual growth rate since 1981, the population would now be close to 1.9 million and the average density over 1,300 per sq.km.

With the same annual growth rate in the project area for the next 30 years, the population would be close to 3.2 millions in 2023, with a density of well over 2,000 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.

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TABLE 5.1

Estimated Population Figures un Gumti Phase II Project Area
(Area in Ha, Density in Number/sq.km)

Zones		Zone A	Zone B	Zone C	Zone D	Total
Area (in Ha)		31,976	26,782	41,400	40,696	140,854
1981	HH No	55,988	42,371	72,432	83,277	254,069
	Pop. No	335,298	249,388	420,928	480,081	1,485,694
	Density	1,049	931	1,017	1,180	1,055
1993	HH No	70,602	53,431	91,339	105,014	320,385
	Pop. No	422,817	314,482	530,797	605,390	1,873,486
	Density	1,322	1,174	1,282	1,488	1,330
2023	HH No	120,574	91,248	155,987	179,341	547,149
	Pop. No	722,081	537,068	906,487	1,033,876	3,199,513
	Density	2,258	2,005	2,190	2,540	2,272

Source : Consultant Estimates based on 1981 BBS census data

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, from 616 in one union of Kasba Thana (Zone B) to 1,748 in a union under Bancharampur Thana (Zone D). As a whole, it should be noted that a greater number of unions of Zone D have a density over 1,250 indicating a relatively higher population pressure in this zone. The density distribution map (Figure 5.1) gives a picture of the different population densities within the project area.

5.3 Socio-Economic Characteristics

5.3.1 Household Size

The average household size in the project area is quite similar in each zone, varying from 5.78 in Zone D to 5.99 in Zone A. At the union level (see Table 5.2) the differences are more substantial though they remain within a very limited range (from 5.2 to 6.5). The mode, median and average of the distribution are within the 5.75 - 6.00 class in each zone indicating very similar patterns in the project area.

Figure 5.1

Human Population Density 1981
Mean People/km² by Union

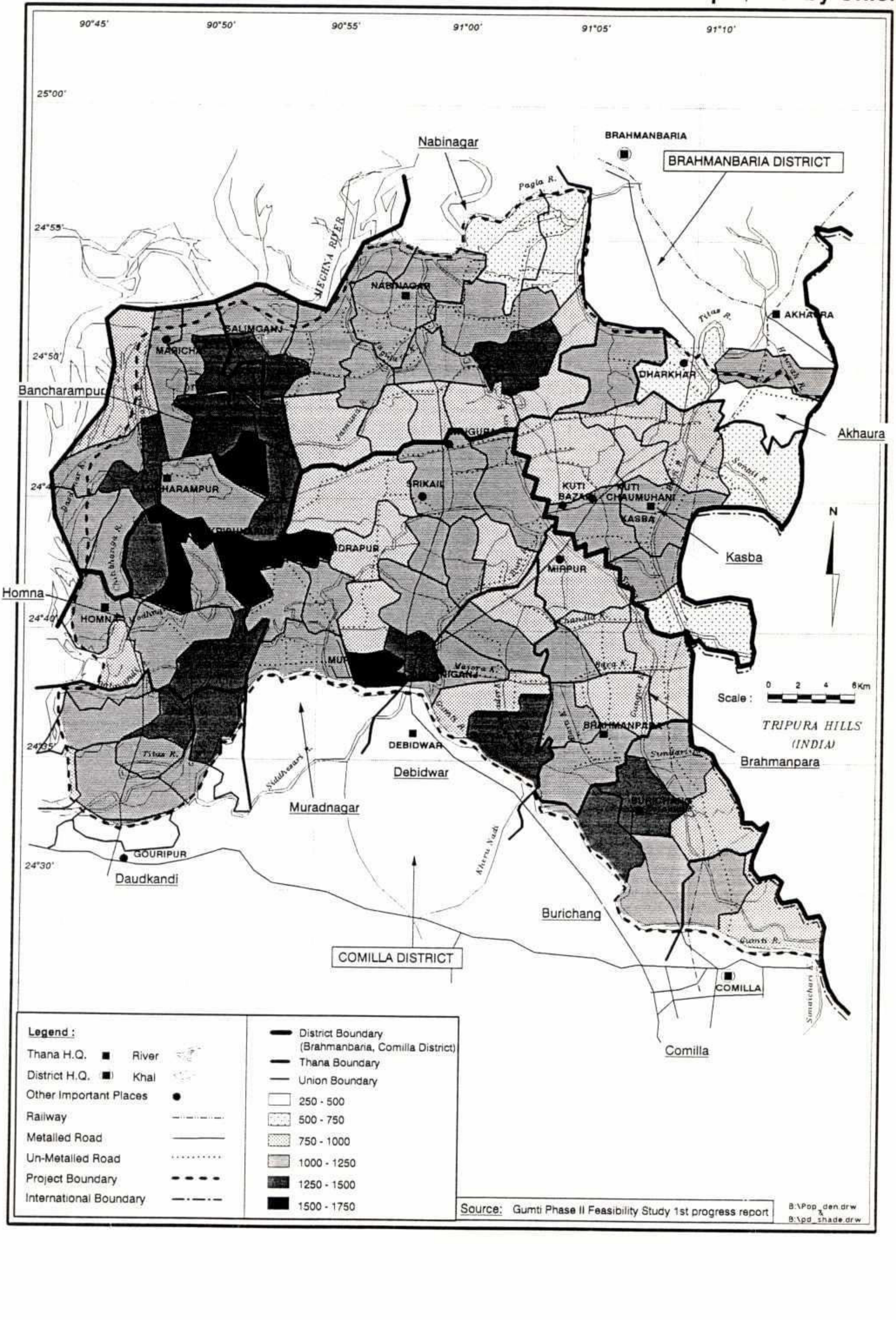

TABLE 5.2

Distribution of Household Size (Zone Wise)

Household Size	A	B	C	D	Total
< 5.50	0	2	2	3	7
5.50 - 5.75	2	4	9	11	26
5.75 - 6.00	10	7	12	14	43
6.00 - 6.25	6	2	4	4	16
6.25 - 6.50	1	2	0	0	3
Total Unions	19	17	27	32	95
Zone Average	5.99	5.79	5.81	5.78	5.83

Source : 1981 BBS Census Data

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 very remote, 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 15.2% in Zone D to 24.7% in Zone A. This is not surprising considering that Zone D is not only the most populated but also the most remote zone of the project, without even a road communication to the Thana headquarters (Bancharampur). From the literacy distribution map (Figure 5.2), it can be seen that the majority of unions have literacy rates between 15 and 25%, with very few below 10% and none above 30%. In the case of Zone D, however, a majority of unions have a literacy rate between 15% and 20% as opposed to between 20% and 25% in the case of other zones.

The pattern of the education levels of the population, defined as the highest class passed, is similar to the literacy pattern, with the highest rates of "no-schooling" and the lowest rate of population with secondary or higher level of education found in Zone D (see Table 5.3).

Figure 5.2

Literacy Rate 1981

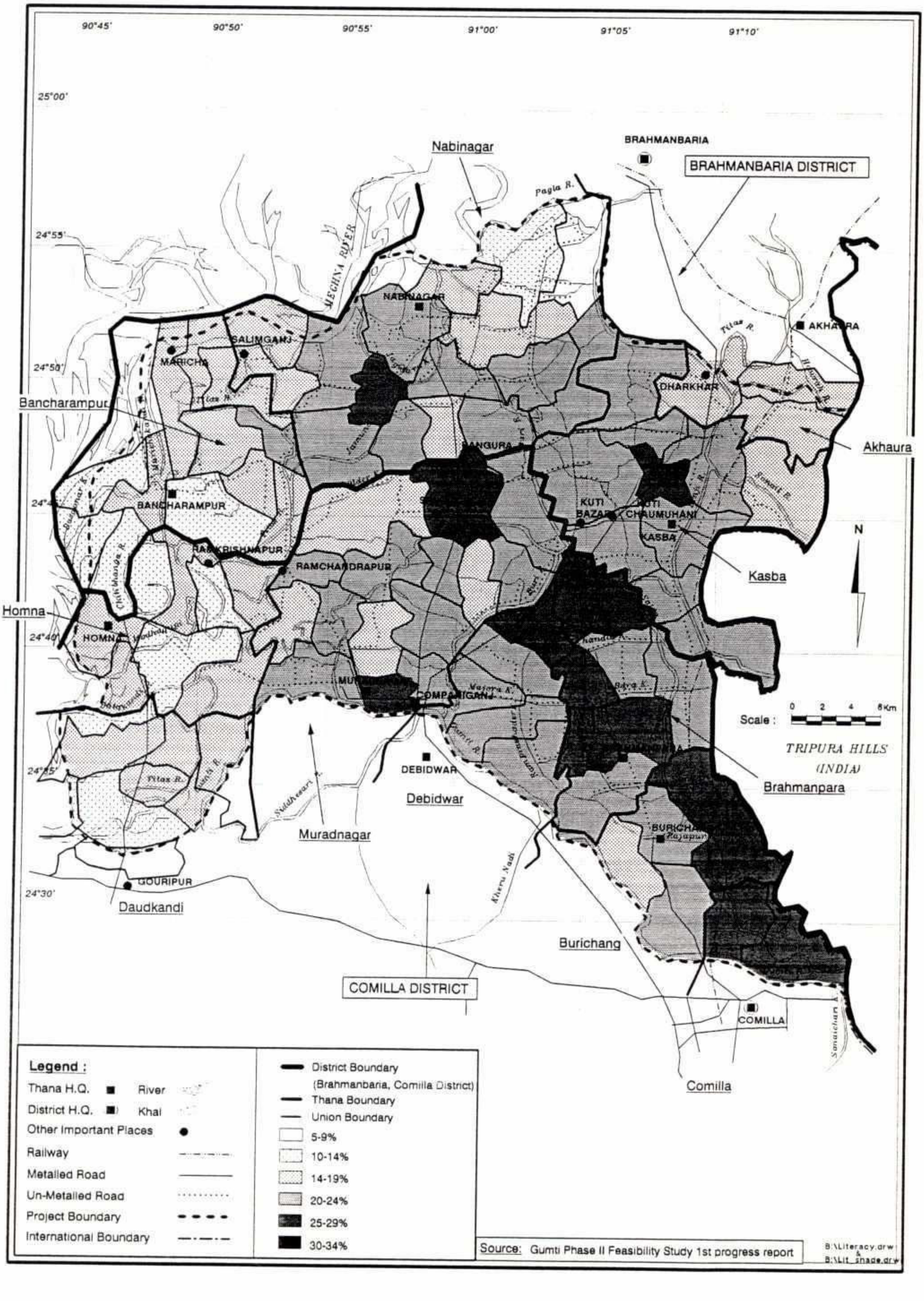

TABLE 5.3

Education Level of the Population (Zone Wise)

Zones	A	B	C	D	ALL
No Schooling	63.4%	67.8%	70.5%	74.9%	69.2%
Class 1 - 5	21.2%	19.1%	18.5%	16.0%	18.7%
Class 6 - 9	10.2%	9.5%	7.9%	6.4%	8.5%
Secondary and More	5.2%	3.6%	3.1%	2.7%	3.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source : 1981 BBS Census Data

The higher number of educated persons in Zone A can be explained by its proximity to Comilla Town. Overall, it seems that the levels of literacy and education decrease as communications difficulties and 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.

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 5.4, the proportion of houses with straw/bamboo roofs is high in Zones A (57%) and B (55%) and much lower in Zone C (40%) and Zone D (22%). This seems to indicate that, though Zones C and D are much more remote, less educated and more crowded, they have a better general standard of housing than Zones A and B. This could mean that household income is higher, probably due to the substantial fisheries resources existing in those areas as opposed to the eastern part. In addition, people's participation meetings held in Zone C indicate that many people work overseas and send much of their earnings back home to their families.

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TABLE 5.4

Percentage of Households by Tenure and Roof Material of their Dwelling Units

Zones	Owned House	Bamboo
Zone A	96.1%	57.2%
Zone B	93.6%	54.8%
Zone C	97.5%	39.8%
Zone D	98.4%	22.4%
Whole Project Area	96.8%	40.4%

Source : 1981 BBS Census Data

As for access to potable water (tubewell and tap water), the pattern is exactly reversed. Most of the households have potable water in Zone A (20% rely on surface water) while the proportion increases to 30-35% for Zones B and C.

The situation in Zone D is much worse, since nearly 46% of the households rely on surface water for their drinking needs. The significance of the differences from one zone to another becomes evident when looking at the distribution map of the proportion of households without potable water presented in Figure 5.3.

5.3.4 Income Distribution and Poverty Line

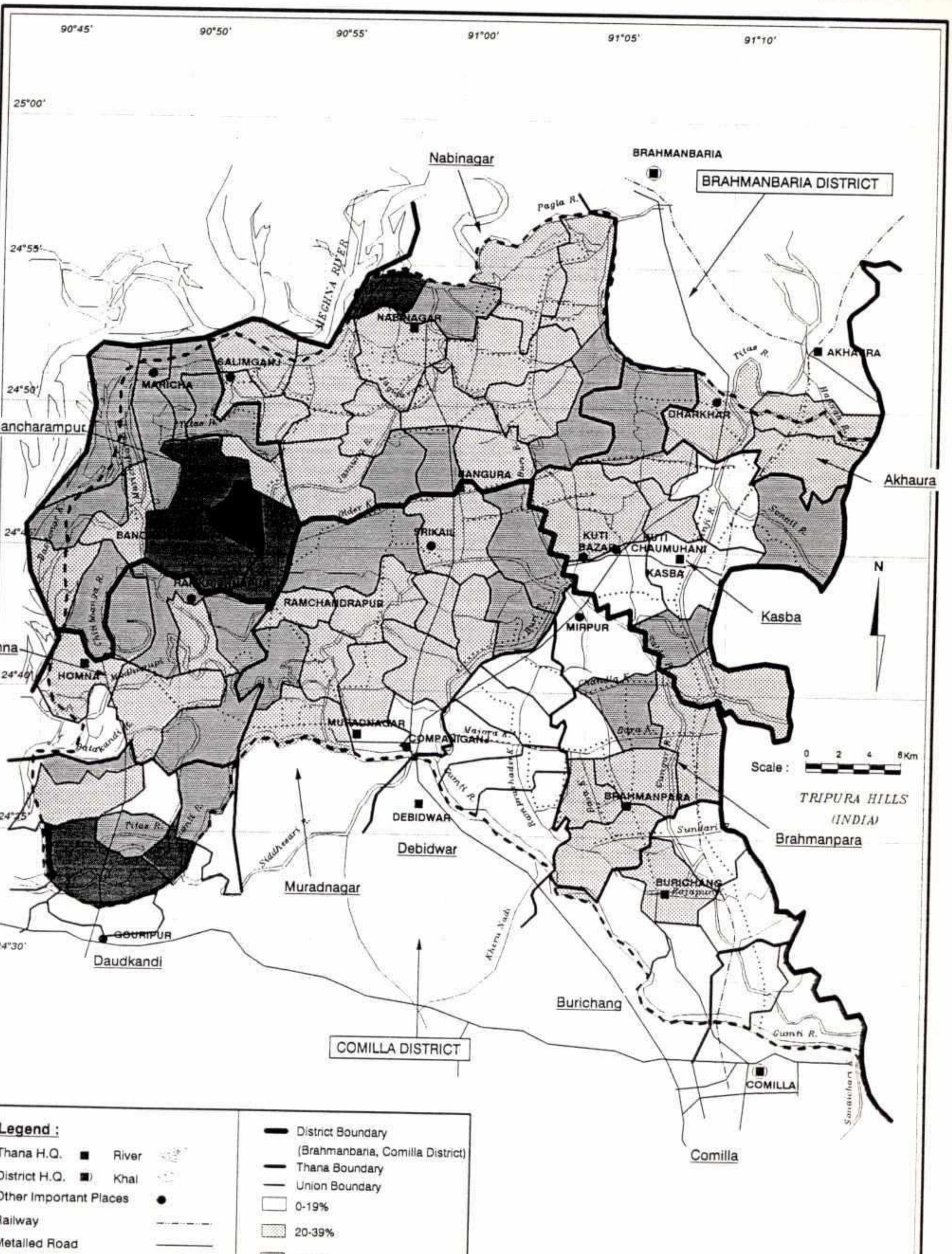
At this stage of the study, the statistics on income which are available are all from secondary sources (Upazila Development Monitoring Project) and cover only one thana of the project area located in Zone A (Burichang). Because significant differences have been noted in the project area in each socio-economic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

As shown in Table 5.5, the income distribution in Burichang closely follows the average pattern of the overall country with a majority of households earning less than 3,000 Tk per month. The incidence of such an inequitable income distribution on the extend of poverty is straightforward and it is estimated that 37% of the households of Burichang thana (36% in Bangladesh) live below the absolute poverty line as defined by a joint WHO/FAO expert group. 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).

Figure 5.3

Households with no Potable Water Supply 1981



Legend :

Thana H.Q. ■	River
District H.Q.	Khal
Other Important Places ●	District Boundary (Brahmanbaria, Comilla District)
Railway	Thana Boundary
Metalled Road	Union Boundary
Un-Metalled Road	0-19%
Project Boundary	20-39%
International Boundary	40-59%
	60-79%
	> 80%

Source: Gumti Phase II Feasibility Study 1st progress report

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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 5.5

Distribution of Monthly Household Income

Income Group	Burichang % of HH	Bangladesh % of HH
< 1000	13.0%	13.0%
1000-2000	24.0%	22.9%
2000-3000	26.0%	25.9%
3000-4000	14.1%	16.1%
4000-5000	5.2%	6.3%
5000-6000	3.7%	4.0%
6000-7000	3.7%	3.1%
7000-8000	3.1%	2.6%
8000-9000	2.6%	2.4%
> 9000	4.7%	3.8%
Average	2,981	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 BBS census it has been possible to assess the extent of the landlessness phenomenon within the project area and to present it in Table 5.6.

TABLE 5.6

Distribution of Landless Households (Zone Wise)

% of Households	A	B	C	D	Total
< 10%	1	0	0	0	1
10% - 20%	9	0	0	3	12
20% - 30%	8	10	14	9	41
30% - 40%	0	4	9	14	27
40% - 50%	1	3	3	7	14
50% - 60%	0	0	1	0	1
Total Unions	19	17	27	33	96
Zone Average	20.6%	31.1%	32.7%	33.6%	30.2%

Source : 1981 BBS Census Data

In 1981, around 30% of the households living in the project area owned less than 0.05 acres (5 decimals) of agricultural land and are therefore considered landless. As shown in the landlessness distribution map (Figure 5.4), this average figure hides significant variations among zones (21% in Zone A, around 32% in Zones B and C and 34% in Zone D) and unions.

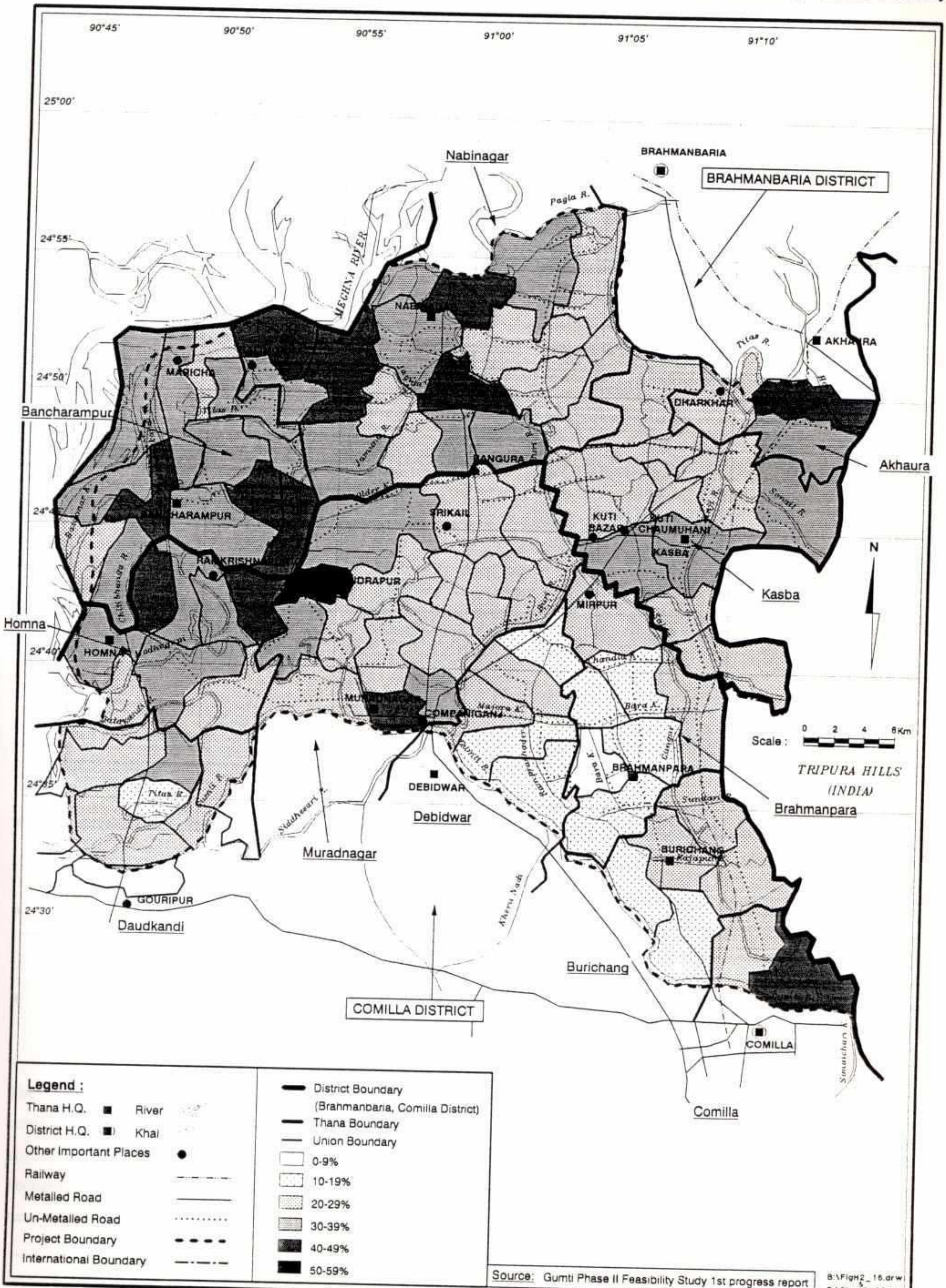
5.3.6 Activity Status and Employment

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 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.

Figure 5.4

Proportion of Population Landless 1981 (< 0.05 Acre)



Source: Gumti Phase II Feasibility Study 1st progress report

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In the project area, the rate stands at nearly 40%, although slight differences occurred among zones with variations ranging from 37.5% in Zone A to 42.8% in Zone D. These differences become clearer when analysing the activity status at the union level. The modal class for Zones A, B and C is 35-40% while it increases to 40-45% in case of Zone D, as shown in Table 5.7.

TABLE 5.7

Distribution of Refined Activity Rates (Zone Wise)

Activity Rates	A	B	C	D	Total
< 30%	0	1	0	0	1
30% - 35%	4	1	5	0	10
35% - 40%	13	8	14	11	46
40% - 45%	1	6	7	16	30
45% - 50%	0	1	0	4	5
> 50%	1	0	1	2	4
Total Unions	19	17	27	33	96
Zone Average	37.5%	38.6%	38.7%	42.8%	39.8%

Source : 1981 BBS Census Data

The higher participation in economic activities observed in Zone D 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) is much lower in Zone D (51%) than in other zones (65% to 71%). 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.

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In the project area as a whole, crop cultivation provides employment to more than 60% of the economically active population. However, as shown in Figure 5.5, significant variations among zones and unions have to be noted, particularly in Zone D where the importance of cultivation is significantly lower than elsewhere in the project area.

When looking at the importance of non-crop cultivation (in fact mainly fisheries), the situation changes, with Zone D at the top (3% of full-time fishermen) and Zone A at the bottom (less than 1%).

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 5.8 presents the numbers of persons employed in agriculture, by district, between 1961 and 1981. For purposes of comparison the two districts adjacent to Comilla are included.

TABLE 5.8

Agricultural Workforce by District 1961 - 1981 (000s)

District	1961	1974	1981
Comilla	1,901	1,331	1,088
Noakhali	801	643	505
Sylhet	1,164	1,232	1,057

Source: (BBS : 1984)

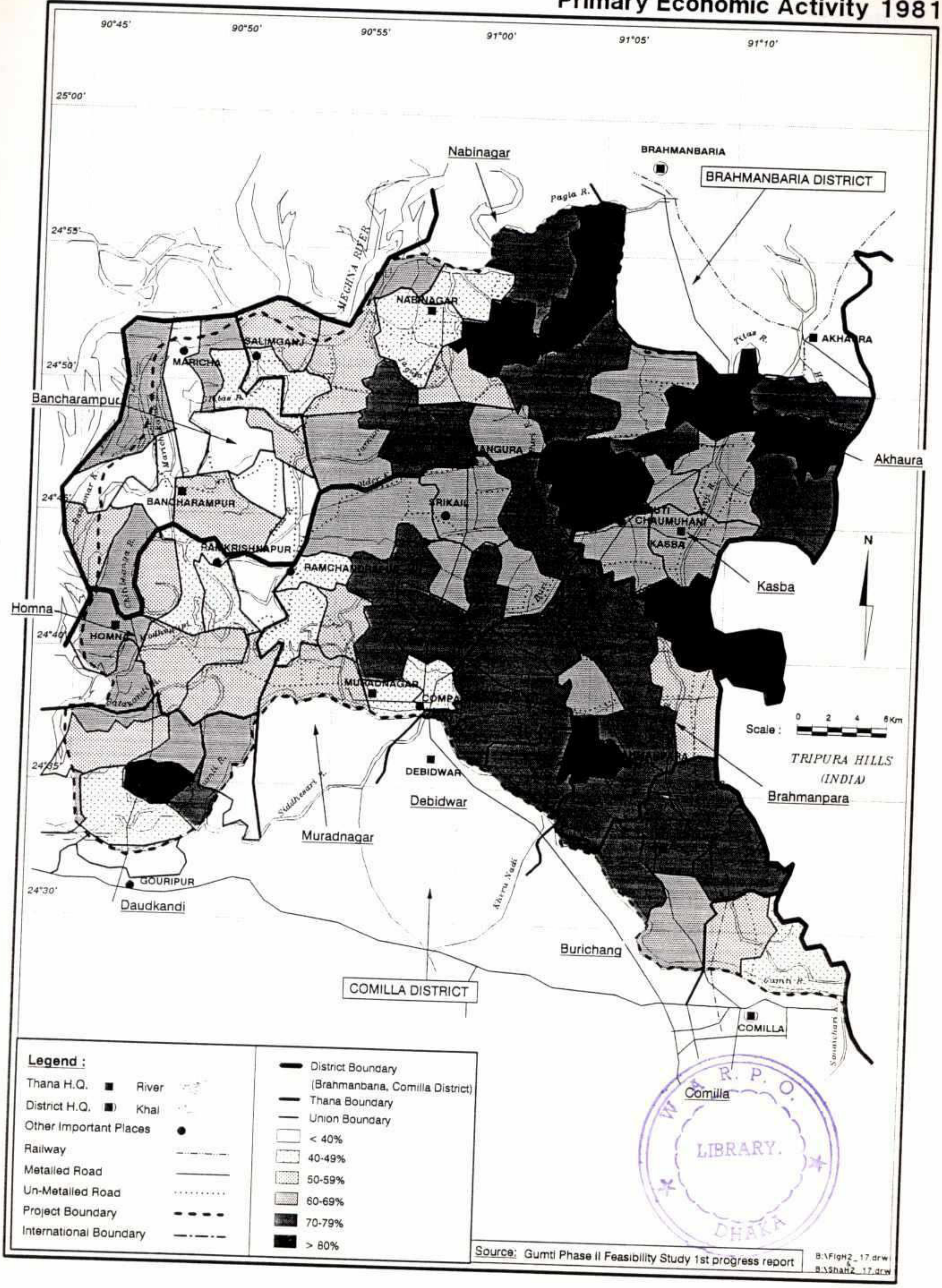
The information available suggests that agricultural employment opportunities are declining while other rural employment opportunities are not growing fast enough to cope with the growth of the rural labour force. Indeed nationally between 1961 and 1981 there has been a decline in the amount of employment 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 took 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 Gumti Phase II 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.

Figure 5.5

Proportion of Population with Agriculture as Their Primary Economic Activity 1981



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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 D seeming to be the most severely affected. This becomes more evident when looking at Table 5.9, which lists the most disadvantaged unions.

TABLE 5.9

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

Thana	Unions	Zone	Mouzas	Area	HH	Population
Muradnagar	Dakshin Ramchandrapur	C	8	2985	2503	14157
Bancharampur	Dakshin Bancharampur	D	4	3048	2535	14674
	Salimabad	D	14	6229	4469	26443
	Pachim Saifullah Kandi	D	9	3746	3283	19409
	Purba Daria Daulat	D	10	4997	3634	21432
	Purba Rupasdi	D	2	3296	2828	17376
	Pachim Rupasdi	D	4	2297	2744	16252
	Purba Tejkhali	D	8	3337	2965	17479
	Purba Ujan Char	D	4	3209	2584	14700
Homna	Purba Chandar Char	D	8	3287	3574	20984
	Pachim Chandar Char	D	8	3969	2872	16333
	Purba Ghagutia	D	17	2934	3443	19058
	Pachim Ghagutia	D	6	3386	3384	18325
Total			102	46,720	40,818	236,622

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

- literacy rates below project average (19.9%);
- % of households without potable water above project average (34.9%);
- % of landless households above project average (30.2%);
- refined activity rates above project average (39.8%); participation in economic activities is higher because children have to work earlier to contribute to the household's struggle for survival;

- % of active population employed in cultivation below project average (62.9%); there is less employment in the farming sector which is usually the main source of rural income. With less employment opportunities in agriculture, the poor have to get engaged in non-formal activities which are usually less remunerative.

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 solely on the sale of their labour. As shown in Table 5.10, 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 higher in Zones C and D than in Zones A and B. Besides wage employment, trading/shopkeeping 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 (canal re-excavation, embankment construction etc.) and in brick fields.

TABLE 5.10

Primary Occupation of Landless People

Occupations	Zone A	Zone B	Zone C	Zone D
Labourer/Casual Worker	45.8 %	37.5 %	41.7 %	33.3 %
Shopkeeper/Trader	20.8 %	16.7 %	20.8 %	29.2 %
Fishermen	4.2 %	4.2 %	8.3 %	8.3 %
Others	29.2 %	41.6 %	29.2 %	29.2 %
Total	100.0 %	100.0 %	100.0 %	100.0 %

Source : Project agro-economic surveys

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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.

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 survive during the monsoon, most of them fish in the floodlands, especially in Zones C and D (60-70%). A few find employment in the water transportation sector as boat drivers (motor boats) or pullers (non-engine boats), obtain occasional labouring work from landlords or borrow from money lenders or relatives.

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.

Low employment opportunities in the agricultural sector are a huge problem for the landless, especially in Zones C and D where the vast majority of the respondents indicated that employment opportunities were declining (70%-75%). 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 also 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 usually belong to the most deprived sector of the rural society, depending mainly on fishing for their survival. The results of the fishermen survey conducted within the course of the study show that just under half of the sample have no other source of income than the sale of fish. Of the remainder, 84 % give fishing as the main source of their household income with farming cited as the major second source (53%). Thus, out of 169 fishermen interviewed, 155 (92 %) are therefore essentially dependent on fishing for their livelihood. Table 5.11 further illustrates this point indicating that significant differences exist between zones with fishermen from Zone D being more exclusively dependent on fishing than anywhere else in the project area.

Fishermen fish throughout the year though the most productive period is from October to December, when the water recedes and fish get trapped in low lying pockets. For the fishermen, the most critical period is before the monsoon (March to May), at a time when less fish are available. During this time, they usually cannot afford more than one meal of rice per day since their cash income is reduced to an average of 10 to 15 taka per day as compared to 30-40 taka per day when the season is good (post-monsoon).

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TABLE 5.11

Main Source of Income of Full-Time Fishermen

Sources of Income	Zone A	Zone B	Zone C	Zone D	Total
Fishing Only	20.0 %	51.4 %	40.5 %	63.1 %	48.5 %
Fishing Main	68.0 %	45.9 %	47.6 %	29.2 %	43.2 %
Other Main	12.0 %	2.7 %	11.9 %	7.7 %	8.3 %
Total	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Source : Project fishermen survey

For these people, the problems constraining their livelihood are linked with:

- the reduction in the catch;
- the lack of capital to invest in fish drying and processing activities which could significantly raise their income and generate employment;
- the management system of open waters: access to fishing rights is controlled by middle men (jotedar) who take the biggest share of the profits leaving the fishermen with only the bare minimum for survival.

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 engaged in other activities such as wage employment or petty business.

During a discussion held in Muradnagar with a group of marginal farmers, they indicated that they grow only one paddy crop from May to October (B aman) which provides a sufficient quantity of rice to feed their family during 2 to 3 months per year (November to January). However, they mentioned that in the last five years, they have harvested only one aman crop, in 1992. Every year from 1988 to 1991 flood water caused serious damage to their crop. In the winter season, on a small portion of their land, they grow rabi crops such as wheat, sweet potatoes, mustard, pulses and chilies. In addition to this, most of them migrate to other districts to work on other people's land, planting and harvesting boro crops (December and April to May)) and engaging in earth cutting schemes. They mentioned that they would like to cultivate boro but there is gas in the ground so shallow tubewells cannot be used to extract ground water.

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.

They identified six major problems which adversely affected their livelihood:

- damage to their aman crop due to breach of Gumti embankment (as happened in 1991) and monsoon flooding.[1]
- irrigation from groundwater is not possible (gas) and surface water irrigation cannot be practised due to insufficient surface water; therefore they cannot cultivate a boro crop.
- 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.
- lack of employment opportunities due to non availability of rural cottage industries in the area.
- sharecropping system is unfair, 50% of the harvest goes to the landlord while all input costs are born by the sharecropper
- 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. A group of farmers in Kasba reported that they depend mainly on farming for their livelihood which provides them with sufficient food reserves throughout the year. They feed their family on the boro and aman produced from their land and they do not need to purchase paddy unless their crops are damaged. Also, most of them earn additional income from the production of vegetables (rabi crops) or by engaging themselves in petty business trading. Occasionally, to face some unexpected hardships such as crop damage due to flood, they will work as daily labourers and/or will request loan/help from relatives.

5.5 Women's Roles and Activities

In rural Bangladesh most of the women's activities are performed within the homestead area and are not remunerated. Their activities are usually considered as 'housework' and most of them are considered not to be economically active. This fact is further illustrated in Table 5.12 based on UDMP data which are available for Burichang thana.

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[1]It should be noted that the section of Gumti embankment which breached in 1991 was not part of the new remodelled section.

TABLE 5.12

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	
Comilla	Burichang	Male	62.66	48.53	47.30	1.23	14.13
UDMP - 1990		Female	62.31	4.80	4.38	0.42	57.51

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 Gumti Phase II Project Area is given in Table 5.13.

TABLE 5.13

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.

It is evident from group discussion and from the women's survey that the majority of women are engaged in non-remunerative productive work with only a few engaged in remunerative activities. Detailed information from the women's survey is given in Tables 5.14 and 5.15.

TABLE 5.14

Non-remunerative Productive Activities

ZONE	A		B		C		D		Total	
	#	%	#	%	#	%	#	%	#	%
Work in own field/garden	26	93	23	96	23	96	24	100	96	96
Handicrafts/weaving/sewing	0	0	1	4	30	0	0	0	1	1
Poultry/livestock/fishpond	15	54	17	71	22	92	22	92	76	76
Make nets/dry fish	1	4	0	0	0	0	0	0	1	1
Post-harvest work	20	71	17	71	16	66	16	66	69	69
Collect/make fuel	18	64	15	63	20	83	24	100	77	77
Total	28		24		24		24		100	

Source: Project Women's Survey.

TABLE 5.15

Remunerative Productive Activities

ZONE	A		B		C		D		Total	
	#	%	#	%	#	%	#	%	#	%
Poultry/livestock/fishpond for sale	6	75	2	50	0	0	0	0	8	40
Process food for sale	0	0	1	25	0	0	0	0	1	5
Work outside the home	1	12.5	1	25	5	100	3	100	10	50
Other (Service)	1	12.5	0	0	0	0	0	0	1	5
Total	8	100	4	100	5	100	3	100	20	100

Source : Project Women's Survey

All women do domestic/family work in the household i.e. participate in reproductive role. The majority of women work in their own kitchen garden growing pumpkins, chilies, beans etc. by the side of their house. The second highest participation is in poultry or livestock raising and the third highest is post harvest work. Around 70% of the female head of a household are engaged in this type of work.

In the women's survey only 11 women reported working outside their homes for remuneration. Among them only one has a salaried job, while the remaining 10 are employed in domestic and post harvesting work. Eight out of ten women are paid in kind i.e. 1/2 to $1^{1}/_{2}$ kg. rice depending on the nature of the work. There is no hard and fast rule as regards food. Among these 10 women, four were heads of household and had no support from relatives.

There is not much work available in the villages. Only a few middle income and rich farmers employ women, mainly during paddy harvesting times. Typical work availability is presented in Table 5.16. As husking is done in mills, many of the poorer women complained of this lost earning opportunity. The cases of Asia and Anwara (Annex G, Appendix 2c) give a more precise picture of seasonal work availability, duration, and remuneration patterns.

TABLE 5.16

Probable Availability of Post Harvest Agricultural Work

Seasonal Work Availability	Duration	Remuneration Pattern
Processing of Rabi crop	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).	One 'sari', one maund of paddy and three meals a day; or in some places 1½ kg rice and three meals a day.
Processing of Aus.	One month (from middle of Asar to middle of Sraban.)	½ kg rice or 1½ kg paddy and food twice.
Taking out fibres from Jute.	7/8 days in Ashwin and Kartik.	About 12 to 16 Tk. per day.
Processing of Aman.	2 months (Agrahayan- Paus).	Two meals and 1¼ kg paddy or 1 kg rice per day.

When a woman is the household head, she has to manage all the household activities. Female children help in the housework while the male children help in collecting fuel-wood, fishing and shopping.

In joint households or in households where more than one adult female member live, they share the work. Generally the young women (i.e. daughter or daughter-in-law) cook, collect drinking water and look after the family. There is a preference for keeping women in the house for as long as possible and not letting them work outside the home.

From discussions with women from different quarters, the major problems and issues faced were identified and are briefly presented below.

- **Drinking Water**

Dry season scarcity of drinking water, water for bathing and for domestic use is considered to be one of the major problems in Gumti Phase II area. In the dry season the hand tubewells often have to be primed with surface water, which may be polluted.

Among the 16 sample villages for people's participation, only in Kalikapur (Zone A) did women report that they collect drinking water from DTWs during the dry season. Among the women interviewed in the Gumti project, poor women who do not own a tubewell stated:

"During the dry season, only rich people, those who have private tubewells, use clean water for domestic use, bathing and washing. The little water left in ponds and khals becomes very dirty. However, we have no alternative but to use it. We bring water for domestic purposes early in the morning because water remains clean at that time. Rich people do not object to us bringing drinking water from tubewells but do not allow us to use the water for other purposes."

- **Fuel-wood Collection**

Whether rich or poor, management of fuel for cooking is considered women's responsibility. Farmers who grow jute keep some jute sticks for cooking purposes. After harvest, straws of wheat, pulses, mustard and paddy are dried and kept for fuel. Dried up branches and leaves of trees, water hyacinths and bamboo sticks are also generally used as fuel in the Gumti area.

In Zones A and B, poor children, men and some women collect firewood from the bushes of the Indian hills. Most of the fuel collected by women and children are used for their own consumption. If they can collect enough, they sell a share and spend the money on household consumption. They have to do this to survive.

Women are anxious to collect and store some fuel prior to the monsoon. During monsoon periods, fuel is costly and it is difficult to get hold of fuel which is dry. From the women surveyed, it was found that 64.3% of respondents in Zone A, 62.5% in Zone B, 83.3% in Zone C and 100% respondents in Zone D collect and store fuel in preparation for monsoon flood.

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■ **Short Term Migration of Husbands**

Women have to manage the household when the household head migrates to find work. Among one hundred sample households, 17.9% of respondents in Zone A and 12.5% in Zone B migrate to find work, spending an average of 83 days per year away from home. No migrants were found among the sample taken from Zones C and D although the people's participation meetings found many migrating from Zone C.

All the migrants send money to their families left behind in the villages. What the poor labourers send is neither sufficient nor regular. In times of crisis, women often borrow money from shops, relatives or money lenders at an interest rate of 10% per month.

In Bandharampur village of Daudkandi (Zone D), it was reported that when the household head works away from home for 10-15 days, he arranges with a shop to provide the necessities required by his family in his absence. If paid in cash, the price of rice is Tk.45 for 5 kgs. But the credit price is Tk.47 for a week or two.

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 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 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 H-IV of Annex H covering the Environmental Impact Assessment.

The way in which the proposed interventions alter the environmental components is addressed in detail in the Environmental Impact Assessment work for the study (Annex H) and summarised in Section 12 of this, the Main Volume of the Final Feasibility Report.

6.2 Ecology

6.2.1 General

The floodplains of Asia have been inhabited and modified for many centuries. As a result, works for irrigation, drainage and flood protection have caused the disappearance of many of the original features of the floodplain.

Bangladesh is no exception as much of the country is a dynamic delta region with approximately 80% of its total land lying within the floodplains of the Ganges-Brahmaputra, a delta of some 40,225 square km (Verghese, 1990; Rashid, 1991).

Recently, there has been an increase in the awareness regarding the effects that these changes are causing to the environment and there has also been a realisation that some of these changes are detrimental to the natural resources on which the people of Bangladesh rely for their every day lives and survival. As a result, some of the projects currently being proposed have started to take the environment into account and have produced useful accounts of the ecology and/or environmental situation in their particular areas.

6.2.2 Data Collection

The most useful information, especially regarding historical records, was provided by the District Gazetteer which contains details of terrestrial and aquatic plants and animals of the Greater Comilla District. However, this information was obviously insufficient for the ecological appreciation of the target areas. Therefore, a short field programme to cover both the wet and dry seasons was devised in order to gather information on the present and past distribution, abundance and species diversity of the terrestrial and aquatic ecosystems in the project area. Valuable information was also gathered from indigenous sources.

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Field Data Collection

After a reconnaissance trip to the project area (October 6, 1992), eight sampling locations were selected and are shown on Figure 6.1. The study stations are located throughout the project area covering all four planning Zones, which are shown in Figure 9.1. Two field trips, covering the wet and dry seasons, each of one week duration were conducted in the area for collecting the samples, field data and other relevant information. The first field visit took place from the 18 to 24 October 1992 and the second one from the 2 to 8 December, 1992. In general, the same sites were sampled for terrestrial and aquatic ecology.

Terrestrial Ecology

Terrestrial ecological data were generally collected during transect walks within the survey sites. At each type of habitat encountered in the transect, field notes and plant species collection were made, to record the presence and abundance of each plant and vertebrate species. It should be pointed out that, with a few exceptions, the invertebrate fauna was not recorded since it required additional expertise not available to the study. In addition to direct observations, it was considered important to tap the existing knowledge available through the local people who were asked about the occurrence of species other than those recorded on the day of the field visit, as well as those species which appeared to be in decline. It was thus possible to assemble a more complete picture of the fauna of the study area. These records generally related to mobile species such as birds, mammals and reptiles.

Local people were also asked to describe the uses that they made of the species, particularly regarding medicinal plants found within the study area.

Those plants and animals which appeared to be dominant or extremely common were recorded as 'widespread'. Less dominant or widespread species were then allocated to one of five groups: common, occasional, uncertain, rare and at risk.

Aquatic Ecology

The principal water bodies can be categorised as: rivers and khals, inundated char lands, beels, ponds, roadside ditches, marshes and irrigated rice fields.

In the present survey, emphasis was given to the collection of biological material from the above mentioned habitats, their subsequent analyses in the laboratory, and preparation of a species list with notes on species' abundance and their role in their respective ecosystem. Samples from the following communities were collected: pelagic (free swimming) plankton, tychoplankton (loosely attached forms), periphyton (forms firmly attached to submerged objects), free floating algal mats, bottom fauna, and aquatic macrophytes.

As for terrestrial ecology, eight sampling locations were selected and these were the same or adjacent to the sites chosen for the terrestrial ecology samples.

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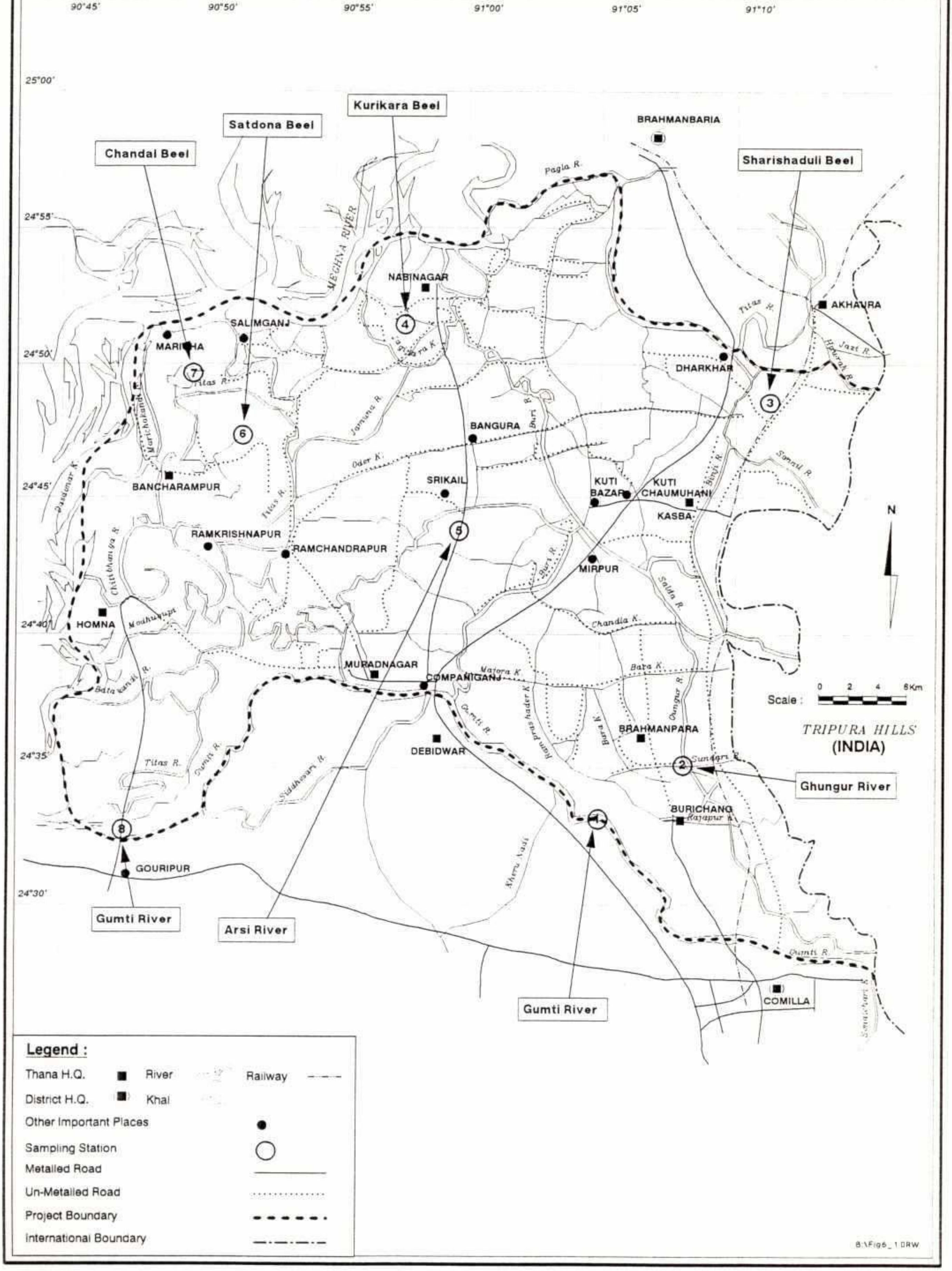
Figure 6.1
Site Location for Terrestrial and Aquatic Ecology Field Data Collection



6.2.3 Study Findings - Terrestrial Fauna

A list of faunal species was drawn up together with their English, Bengali and scientific names, and taxonomic position. The list also includes details of habitats, past and present occurrence, status and known feeding habits. Sampling stations represent locations where the species were recorded. This information is given in Table D.3.2 in the Ecology annex, Annex D. Table 6.1 shows the distribution of the main groups of animals according to the sampling stations. It is interesting to note that with the exception of stations 3 and 7 which had 77 and 56 species respectively, all other species had a fairly similar number of species.

Overall around 90 species of vertebrates were discovered during the study period. Of these, a total of 16 species of mammals, 50 species of birds, 16 species of reptiles and 5 species of amphibians were recorded.

TABLE 6.1

Distribution of the Main Faunal Groups by Sampling Stations

Faunal Group		Sampling Station							
		1	2	3	4	5	6	7	8
Mammals	16	8	11	15	8	12	8	6	10
Birds	50	37	36	41	39	38	40	37	40
Reptiles	16	12	13	16	11	15	10	8	14
Amphibians	5	5	4	5	3	4	5	5	3
Total	87	62	64	77	61	69	63	56	67

Mammals

Overall, mammals diversity was not very high with only 16 species recorded. Of these, the largest number was found in sampling stations 3 and 5, in the north east and central part of the project area. The lowest number of mammals was found in station 7. The Laye Indian civet and the Fishing cat were only recorded in Gopinathpur. These two species are nationally endangered and very few are observed today. Mammals are an important component of the ecosystem and some of them such as the predators, occupy the top position in the food chain. They prey on a range of smaller animals which feed on crops in the field and in storage.

A species of note was the Gangetic dolphin or Sisu (*Platanista gangetica*) listed as an internationally threatened species (IUCN, 1990) which was commonly found in the project area. Sisu are especially abundant in rivers during the rainy season and may also move on to the floodplains. During the dry season they stay in the deeper parts of the rivers such as the Titas. They feed mainly on fish. Their presence in the ecosystem is an indication of deeper areas in a river, higher abundance of larger fish species and fish migratory routes within the river channels. Further work should be carried out to establish the status of this species and to possibly identify other cetaceans in the area.

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Birds

A total 50 species of birds were identified in the project area, of these 30 were terrestrial and 20 were aquatic or water dependent. Birds were the group with the largest number of species at all sites representing 53% to 66% of the total fauna by station. The majority of the birds were resident species with very few migratory ones. The bird species recorded during the eight-week sampling period represent 15% of the 650 bird species reported for Bangladesh. It is feasible that a larger number of species may be found in the area, particularly if surveys are carried out during the main bird migrating season. The area to the north-west of the study area had been identified previously as a potential good site for migratory birds (FAP 5 Regional Study). Unfortunately, it was not feasible to verify this possibility during this short study.

A large number of insectivorous birds were recorded in the project area especially in those localities located in higher grounds. These birds play an important role in the agro-economy of the region as they act as biological controls of agricultural pests as well as being pollinators for a variety of plants . The use of biological controls was found to be in practice in the project area in stations 1 and 2. Predator birds also play an important role by consuming rats and other pests which create a serious threat to the paddy cultivation.

Birds are particularly valuable as environmental indicators as they often occupy key positions in the trophic chain. They are also amongst the more obvious components of the ecosystem and many species are habitat specific and very sensitive to habitat alterations.

Table 6.2 shows the distribution of aquatic and terrestrial birds by sampling station. Aquatic birds were found around ponds, beels, floodplain and rivers. These habitats provide suitable breeding and feeding grounds and food availability is usually high with fish, molluscs, aquatic plants and seeds, etc. The largest number of aquatic species was found in the areas of stations 4, 6 and 7, which are some of the most important wetlands in the study area.

TABLE 6.2

Distribution of Terrestrial and Aquatic Birds by Sampling Stations

Birds		Sampling Station							
		1	2	3	4	5	6	7	8
Terrestrial	30	27	26	26	19	28	21	17	30
Aquatic	20	10	10	15	20	10	20	20	10
Total	50	37	36	41	39	38	41	37	40

According to the local people, aquatic birds in general are gradually decreasing in numbers year after year due to the loss of their natural habitats, especially the loss of their natural breeding and feeding grounds. Increased human activities such as shooting and trapping, are believed to be the main cause of this noticeable decline. Reports from local people living around beel areas state that on occasions fishing nets are used for capturing birds during the night.

Reptiles

There were 16 species of reptiles recorded in the project area. Of these, monitor lizards and skinks were often seen close to water bodies for feeding. Water snakes are very common to the floodplain of the study area. Highly poisonous snakes belonging to the family Elapidae were recorded with the help of local people. Freshwater turtles, monitor lizards and water snakes found in the study area are carnivores feeding on fish and other small animals in the freshwater habitats.

Amphibians

Five species of amphibians were recorded during the field study. Frogs are important to the agricultural production because they help to control various kinds of pests in cultivated land. The Bull frog was previously common and widely distributed throughout the country but its population has sharply declined both at a national as well as a local level.

The decline in frog populations is currently a worldwide problem and relatively little is known regarding the cause of this decline. A Specialist Group was set up to look at this problem recently by the Species Survival Commission of the IUCN - The World Conservation Union.

Wildlife Pests

Some of the animal species found in the project area are considered as agricultural pests, causing damage to crops in the different stages of cultivation or harvest. These include various species of rats such as the Indian field rats, bandicoot rats and domestic rats among the mammals. Pests included and parakeets and purple moorhens among the birds. The effects of terrestrial birds like parakeets were only reported by the local farmers from the eastern side of the project area, while those from the purple moorhen were reported from the north-west part of the project area. Rats are widely distributed in the project area. It is possible that the rat population may increase in Zones A and B due to the drier conditions resulting from control flooding and polderization.

Endangered and Threatened Species

According to Khan (1991) and Sarker (1988), 25 animal species recorded during this Study are nationally threatened or endangered. Field records suggest that 7 more species are rare and 6 species are at risk within the study area. The rest of the species are either common or occasionally observed by the local people but not rare. Two internationally threatened mammal species, the Bengal Fox and the Gangetic Dolphin were recorded in the project area (IUCN, 1990). The Gangetic Dolphin was found to be relatively common in the rivers within the project area, especially in the Gumti and the Titas.

According to the Gazetteer for the Greater Comilla District (Khan, 1977), several mammal species such as the Barking Deer, Tigers and Panthers occurred in the region some 100 years ago. At present it is impossible to confirm this reports by the local people in the study area. The systematic position as well as the scientific, English and Bengali names of these Gazetted extinct animals are as follows:

Systematic Position	Scientific Name	English Name	Bengali Name
Class - Mammals			
Order - Artiodactyla			
Family - Cervidae			
	Muntiacus muntjac	Barking Deer	Ruru Harin
Order - Carnivora			
Family - Felidae			
	Panthers pardus	Leopard	Chita Bag
	Panthers tigris	Royal Bengal	Tiger Bagh

6.2.4 Study Findings - Terrestrial Flora

A list of the flora recorded in the project area by sampling station was prepared and is presented in Table D.3.6 of Annex D, the Ecology Annex. This list also includes details of the scientific, English and Bengali names, habitat, past and present occurrence, and of some of the uses made of the species. The plant species were divided into three main groups: trees, shrubs and herbs. The distribution of these plants by group in the sampling stations is presented in the Table 6.3, where it can be seen that sampling station 5 has the largest number of species and station 7 has the lowest.

TABLE 6.3

Distribution of Plant Groups by Sampling Stations

Plant Group		Sampling Station							
		1	2	3	4	5	6	7	8
Trees	44	28	23	24	17	39	26	13	28
Shrubs	19	11	07	11	12	17	10	11	12
Herbs	22	17	20	15	14	18	13	11	17
Total	85	56	50	50	43	74	49	35	57

Terrestrial plant communities are capable of using sunlight to accumulate large biochemical reserves, which form the primary energy source for the rest of the consumers. During the flood season this process is interrupted on the flood lands, because terrestrial plants can not breathe under water. Besides their vital role as primary producers in the floodplain ecosystem, plants offer crucial resting, feeding and breeding grounds for many wild mammals, birds and reptiles.

The natural vegetation found in the project area also fulfils many of the needs of the local people, being used for fuel, medicinal and construction purposes and as food items (see Table 6.4). Not surprisingly, nearly 73% of the plants in the study area are used for fuel and nearly 50% of the recorded floral species are used by the local people for medicinal purposes to cure various diseases and injuries in preference to the high cost modern medicine which may have adverse side effects. Details were recorded on the medicinal plants found in the study area, together with their scientific and local names, their chemical composition and their use. This is presented in Annex D, Table D.3.9. From this table it can be seen that Station 5 had the highest number of medicinal plants, representing nearly 90% of the total number of medicinal plants recorded for the study area. Stations 6 and 8 each had 66% of the total and Station 7 had the lowest, representing 49% of the medicinal plants in the study area. The distribution of the main vegetation types in the Gumti Phase II Project area are shown in Figure 6.2.

TABLE 6.4

Distribution of Plants According to Their Major Uses

Plant Group	Major Uses									
	Reli.*	Fibre	Timber	Med.*	Food	Fuel	Fodder	Con.*	Orn.*	Craft
Trees	0	1	32	18	20	40	5	7	3	3
Shrubs	2	0	0	13	1	11	0	0	2	2
Herbs	1	0	0	16	9	12	3	0	1	2
Total	3	1	32	47	30	63	8	7	6	7

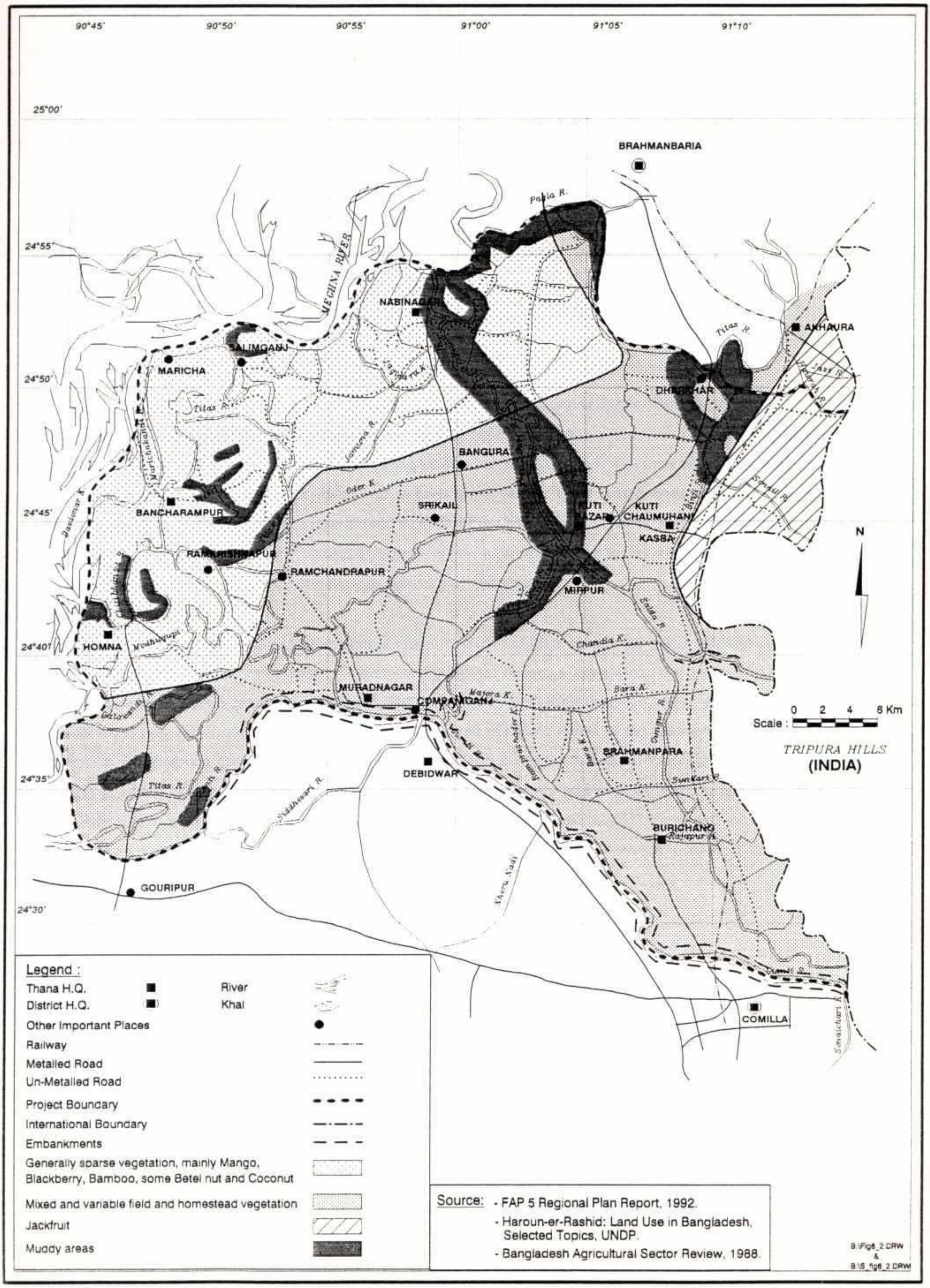
Note:
Reli.* = Religious; Med.* = Medicinal; Con.* = Construction; Orn.* = Ornamental

6.2.5 Study Findings - Aquatic Ecology

Aquatic flora and fauna found in the project area, together with details of their habitat and abundance at each site, were listed. Details are presented in Table D.3.10 to D.3.15 in Annex D. Overall there were approximately 133 algal genera and/or species. The highest frequency of them was recorded in Station 3, with the lowest in Stations 1 and 7.

Figure 6.2

Distribution of Main Vegetation Types



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National Diversity

Approximately 51% of the planktonic algal genera reported for the country are found in the Gumti Phase II study area, with 39% of the Chlorophyceae (green algae), 62% of the Bacillariophyceae (diatoms) and 57% of the Cyanophyceae (blue-green algae) also represented. The Euglenophyceae (flagellates), Dinophyceae (dinoflagellates), Chrysophyceae (chrysomonads) and Cryptophyceae (cryptomonads) were represented in the Project area.

An extremely interesting finding was the Chloromonad *Gonyostomum semen* which appears to be a new record for the country. This rare algae was only found in Site 3 (Sharishaduli Beel) where it was found in bloom during the field visit in December. Sharishaduli Beel is in the vicinity of a proposed polder (Intervention 2). It is unclear at present what is the status of this species in the project area or the region, or what role it is playing in the ecosystem. It is therefore recommended that further studies be carried out before any intervention takes place.

The aquatic ecology of the area depends very much upon the intensity and duration of the flood and on the high variation in the flood pattern from year to year. In the light of this complex connection, it is difficult to predict what would happen each year. In general, when the major rivers are flooded, the water enters the small rivers, channels, inundated charlands, flood plains and in high flood years, it may reach homestead ponds. Pelagic and benthic consumer food chains are operational in most of the habitats. As trophic chain links (biological and ecological), they are important for terminal biological production represented as fish harvest. Thus, their successful sustainability is essential for the productivity of the area.

The life cycle of organisms related to the trophic chain in the floodplain, where the water retention pattern may be of 3 to 4 months, is rather different. When the floodplain becomes inundated, the perennating life forms start germinating and soon cover the area. All these life forms, including those brought into the ecosystem by the flood water, undergo several changes using the dissolved nutrients found in the sediments and the residuals of agro-chemical applications. The process continues for 2 to 3 months and the floodplain capture fisheries is the outcome of the whole processes. With the recession of flood water and with an increasing fishing activity, aquatic life forms in the floodplain ecosystem are severely disturbed and many organisms start the mode of perennation to survive until the following year. By the end of October and November most of the previously flooded areas become agricultural fields.

6.2.6 Fish Ecology

Over 90 species, belonging to 10 Orders and 27 Families, were recorded during the study. Approximately 50% of which were actually observed in the catch. The rest were reported by the fishermen of the area. This represents around 35% of the total number of freshwater fish species currently known in the country. The family with the largest number of species was the Cyprinidae with 24 species, followed by the Bagridae with nine species, and Eleotridae with six. Overall, there were 24 species of carps and 24 species of catfishes. It is very likely that these figures may increase after a more in depth analysis of these fauna, especially if all species are considered and not just the commercial ones.

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Of the crustaceans, only Golda Chingri or Golda Icha *Macrobrachium rosenbergii* and small shrimps or Choto Chingri *M. styliferus* were recorded in the catch. However, according to fishermen's reports, 10 species of palaemonids and one ocypodid, Kakra (*Ocypoda certophtalma*) also occur in the area. Clearly, the number of invertebrates found in this vast floodplain is also expected to increase after due consideration is given to this important aspect of the ecology of the area.

Fish Migrations and Movements

In an area of floodplain as vast as the Gumti Phase II Project area, fish migration is an important issue for the whole energetics of the system, especially since the number of fish species is so large. In addition, it is important to note that although some fish are in general referred to as 'migratory' fish, by and large all fish species migrate or move from one area to another in the floodplain.

Environmental Stimuli Influencing Fish Breeding and Migration

Breeding begins during the pre-monsoon flood and depending on the rain and water volume in the river and floodplain, most of the catfish, live fish and other species such as Magur, Singi, Koi, Tengra, Pabda, Air, Boal, Gazar and Sol, start breeding towards the end of March and early April. It would appear that piscivorous fish such as some of the catfishes Boal, Gazar and Sol breed earlier than the non-piscivorous species. Optimal environmental conditions for breeding are tempestuous and include flash floods, heavy continuous rain and thunder, which together stimulate fish breeding, especially for Ghonia, Boal, Pabda, Koi, Batasi, Puti and Laso.

It should be pointed out that intervention 1 currently under consideration in Zone A (see Figure 4.6 for the proposed interventions) and which involves control flooding in approximately 73% of the zone, will most likely interfere with the reported fish breeding of species such as Ghonia. The area in Zone A is influenced by flash floods from the Tripura Hills in India. It is currently unknown if there are other species using the area in a similar way. The intervention's effect on fisheries is discussed more fully in Section 4 of this volume and in Annex F.

Fish Migration

In general, a series of environmental factors appear to trigger fish migrations, although these may not always be effective as fish are on occasions left stranded. Some of the main factors influencing fish movements include depth of water, (there seems to be a general tendency for bigger fish to leave the floodplain earlier than the smaller fish), dissolved oxygen concentrations, temperature, light (many fish prefer to move at night) and lunar phase.

In the present study it was not possible to examine fish migration and/or movements in the floodplain or the channels. However, since fish access to the river channels and floodplain areas is crucial to the ecology and to the fisheries as a whole in the Gumti Phase II study area, it is recommended that such a study be carried out before any intervention takes place in areas already identified as important for access.

In addition, full polderization of part of Zone C (Intervention 4) has been proposed very close to the main area of access to the early floods from the Meghna River. The severe effects of such a polder on the important fisheries of the area have been described in detail in the Fisheries Annex F. However, it should also be emphasised in this Annex that the floodplain area in Zones C and D is a vast wetland which is believed to be a haven for numerous species of flora and fauna. It is therefore believed that the proposed polder scheme will also have severe consequences on the wildlife, both flora and fauna, of the area.

Declining Fish Species in the Gumti Phase II Study Area

A preliminary list of declining fish species from the study area was compiled from fishermen's accounts and from information gathered from the Thana Fisheries Officers. This list (Table D.4.1 in Annex D) shows that approximately 41 species appear to be declining in certain thanas. The overall change has been noted in the preliminary list of fish and prawns in the study area but it should be pointed out that this list is incomplete and further work should be carried out before any conclusion can be drawn from it. However, it does highlight the fact that several species have noticeably declined in the last few years. The decline of these species should be viewed not only from the conservation perspective, but from the economic viewpoint as well. The sustainability of these fisheries resources should become one of the top priorities for the local and central governments since the livelihood of many people is based upon them.

Increasing Species in the Gumti Phase II Study Area

A total of 12 species were reported as increasing in the Thana of Bancharampur although some of these same species had already been reported as declining in other thanas. It is possible that these changes are real and that the species simply move within the floodplain from less favourable area to a more suitable one. A more detailed study of these fluctuations in species abundance is strongly recommended as the changes in distribution and abundance could be an indication of the health of the floodplain species.

6.2.7 Conclusions and Recommendations

Floodplain environments are very dynamic in nature and provide a whole mosaic of shifting types of habitats for all species inhabiting them. The result is a wide variety of floral and faunal species that are extremely valuable to the local people both in ecological and economic terms. Despite the short period of time available for this study, it was possible to establish that the Gumti Phase II Project area is a remarkable reservoir of biodiversity.

As far as the species are concerned, both animals and plants are extremely important to the functioning of the floodplain ecosystem but they are also extremely significant because most of them are used by the local people in the area for their every day needs. Undeniably, the use of these resources is intense in the study area as well as in the rest of the country. However, a certain equilibrium, presumably very fragile, appears to exist between the natural resources and the people in the area. It is also likely that in certain areas such as embankments, road sides, ponds and fields, the animal and plant species are interdependent with the people of the area, mutually benefiting each other. Economical benefits are also numerous as the local people of the project area use many of the natural products found in the floodplain as food, timber, fuel, animal fodder, construction material and for medicinal purposes. Without this natural reservoir they would have to rely on man-made products and in modern medicine, often well beyond their reach.

The productivity of the study area in terms of fish yield has been addressed in the Fisheries Annex F, and it is believed to be directly related to the luxuriant plant biota, both micro and macro, available in the floodplain which serve as shelter, feeding and reproductive grounds for fish. To maintain this level of productivity in general as well as in fish production terms and to maintain the healthy state of the floodplain, it is indispensable that periodic flooding be allowed in the main areas of the floodplain, especially in areas such as Nabinagar, Bancharampur, Homna and the northern part of the Gouripur area. Without this second flooding, a large proportion of the existing aquatic habitats which are still to be studied, will perish.

The beels located in the eastern part of the project area support a high number of important aquatic taxa, including a new distribution record for an algal for the country. The viability of these beels fully depends upon the timely entry of flood water through some channels from the Indian territory, the Gunghur River and the Titas River.

It is therefore imperative that water management and the sustainability of the resources are given the highest priority in any proposed and future developments. In addition, further studies need to be made before any intervention takes place, in order to establish with certainty the extent of the diversity of the study area and of its value, in ecological and economic terms.

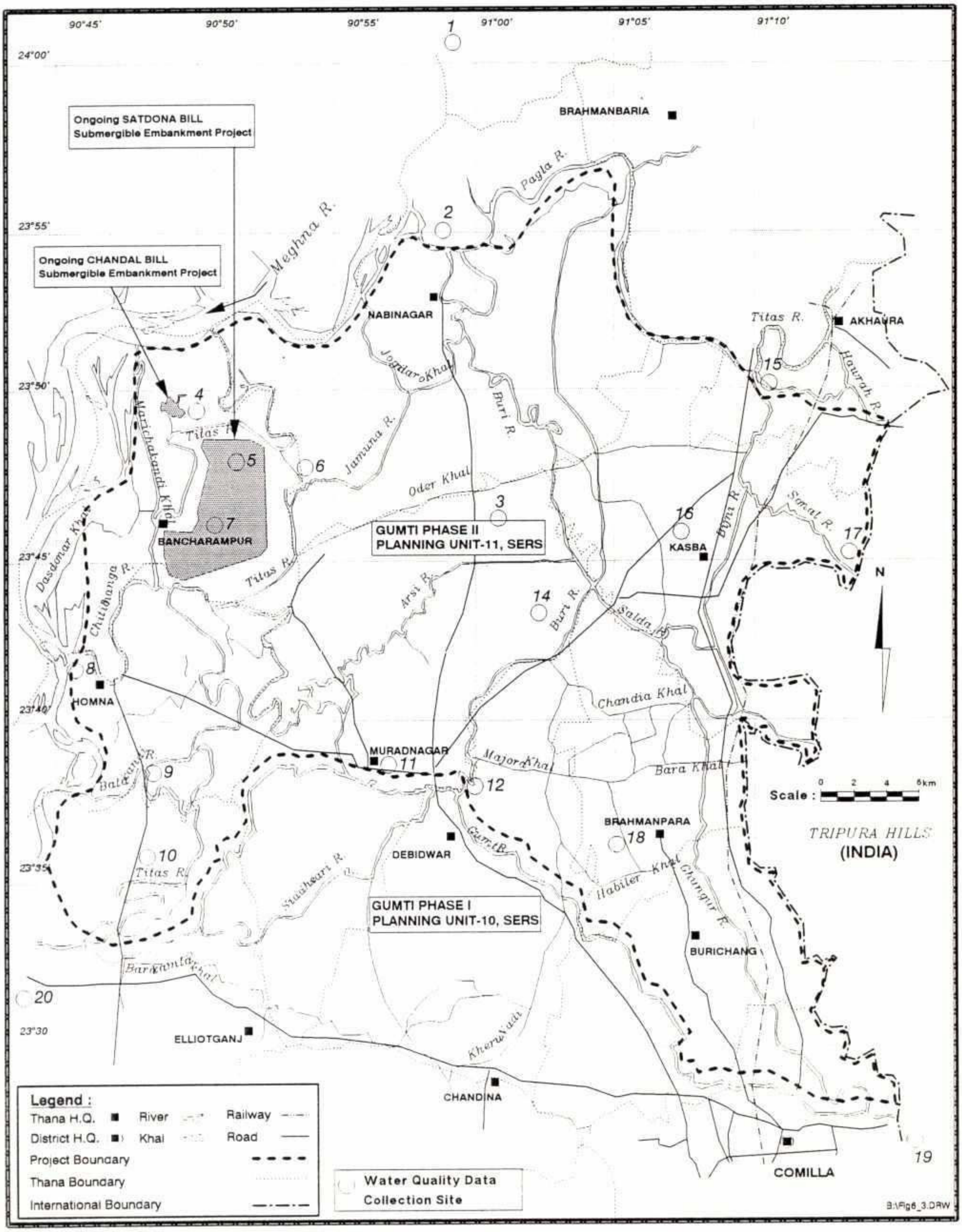
6.3 Water Quality

Surface water quality was tested in both the wet and dry seasons in the study area, the locations of the field data collection are shown in Figure 6.3. The results are given in Tables H.2.1 and H.2.2 in Annex H, and the data is interpreted and compared with national standards for water quality in Section H.2.6.

The situation in terms of groundwater quality has already been outlined in Section 2.3 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 in it 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 and irrigation. Combined with the fact that the level of nutrients in the soil is also low, would seem to indicate that the biological processes are the reason that the area is as agriculturally productive as it is. This has implications for agricultural productivity in that there would seem to be even more need to diversify crop types to reduce the risk of land resource decline due to continuous mono-cropping.

Figure 6.3
Site Locations for Water Quality Data Collection



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 5.3. This has been confirmed through the people's participation work which showed difficulties being experienced in 14 of the 16 villages sampled, the 2 with adequate provision being in Zone B. The 1981 BBS data shows very low levels of provision in some western parts of the study area and the health surveys have also confirmed this. However, checks comparing trends in the BBS data between 1981 and 1991 in the Noakhali north area indicate that although the 1981 provision levels were low, there were very significant improvements in the following ten years (the 1991 data is not available for the Gumti area, which is a major shortcoming in all the socio-economic analysis for the study). This may well also be the case in the Gumti Phase II study area, but overall the area is still poorly provided for and extensive 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, especially in Zone A. The only safe source of potable water in the area is groundwater, but as reported in Section 2.3 there are problems in some areas with this in terms of salinity, gas and also the depth required. This makes it one of the more difficult and expensive areas for tubewell provision in the country and especially when compared to the north of the country where shallow tubewell water is easily available with simple technology down to household level. The quality of groundwater has been assessed in Section 2.3 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 H.IV of the EIA Annex H. The study found that there are serious problems with waterborne disease in the area, with malaria being a problem in the western part of the study area and diarrhoeal diseases in the eastern half.

The findings of the nutritional survey indicated that fish is very important indeed in the western part of the study area providing by far the greatest proportion of protein. It was noted that where Dhal was consumed in the project area, it was brought for cash and very little of it is actually grown locally.

6.6 Culture and Heritage

6.6.1 Settlement History

The history of human settlement in the Gumti 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 erosion and accretion by major rivers and seismic activity have possibly destroyed much evidence) and also because the high density of human population, which has meant that the materials from any substantial construction that has been abandoned have often soon been claimed 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 well organised human settlement within the area that now comprises Comilla District as early as the years 340 BC to 380 AD. The earliest known written accounts referring to human occupation are from Buddhist writings from the 7th Century AD. There are also significant remains of Buddhist societies of this time just outside the immediate study area, located 20 km west of Comilla and south of the Gumti River near Chandina on the main Comilla to Daudkandi road. It would appear that there was a sophisticated Buddhist dynasty governing the area from before the 7th Century up until the Turkish invasion at the end of the 13th Century AD. Comilla itself (then known as Tippera) appears to have been set up as an administration area in 1519 and administered by Zamidars (local large land owning families). However there were many conflicts with the neighbouring areas, including Ragamatia, up until 1618 when the area came under the direct administration of the Mughals. European incursion into the area appears to have commenced by Portuguese pirates based in Chittagong soon after 1688. This was followed in 1765 by the activities of the East India Company who administered revenue collection using local Nawabs. There was also a French trading community at Companiganj on the Gumti River around this time. British administration of the area was carried out from Dhaka up until 1784, then from Mymensingh and latterly having a British Resident at Comilla who was administered from Chittagong. Comilla became a separate District (known as Tippera) in 1790 and was split into two when Noakhali District was formed in 1821 with boundary adjustments between the two in 1873 and 1875. There was a major change in administration structure in 1905 when Bengal was divided and East Bengal and Assam were split from West Bengal and administered separately. This boundary was modified in 1911 as a result of local opposition.

Anti British nationalist movements were active from Comilla in 1820, with notable calls for reform of the colonial administration system from 1840 and major civil unrest in 1857. There were religious riots in 1907 attributed to the division of East Bengal and Assam which proved to be divisive and caused major population movement with in-migration from Mymensingh and out-migration to Assam. This appears to have been resolved to some degree in 1911 when the administration boundary was amended to follow the Meghna River. The non-co-operation movement was active from 1920 and there was 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 name of the District was changed to Comilla in 1960 and the liberation war with West Pakistan occurred in 1971 resulting in the formation of Bangladesh as an independent state.

The area is, in comparison to other parts of Bangladesh, relatively mixed in terms of the present cultural and ethnic background of the inhabitants. Many of the 85% majority Muslim population being converts from Hinduism who were resident in the area at the time of the Mughal take over. Of the 15% of the District population who were reported in 1961 to be Hindus, many have caste specific occupations. These include fishermen and weavers and many are concentrated in the western part of the study area. There are a few Buddhists remaining near Comilla and there are tribal people in the adjacent hill areas to the east some of who have converted to Christianity relatively recently. There are also very small Christian communities some possibly of Portuguese origin and activity by Australian and New Zealand missionaries existed in Comilla since 1857.

6.6.2 History of Hazards

The area appears to have sustained high population densities for a considerable period, even in historical times, and is an indication of the richness of its natural resources. The population of the western part of the study area increased in the 1890's due to in-migration. This is possibly linked to lowering of flood risk and extent as the Jamuna River started to take greater flow than the Old Brahmaputra following its relatively rapid change of course at the end of the 18th century brought about by a combination of factors including seismic activity, river capture and change in the course of the Teesta River.

Between 1911 and 1921 the district recorded the lowest death rate in the country but even so this was relatively high by present day standards. By 1921 the mean population was estimated to be 1574 people per square mile (607/km^2) and was considered to be approaching "saturation point". These high densities have been explained by the apparent prosperity created by agricultural activity and particularly jute production. However this made the area very vulnerable and the 1929 jute depression effected the area disproportionately badly. The area was also badly disrupted by the second world war which was a major contributing cause, along with flooding and a cyclone, to the 1943 famine.

There is written evidence of serious flooding in the area as a result of failure of the Gumti River embankments (these were reportedly built sometime before 1669) as early as 1783, 1784, 1788, 1789 and 1794 resulting in a flood induced famine in 1784. Further floods have been reported in 1853, 1870 and 1906 and floods were one of many causes of the 1943 famine. Since then floods which were caused by combinations of Gumti River bank failure, main river flood levels and high rainfall were recorded in 1954, 1961, 1966, 1969, 1970, 1987 and lastly in 1988. Droughts were recorded in 1779, 1783, 1799, 1896 and latterly in 1974 and led to a famine.

The area has one of the higher tornado risks in the country and the last major one occurred in 1969, causing severe damage to 118 villages in the Comilla area and destroyed 30% of the housing in Homna, killing 42 people there. There have been major cyclones in 1893, 1895, 1943, 1960, and 1961 with the last being the most severe in the area as it was combined with a tidal bore northwards up the Meghna estuary and directly hit the study area. This caused extensive damage with 50% of the Katcha houses in Daudkandi Thana being destroyed. Subsequent cyclones include 1965, 1970, 1985 and April 1991.

The study area lies in a medium level earthquake risk area, but there was a serious event in 1897 with its epicentre to the north. There was severe damage to embankments as liquefaction occurred and most masonry buildings were damaged, many of them badly. There were resulting changes in ground level which had significant 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.

There have been cholera epidemics in 1893, 1895, 1896 and 1900. The 1943 famine was accompanied by a cholera and smallpox epidemic. There was an influenza epidemic in the area in 1918-1919 and a serious outbreak of malaria at Kasba between 1921-31.

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6.6.3 Archaeology and Cultural Sites

There are reasonably good 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 and the density of human settlement 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:

- Chandima (Barkamta) Buddhist remains from the 8th century. These lie in the Gumti Phase I area just south of study area on the main Daudkandi to Comilla road. There is also a Hindu shrine of Kali dating from 1670.
- A 16th century fort and Hindu Dighis at Kasba in planning Zone B.
- Hindu Dighis at Nabinagar (previously known as Kaitaba) in planning Zone C.
- A British colonial period bungalow of a jute merchant at Kuti, west of Kasba in planning Zone B.
- The town of Homna in planning Zone D is an old Zamidar headquarters from Mughal times.
- Muradnagar on the Gumti River in Zone C is also an old town.
- Companiganj was an East India Company trading port on the Gumti River and is also reputed to have been settled by French people at one time.

6.6.4 Landscape and Recreation

Although the area has been highly impacted by a long period of human settlement, the dynamic nature of landscape change and seasonal flooding has created a major wetland of regional importance at the western end of the study area. The landscape itself is very flat and unremarkable in terms of topography but the vastness of its flooded area during the wet season has a unique aspect. There are 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. In the regional context the Meghna flood plain north of Homna at Bancharampur may be deemed to warrant some level of protected or managed status.

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. This is despite, or perhaps because of, the high population densities. The south east part of the study area lies within the urban influence of Comilla town and there would appear to be some need for consideration of it in the context of urban expansion and perhaps some need for development control linked to provision of open space and "green belt" policies.

7 Infrastructure

7.1 General

During People's Participation meetings there were no complaints concerning existing infrastructure being regularly flooded. This is born by the fact that the village areas and roads have logically been raised above normal (and generally above 1 in 10 year) flood levels.

An infrastructural survey was carried out during the course of this project, the results of which are discussed in Annex I. In addition, secondary data was collected for roads and navigation. Because the amount of traffic in the area was not considered to be an issue for the recommended options, primary data was not collected.

7.2 Existing Transportation Network

7.2.1 Road Transport

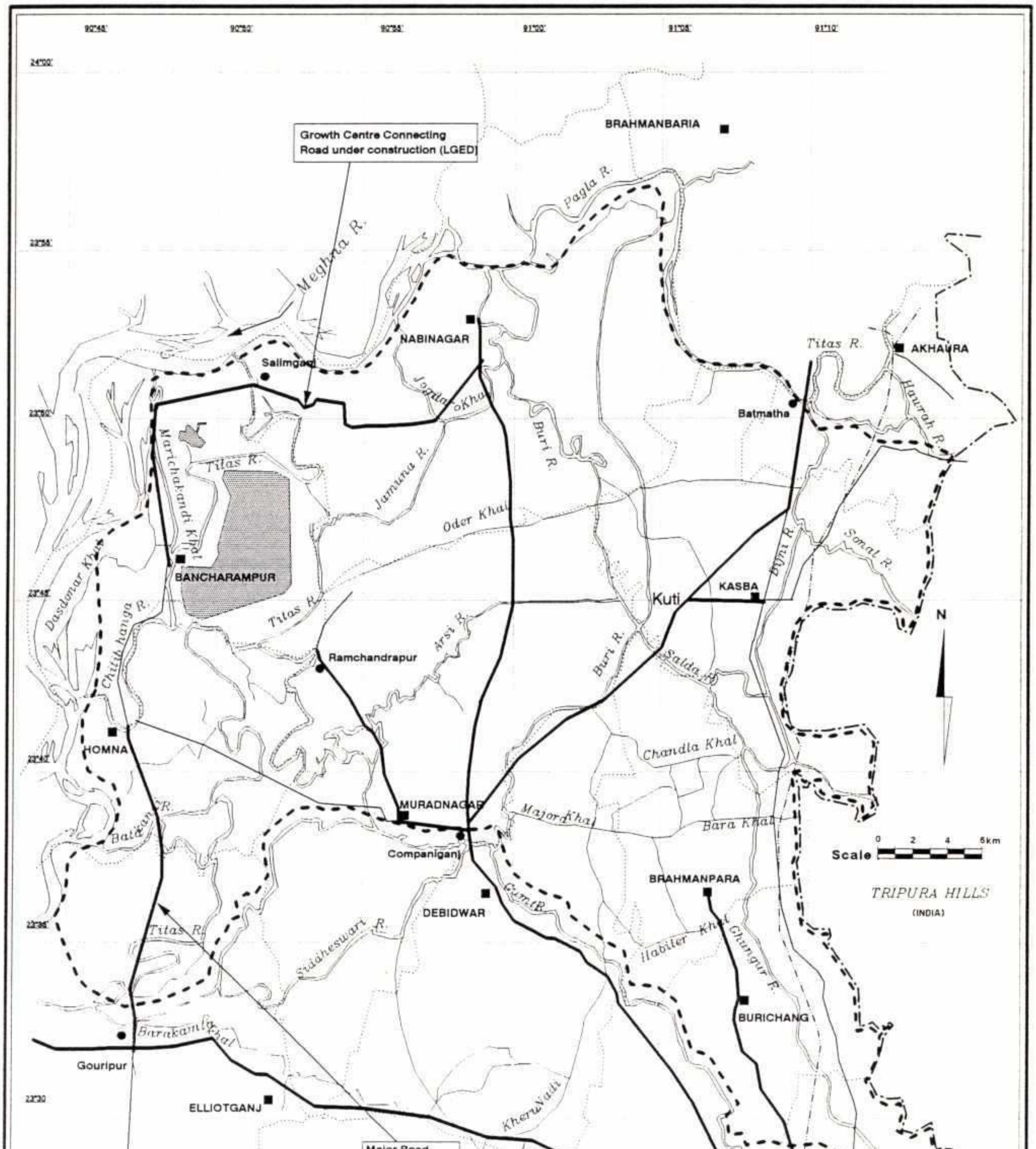
The major road connections within the project area are shown in Figure 7.1. The major routes under the responsibility of the Roads and Highways Department (RHD) are:

- Comilla-Brahmanbaria-Sylhet (Companiganj to Batmatha within the project area)
- Kuti-Kasba
- Companiganj-Nabinagar
- Companiganj-Muradnagar-Ramchandrapur
- Comilla-Burichang-Brahmanpara
- Gouripur-Homna

Since the 1990 Report field work and data collection, significant road developments have been undertaken by the Roads and Highways Department (RHD) and the Local Government Engineering Department (LGED), the latter particularly under the auspices of the Japan International Cooperation Agency (JICA) funded Model Rural Development Projects for Kachua, Nabinagar, Bancharampur and Debidwar thanas, and for Homna and Daudkandi thanas. The Gouripur-Homna road, said in the 1990 Report to have three gaps to be bridged, is undergoing major upgrading which is now substantially complete. The Nabinagar-Salimganj-Bancharampur-Homna road, said to be of lesser importance, is also currently being upgraded/constructed as a growth centre connecting road by LGED. Both roads will be above peak flood levels and therefore have major significance not only for communications but also as flood protection embankments.

Under the 1990 Study, a week-long traffic survey was carried out during February 1988 on the three major routes diverging into the project area from Companiganj. The results from this traffic count are presented in Annex I. As would be expected, the movement of commodities on the main road to Brahmanbaria and Sylhet, especially that of general merchandise, was found to be very much in excess of that on the roads to Nabinagar and to Ramchandrapur.

Figure 7.1
Major Roads



The Comilla-Sylhet road is not designed to a 1 in 20 year return period and in 1988 about 6 km of the road was submerged by up to 0.7 m for about one month. During the same year, the Gouripur-Homna-Bancharampur road was submerged over its whole length, together with major portions of the Companiganj-Nabinagar and Companiganj-Muradnagar-Ramchandrapur roads. On occasions when the Gumti Right Embankment has breached, the whole of the Comilla-Burichang-Brahmanpara road has been submerged. Even the major roads cannot therefore be guaranteed as passable in all seasons. The fact that some of the roads do become submerged has been taken account of in our proposals, which aim to use existing roads as flood embankments, and allowance may have to be made for raising them, both for access and flood control purposes.

7.2.2 River Transport

Month long sample surveys were performed during March/April and September/October 1988 under the 1990 Study, to ascertain the water borne traffic entering and leaving the project area. The results are reproduced in Annex I, and the survey locations are indicated in Figure 7.2. Traffic surveys were not carried out at the outfall of the Lower Titas on the Gumti River because the route was observed to be little used, or at its offtake from the Meghna at Salimganj, because a newly-built road bridge has severely restricted headroom.

Reconnaissance trips from 1 November to 3 November 1992 confirmed the general pattern of navigation given in the 1990 Study. However, the Study did not adequately convey the importance of Nabinagar as a navigation centre. The town has a bustling river front, with general cargoes of earthenware items and large rafts of bamboo, as well as the launch terminal for services along the Pagla/Titas River. The Nabinagar waterfront appears to be cut off from the Pagla by the Buri regulator complex under the BWDB Study FCD and FCDI proposals, with no provision for a lock. Even with a lock the traffic would probably be inhibited. It is considered that the closure ought to be moved upstream to the outfall of the Buri Nadi into the old loop of the Pagla, just north of Kanikara.

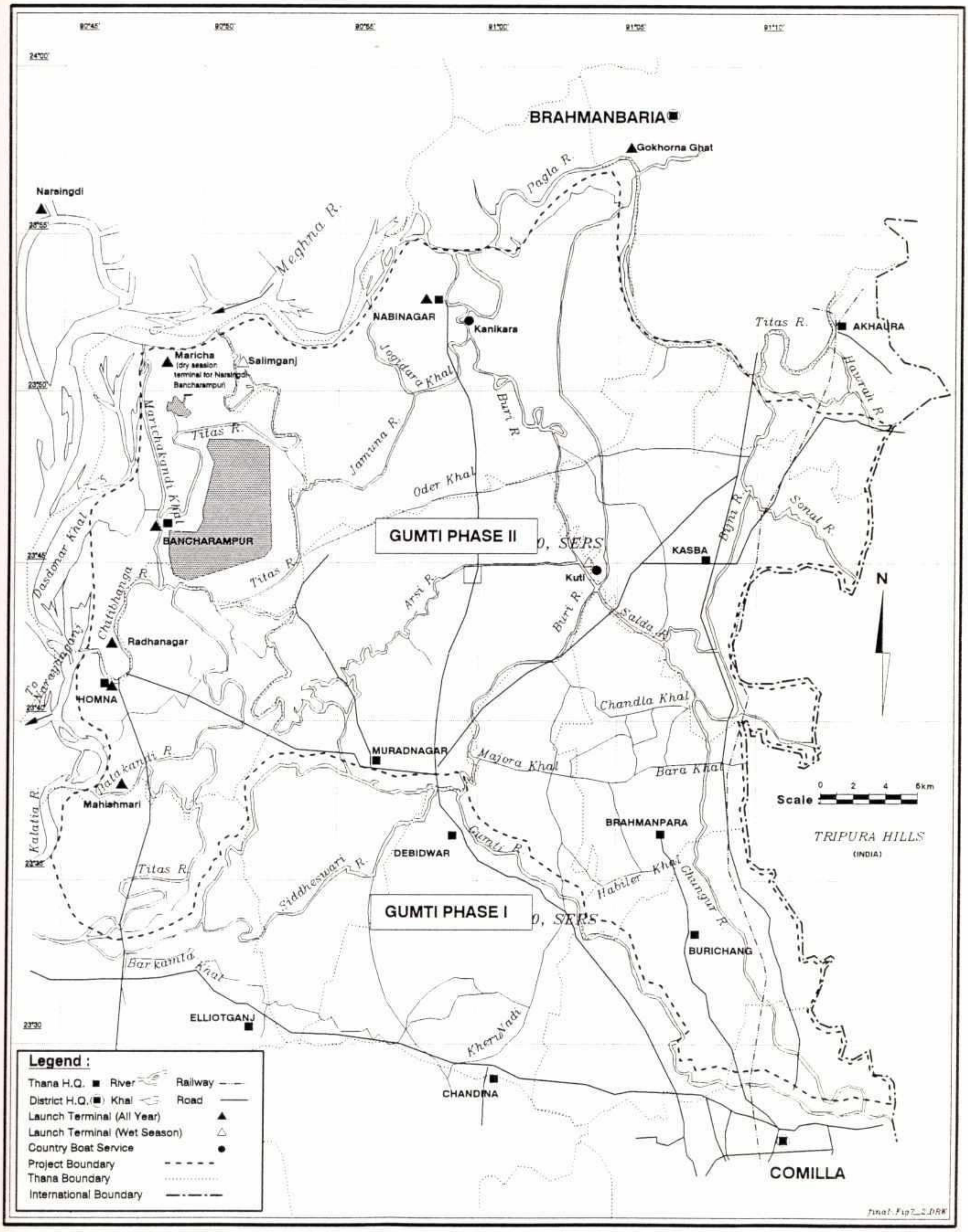
Even at this location a small lock is desirable to admit country boats. Kanikara itself appears to be a major base for country boats, even by comparison with Nabinagar. There are 150 engine boats based within the Buri Nadi according to information gained during the November 1992 reconnaissance trips. It is understood that some of these ply upstream as far as Kuti.

7.3 Power Lines

A map of the existing distribution system and developments under way for Bangladesh as a whole (33 kV to 230 kV) and Comilla and Brahmanbaria districts (11 kV to 230 kV) was collected.

The 132 kV Sidhirganj (due west of the project area) to Comilla transmission line passes over the boundary of the project. A 230 kV transmission line has recently been constructed connecting Ashuganj (north-west of Brahmanbaria) with Comilla. There is a network of 33 kV line over the project area, connecting most of the thanas with other important townships. The Rural Electrification Board (REB) operates the 11 kV and other low tension transmission lines for rural electrification and connection of irrigation equipment.

Figure 7.2
Existing Navigation



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REB plan to extend their 11 kV network to the Nabinagar area this year. They stated that it would be possible to provide power to the proposed pump stations near Nabinagar at normal agricultural rates. They also confirmed that no payment would be required for transmission lines to the proposed pump stations.

7.4 Flood Protection Infrastructure

The main flood protection infrastructure for the project area is the northern embankment to the Gumti River. This is discussed in Section 2.2.1.

The flood proofing methods used in the area, apart from the heightened River Gumti embankment, are to ensure that villages and major buildings are above normal flood level. This will be largely unaffected by the project proposals. However, the heightening of the Comilla to Sylhet road between Companiganj and Kuti will be a significant benefit, as this will further protect the road as well as ensuring conveyance during high floods. The Roads and Highways Department did state that at some stage in the future, they planned to improve the road by bringing the full section to the 1 in 20 year design level and apply a blacktop surface to it.

The proposed left embankment to the Gunghur and Salda Rivers (within Zone A) will also provide access for the villages. Also, the existing roads in Zone B will be raised to the 20 year return period levels. As none of these project proposed embankments link major towns, it is not proposed to surface them. However, they can be surfaced at a later date if traffic counts show that this is required.

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 committee members, it is also important to seek the support of other 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).

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(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**

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 fertilizers and a team of mechanics provides maintenance services to farmers. The distribution of seeds and fertilizers 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 fertilizers, 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 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 bureau 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 two in the study area, namely Brahmanbaria 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 form 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

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- 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. fertilizer, 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. Comilla-Proshika is well represented in the project area. Other NGOs who are also represented are Enfants du Monde (EDM), DAKUB and Palli Unnayan Sangstha.

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.

There are different types of development within the recommendations and not all will follow the same format, each must be formulated according to the specific requirements. The most significant features described above must be taken into account when implementing any projects or programmes.

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e) Analyse the findings once more and draw up firm 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 should be 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 animateurs 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 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 10 of the 11 thanas with representatives listed in (f) above.

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

Figure 9.1

Location of People's Participation Villages

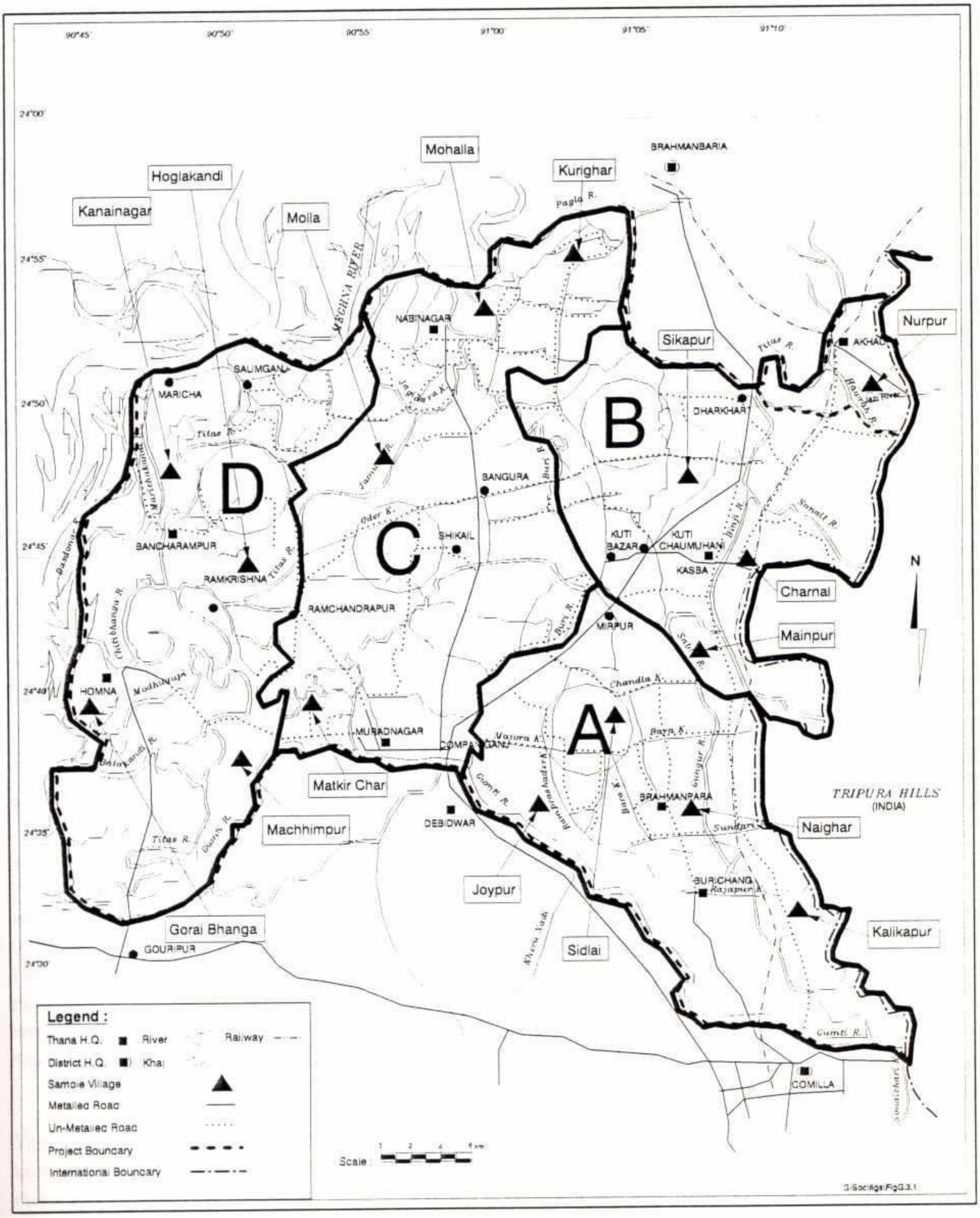

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TABLE 9.1

List of People's Participation Villages

Zone	Thana	Union	Mouza	Village
A	Burichang	Bakshimail	Manoharpur	Kalikapur
A	Brahmanpara	Purba B.	Naighar	Naighar
A	Brahmanpara	Paschim Chandala	Sidlai	Sidlai
A	Debidwar	Fatehabad	Joypur	Joypur
B	Akhaura	Dakshin A.	Nurpur	Nurpur
B	Kasba	Uttara Badair	Sikapur	Sikapur
B	Kasba	Kasba	Charnal	Charnal
B	Kasba	Kaimpur	Mainpur	Mainpur
C	Nabinagar	Natghar	Kurighar	Kurighar
C	Nabinagar	Paschim Rasullabad	Molla	Molla
C	Nabinagar	Purba N.	Mohalla	Mohalla
C	Muradnagar	Muradnagar	Matkir Char	Matkir Char
D	Daudkandi	Bitikandi	Machhimpur	Machhimpur
D	Bancharampur	Salimabad	Satdona	Hoglakandi
D	Bancharampur	Dakshin B.	Kanainagar	Kanainagar
D	Homna	Uttara Homna	Gorai Bhanga	Gorai Bhanga

9.3 Analysis of People's Responses

9.3.1 General

Attendances were considered to be satisfactory for a balanced set of views. Generally, attendance was 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.

The meetings were lively, and contributions came from people from all walks of life. Where specialised knowledge about a particular problem was sought the animateur would invite contributions from people with that specific knowledge; eg capture fishing in the Meghna would be the province of men who actually fished this major river.

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 people's participation meetings is given in Table 9.2. The main points of the meetings are also given in detail in Annex G, Section G.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 Zones A and B, there was also a great deal of support for protection against flash floods, which came into the country from the Tripura Hills. It should also be noted that the meetings were held in the villages well before the extremely severe flash flooding of February and May of 1993.

In none of the four zones was normal annual flooding considered to be a problem. Villages and infrastructure had been set at a sufficient level to receive no harm from normal floods. Also, farmers had come to terms with normal flooding and had adjusted their crops accordingly. However, in Zones A, B and C during the second round of meetings, when it was explained that by flood protection areas of B aman could be replaced by T aman, the farmers were in favour of such a change. The obvious drawback to capture fisheries was always commented upon. In Zone D, the villagers were not in favour of flood protection. This was because they did not want their fisheries and navigation disrupted.

The major problems highlighted by the women's groups was scarcity of tubewell water for drinking and washing, collection of firewood for cooking during the monsoon. Women also stated that they wanted remunerative work and were prepared to help in maintenance activities.

9.3.3 The Third Round of Meetings

The method of selecting sample villages for participation is a very cost effective way of determining the people's needs, thoughts on development and concerns 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. An example of this is Nurpur village, where villagers' proposals concerned re-excavation of small local khals. Whilst the proposals may have been sound as small scale water resource schemes, they were too localised for consideration within a Feasibility Study for an area of approximately 140 000 Ha.

The second problem is that a proposed scheme, for example a submersible embankment scheme in Zone D, may not be in an area in which one of our sample villages lies. It is for these reasons that the third round of participation meetings took place at thana level, with Government Officials at thana and union level, as well as representatives from NGOs.

Zone A

The thana officials pointed out that the scheme was very similar to the "North Debidwar, Brahmanpara and North Burichang Flood Control and Irrigation Project". This was a project discussed in a joint application of 17 union parishad chairmen and submitted to the Minister, Flood Control and Water Development on 11 November, 1991.

The scheme was well received in the three thanas as flash flooding was known to be a serious problem in the area. Brahmanpara thana was generally flooded twice a year, causing damage to boro and aman crops.

TABLE 9.2

Summary of Round 1 of the Public Participation Meetings

Issues/ Problems	Zone A				Zone B				Zone C				Zone D			
	Joypur	Kalikapur	Naighar	Sidlai	Nurpur	Shikerpur	Charnal	Mainpur	Matkerchar	Molla	Moballa	Kurlghar	Masimpur	Goaribhanga	Kanainagar	Hoglakandhi
Peak flood depth	2 feet; during flash flood 4' for 3-4 days	3 feet	7 feet	Above 4 feet	2 feet	3-4 feet	2 feet	4-5 feet	3 feet	6 feet	15 feet	15 feet	5 feet	12 feet	14 feet	10 feet
Early flood damage	Comes from Tripura Hill; No flood in 1992	Comes from Tripura Hill; No flood in 1992	May-June damage to Boro during harvesting	May-June damage to Boro during harvesting	Comes from Tripura Hill; No flood in 1992	Comes from Tripura Hill; No flood in 1992	Comes from Tripura Hill; No flood in 1992	Early flood from Ghungur/ Salda causes crop damage	No flood in 1992	No flood in 1992	No flood in 1992	May to Nov. flood water stays because of poor maintenance of internal khals	No flood in 1992	No flood in 1992	Excessive water April to November	Much water April to November boro and B aman damage
Flash floods	From Tripura hill, villagers do not consider it as major problems	Flash flood from India	Flash flood more than once a year	Flash flood though not severe damage	Flash flood is not so much a problem now	Flash flood from Bijni river during pre-monsoon period	Flash flood causes damage to crops two to three years in five	Comes from Ghungur and Salda river	Comes from Titas and Gumti	Comes from Titas and Meghna	Comes from Titas and Meghna	Comes from Titas and Meghna	Comes from Titas and Gumti	Comes from Titas and Meghna	Comes from Titas and Meghna	Comes from Titas and Meghna
Drainage Congestion	Internal Khals cannot drain the water	Silting up of the local khals	Road (Sylhet-Comilla) with few bridges impedes drainage of water	Khals & rivers re-excavated for drainage and also for reservoirs	Rivers and Khals are silted up	Drainage problem in the beel area; khals are silted up	Insufficient cross drainage structures under the railway line	Rivers and Khals are silted up	Khals are silted	Siltation of Khals and Rivers	Siltation of Khal and River	May to Nov. flood water stays because of poor maintenance of internal khals	No problem	Rivers & Khals heavily silted	Khals heavily silted, causing congestion of water	Khal and Beel silted up
Irrigation facilities LLP/DTW/STW/ other	STW - No. 40 in dry season cannot supply sufficient water	Shortage of surface water problem for LLP Dry season low water table STW & DTW problem	DTW 8 STW inoperative during dry season	DTW-6 STW-15	LLP-3, STW-5 villages prefer LLP for irri-gation. Shortage of water is a great problem	DTW-5; STW-5	More than 200 STW-4 Artesian well working	LLP-7 STW-8	LLP-6 dry season problem of surface water	None	22 LLP	STW-15 LLP-40	STW=3 LLP=3 Power pump=100	STW=4 LLP=15 Power pump=200	STW=10 LLP=3 Power pump=200	DTW=2 STW=1 LLP=70 Rower pump=100
Ground water salinity DTW/STW	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Saline; DTW Not possible	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem
Gas problem DTW/STW	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Gas problem STW Not possible	Gas for STW	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem	Not a problem
Seasonal falling of water tables	It is a great problem during dry season	Great problem for irrigation by DTW & STW	Dry season falling of water is the great problem	Dry season problem is there. STW preferred to DTWs. People consider it less expensive	Dry season problem for STW	Water table goes down during later part of dry season	Though the GWT is dec-lining it is not alarming	Surface & ground water decrease during dry season	Dry season problem	Dry season problem	In dry season less water in khals and rivers	Dry season water level falls	Shortage of water January-March	Shortage of water January-March	Shortage of water December-March	Shortage December-March

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Issues/ Problems	Zone A			
	Joypur	Kalikapur	Naighar	Sidlai
Road Communication	Not too much of a Problem	Not too much of a Problem	Renovation of existing road	Renovation of Road and some bridges needed
Navigation	Not arise	Not arise	Not arise	Navigation problem
Electricity	No electricity	No electricity	No electricity	Electric poles are there, electric supply needed
Drinking water	Specially in March April drinking water a great problem	Most drinking water brought from DTW in dry season	Not sufficient	Not sufficient
Fishing	Not much surface water	Flood plain fishing is insignifcant	Not much surface water	Dry up surface water
Education	Primary & Madrasa Exists	Primary & Madrasa Exists	Primary & Madrasa Exists	Primary & High School Exists
Health	Health facilities 2.5 Km. Thana Headquarter	Health facilities 3.0 Km. Burichang	Health facilities 1.5 Km. Brahmanpara	Health facilities 5.0 Km. Brahmanpara
Lack of wage payed Opportunity	Poor women want remunarative work.	Educated & uneducated want remunerative work.	Poor women Collect fire wood from Indian Hills for sale & for domestic use.	Women want work facilities.

Issues/ Problems	Zone B			
	Nurpur	Shikerpur	Charnal	Mainpur
Road Communication	Not too much of a Problem	Improvement of internal Road and Bridges required	No problem	No problem
Navigation	Not arise	Not arise	Not arise	Not arise
Electricity	Reliable electric supply	Electric supply is irregular	Electric supply is irregular	Electricity needed
Drinking water	Paucity of drinking water during dry season	Not so much a problem	HTW are not yet affected	Not so much a problem
Fishing	Due to shortage of water, Pond fish also suffer	Scope of culture fisheries but multiple ownership of pond is a great problem	Scope of culture fisheries is there	Poor people live on fishing from June to to October. Beels and khals need to be excavated
Education	Primary school. No other facilities for education	Madrasa, Primary school	Primary Secondary College	Primary Madrasa
Health	Scabage & diarrhoea is prevalant due to scarcity and polluted water. Akhara 2 Km.	12 Km Kasba Health Complex	Health complex is nearby	Facilities there.
Lack of wage payed Opportunity	Women of this village badly wanted work or any kind of organisation for income generating programme.	Women are ready to give their labour in any remunerative work.	Both educated and uneducated women want remunerative work	Work is needed for women

Issues/ Problems	Zone C			
	Matkerchar	Molla	Mohalla	Kurlghar
Road Communication	Road Communi-cation is a problem	Has to be improved road & bridge needed	Road has to be built	Road communi-cation problem
Navigation	Navigation problem	Dry season Navigation is a problem	Navigation is important	Navigation is important
Electricity	No electricity	Electricity needed	No electricity	No electricity
Drinking water	11 HTW 3000 people; not sufficient	Not so problem. About 50 tubewells	6000 people but only 10 tubewells. 40% people drink river water	5000 people 100 tube-wells
Fishing	Catch fish in flood plains & in river	Three to four months from flood plains	Capture fishery in river and flood plain is important	Capture fisheries in rivers
Education	High school 1.5 km. Not so much a problem	Primary	Primary & Madrasa Higher education is a problem	Primary and Madrasa
Health	Available 6 km away.	Govt. Hospital 1.5 Km.	Diarrhoea is very comman. 2 Km Nabinagar	No health facilities
Lack of wage payed Opportunity	Work is needed.	Both educative and uneducative women want remunerative work.	Women want remunarative work.	Women want remunarative work.

Issues/ Problems	Zone D			
	Masimpur	Goaribhanga	Kanainagar	Hoglakandhi
Road Communication	Roads and culvert needed	Roads & culvert needed	Road commu-nication needed/ repair of roads	Road Needed
Navigation	Is very important	Is very important	Important source of communi-cation	Important source of communi-cation
Electricity	Electricity for irrigation	No electricity	Electricity needed	No electricity
Drinking water	Not enough tubewells	Paucity of drinking water	Drinking water problem	Drinking water problem
Fishing	Too little water	Too little water	Problem is using current net, F. Net costly	Important source of living
Education	Facilities are there	1 Madrasa 1 Primary school education	1 Primary school	1 Primary School
Health	Health Service inadequate	One health clinic in Homna 6 Km away.	Nearest Health clinic 6 Km away	Nearest Health clinic 6 Km away
Lack of wage payed Opportunity	Limited work source.	Limited work facilities.	Work is needed.	Limited work source

The main concern of those present was the effect on the area to the east of the Gunghur River. By preventing flash floods to the west of the Gunghur, water levels to the east would be much higher than they are at present.

The project staff replied that in addition to the embankment, the Salda and Buri Nadi would be excavated, which would improve drainage from the area. In addition, structures would be provided to allow a portion of the flow through the area in a controlled manner.

Representatives from Debidwar thana were concerned that the protected area should be properly drained. They were reassured that 3 drainage structures were to be provided into the Buri Nadi. In addition, the existing khals would be re-excavated to improve drainage within the area.

Burichang thana requested facilities which would provide irrigation from the River Gumti and River Salda.

The project staff stated that they would maintain existing LLP arrangements by providing flanged metal pipes through the Gunghur embankment, through which water could be pumped. However, there were no proposals for further extraction from the River Gumti. This was because India was completing an upstream irrigation network which would be fed from the River Gumti. Future water supply from the river was therefore not assured.

Zone B

No objections were made against the two embankment schemes outlined in Zone B and their positive effect on flood flashes was noted. The fact that the embankments were to be constructed wherever possible on existing roads was appreciated, as it would minimise the need for land acquisition.

Zone C

The fairly complicated schemes to re-excavate the existing khal and river systems and provide pumping stations, offtaking from the River Titas, were explained to the two gatherings at Nabinagar and Muradnagar. The construction of embankments around the irrigated areas was also discussed.

Although the excavation was approved of by all parties, concerns were expressed in Nabinagar about the strength of any embankment. It was correctly pointed out that overtopping of an embankment would cause far greater damage than if no embankment were there.

In addition, concerns regarding the effect on a thriving fisheries industry were expressed. Union Chairmen were split in their opinion concerning the embankment. Some supported the idea because it meant that 3 crops could be grown and others pointed out that 80% of the area depended on fishing for their living and they would be badly affected by full scale embankment protection.

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Zone D

The outline proposals for khal excavation (for better irrigation and drainage) and possible submersible embankments were outlined to the meetings in Bancharampur, Homna and Daudkandi thanas.

In all thanas, the proposals to carry out khal and river re-excavation were well received. In Bancharampur thana, one of the Union Chairmen supported the option favoured in the 1990 study, to place a polder along the left bank of the Meghna River. It was agreed that since flooding was due more to rainfall than to the Meghna water levels, pumping the drainage water out was also required. After discussions comparing the benefits from the additional cropping and work for day labourers, with the dis-benefits from the destruction of floodplain fisheries, the majority of the Union Chairmen supported this measure. However, in Homna and Daudkandi, all those present were not in favour of full FCDI protection. It was considered that if measures were taken to re-excavate the principal rivers and khals, then present problems of irrigation, fishing and navigation would be overcome and any form of flood control against the Titas and Meghna would not be necessary.

In Homna and Daudkandi, representatives were of the opinion that the Gumti north embankment should be extended. At present the flash flooding which occurred in the Gumti was contained within the embankment, only to be released at this location. At the time of the meeting such flooding occurred, due to the rainfall which occurred around 20 February, 1993. The project staff were taken to the area in question to see the extent of flooding for themselves. It was also explained that flash flooding brought unwanted fine sand into the project area and hampered efforts to keep the khal system properly excavated.

The concept and need for submersible embankments were accepted at the meetings, as low areas were known to face damage to the boro crop when water levels rose too early.

9.4 Conclusions

The three rounds of participation meetings were considered to be extremely useful. They were not used to push pre-conceived ideas at local people, but to identify problems and their solutions from those who would be most effected.

The very diverse nature of the different parts of the project area yielded differing sets of problems and solutions. Whereas flood control embankments were very appropriate in Zone A and parts of Zone B, they were less so in Zone C and generally thought to be quite inappropriate in Zone D.

The three rounds of meetings, which were carried out before any idea of costs or EIRR were known, strongly indicated that a single solution of FCD or FCDI embankment was not wanted. Instead, protection against flash flooding, cheap methods of irrigation supply, and drainage were required, with different priorities in different areas. It was also important not to diminish the huge floodplain fisheries present in much of the project area or to interfere with the navigation of the area.

From this basis, it was decided to propose a set of discrete, phased, interventions which would be sympathetic to the environmental considerations for the area.

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10 The Gumti Phase II Hydraulic Model

10.1 General

The analysis of flood conditions within the project area has been largely based on computational hydraulic modelling, in view of the complexities of the system.

The hydraulic studies have a central role in the assessment of the impact of the river and drainage engineering proposals in the Gumti Phase II area. 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 modelling also provides parameters for the design of the engineering works.

The NAM hydrological model allows runoff (discharge) to be estimated from a knowledge of rainfall, evaporation and groundwater abstraction.

The hydrodynamic model provides a simulation of water levels and discharges at each node 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.

10.2 The Models

NAM is a deterministic model of the lumped, conceptual type. It operates on a daily time step, taking in data on rainfall, evaporation and groundwater abstractions, and producing as output, river flows at the catchment outfall and values for its internal state parameters. The principal restrictions of NAM are that it does not couple surface inundation from river flow or irrigation into the sub-surface water balance and that it contains only a restricted amount of attenuation for high values of runoff (floods).

The simulation of water levels, flow rates and flow velocities in the river system is carried out with the MIKE11-HD hydrodynamic model (hereafter called MIKE11). The model is well tried on rivers in Bangladesh through the efforts of the SWMC. MIKE11 is a deterministic model based on the St. Venant equations of open channel flow and the Abbott-Ionescu finite difference scheme. It represents flow in river channels, through structures and over floodplains. Like all mathematical models it is based on a variety of assumptions and numerical approximations which determine its scope of application.

10.3 Model Application and Post-processing

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 not practical. 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 following:

- 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 the 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.

This rationale was adopted in the present study.

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. This section describes the post-processing of MIKE11 results for each of these disciplines. Figure 10.1 is a flow diagram illustrating the procedure used. For the purposes of agricultural and fisheries analysis the area was sub-divided into a number of post-processing areas; these are shown in Figure 10.2.

10.4 Development of the Models

The development and calibration of the models used in this study was carried out by the SWMC as part of their work on the South East Regional Model. No further development and calibration was undertaken by the Gumti Phase II modelling team.

10.4.1 NAM Hydrological Model

For the purposes of the NAM modelling, the South East Region was divided into 24 catchments. The catchment boundaries are delineated on what may be loosely considered watersheds, along natural topographic features or artificial embankments. At least one rainfall station and one groundwater observation well with a continuous record were available for each sub-catchment.

The NAM Model calibration was carried out over the hydrological years 1986, 1987 and 1988. The parameter values in the model were changed until a good match was achieved between the simulated and observed groundwater level hydrographs. There are no discharge gauging stations in the region against which the runoff estimates from NAM can be calibrated.

Figure 10.1

Post-Processing Analysis

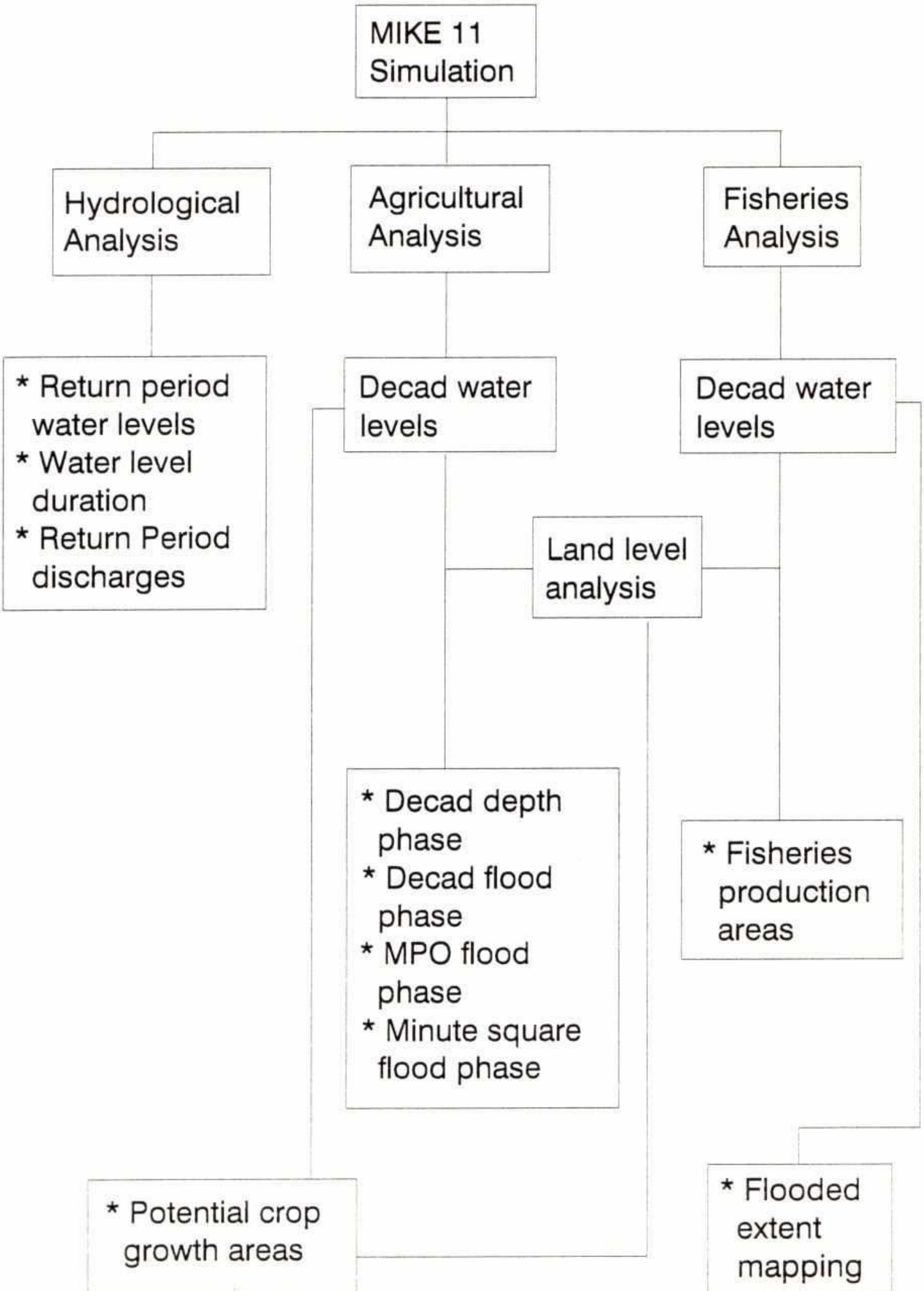

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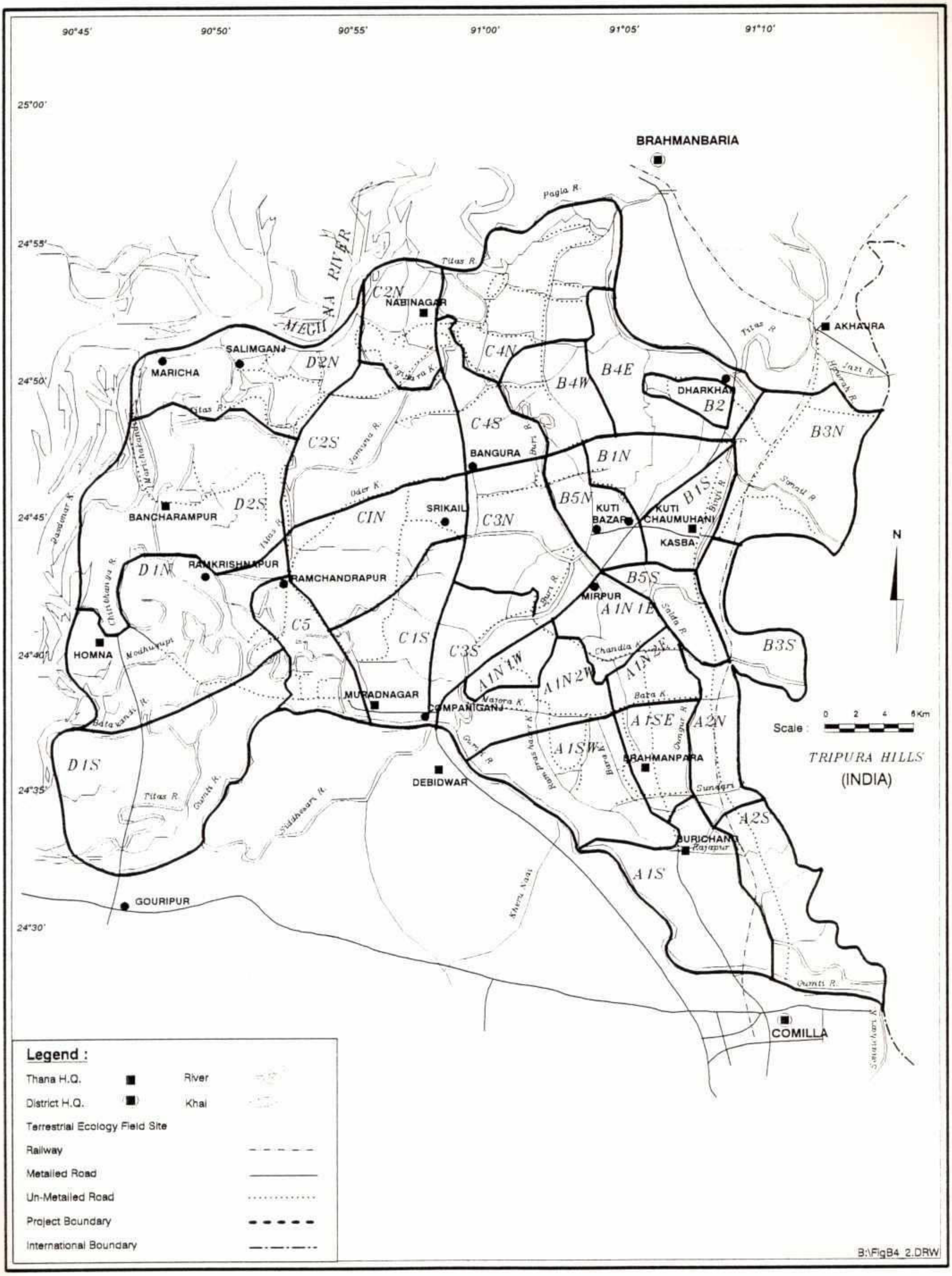
Figure 10.2
Sub-divided Areas for Post Processing



The model was verified from April 1989 to March 1991. The verification was good in areas where the groundwater level fluctuations were accurately recorded.

10.4.2 MIKE11 Hydrodynamic Model

The modelled area is bounded to the south by the Gumti River, to the west by the Meghna River, to the north by the Titas (or Pagla) River and to the east by the border with India.

To select the channels for the model several criteria were applied,

- the importance of the channel in terms of drainage
- the possibility that the channel serves as an important route for flood water from outside the area
- the importance of channels in their action as link channels from one area to another
- the importance of the channels in future developments

The schematisation was based on topographic maps with reference to aerial photographs and satellite images to give more up to date information.

Floodplain geometry is attached to the river cross-sections to accurately represent overland flow and storage available at high flood levels. The boundaries of the floodplain cells are selected on the basis of the flow direction in the floodplain determined from land contours and the orientation of road, rail and flood defence embankments. The resistance to flow on the floodplain is higher than that of the river, owing to the irregular surface and vegetation.

The schematic network plan of the Gumti Phase II model is shown in Figure 10.3. While the basic information is one dimensional, the construction of a dense network based on the rivers and khals of the region introduces a quasi two dimensional aspect to the model. This allows the simulation of the one dimensional dry season flow and the more two dimensional monsoon season flow.

The model was originally calibrated 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 model was verified for the period January 1990 to March 1991.

10.5 The Model of Present Conditions

Water levels in the Gumti Phase II area are dominated by levels in the Meghna, when peak levels occur in the Meghna the area is effectively a huge lake. With the exception of the areas in the extreme east and south-east, the backwater effect of the Meghna extends throughout the area.

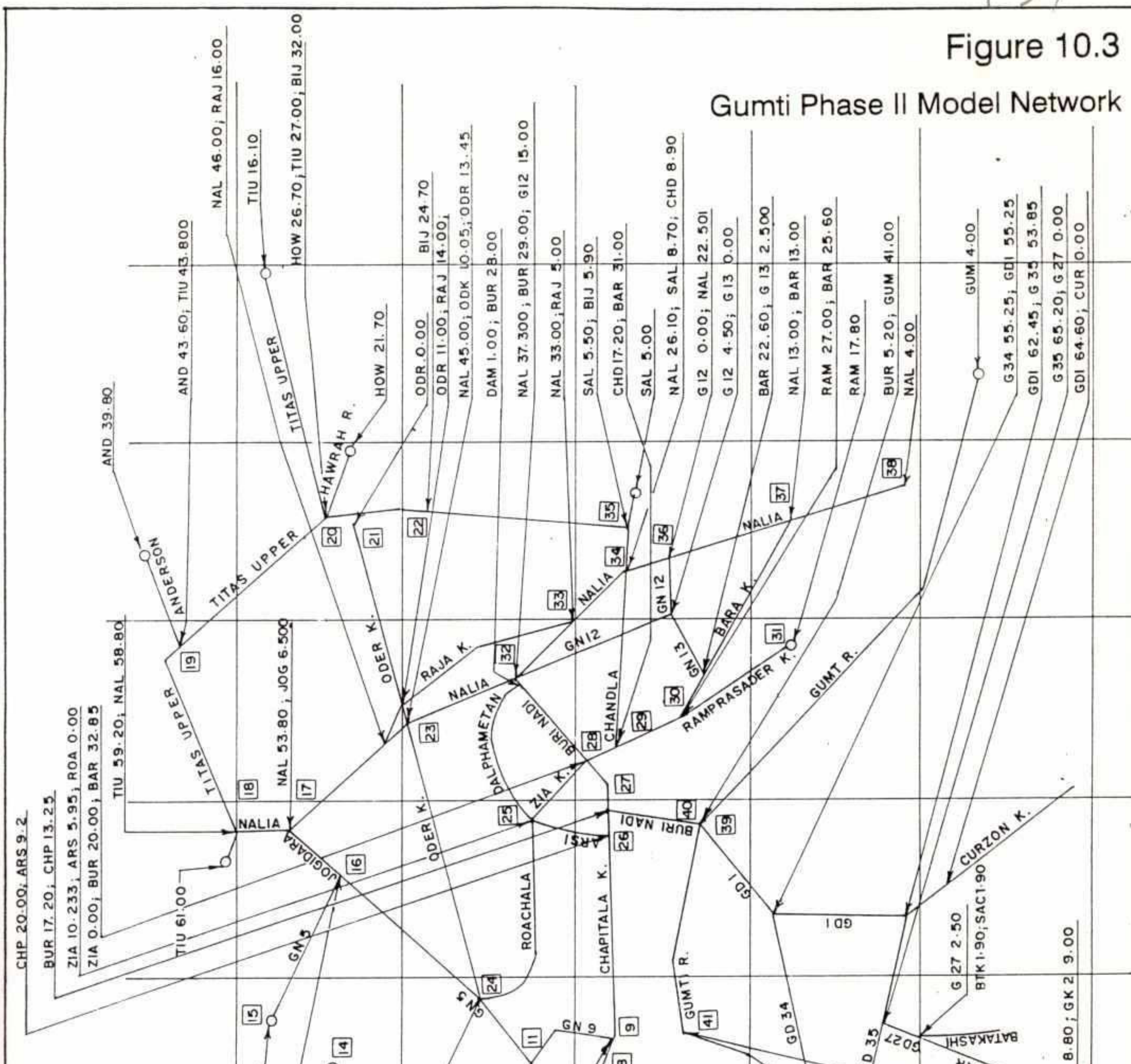


Figure 10.3

Gumti Phase II Model Network

In the pre-monsoon period, before the Meghna rises, the areas in the east and south-east are subject to flooding by flash floods from the catchments in the Tripura Hills.

In the pre-monsoon period, flows from the catchments in India are transferred to the Meghna via the Bijni and Nalia rivers. Some of the flow which enters the region in the south east flows across Zone A and via the river system to the south of the Oder Khal to reach the Meghna between Homna and Daudkandi.

Once the Meghna rises, during June, flows in the Nalia (Buri Nadi) reverse so that water enters the area from the Meghna. This water is transferred as floodplain flow and channel flow in the Oder Khal and the river system to the south to reach the Meghna between Homna and Daudkandi.

North of the Gumti right embankment the hydraulic conditions within the study area are extremely complex. In the pre monsoon, water flow is dominantly from south to north whilst at the height of the monsoon it is from north to south and then from east to west; the study area acts as a major flow route from the Meghna upstream of Nabinagar to the Meghna downstream of Homna.

Table 10.1 presents the model predicted flood phases, for the Without Project simulation, for the post-processing analysis areas in the Gumti Phase II area. These are the results for the decade with the deepest flooding. The areas in Table 10.1 relate to the areas shown in Figure 10.2.

These clearly indicate that the worst flooded areas lie adjacent to the Meghna. The depth of flooding generally decreases in an easterly and south-easterly direction. The shallowest depths of flooding occur in the east of the area where the topographic elevation tends to rise towards the Tripura Hills. The low lying areas in the east of the region suffer deep flooding because of flows from the Tripura Hills and drainage congestion as a result of the backwater effect from the Meghna.

10.6 Modelling Interventions

For the purposes of assessing the relative merits of different options prior to the With Project model run, which will include the selected options, model runs over periods shorter than 25 years were carried out.

10.6.1 Initial Design Options

The initial design options were conceived by taking account of the diverse situations which occur in the Gumti Phase II Project Area. For the purpose of selecting design options it is convenient to split the project area into four zones of flooding and agricultural type; these zones are shown in Figure 9.1. It should be noted, however, that the zonal boundaries need not form a barrier to the boundaries of any scheme therein.

The proposed developments, determined mainly from people's participation meetings, are presented below zone by zone and summarised in Table 10.2. Figure 10.4 is a diagram showing the initial design options.

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TABLE 10.1

Present Condition Flood Phases
for the Gumti Phase II area

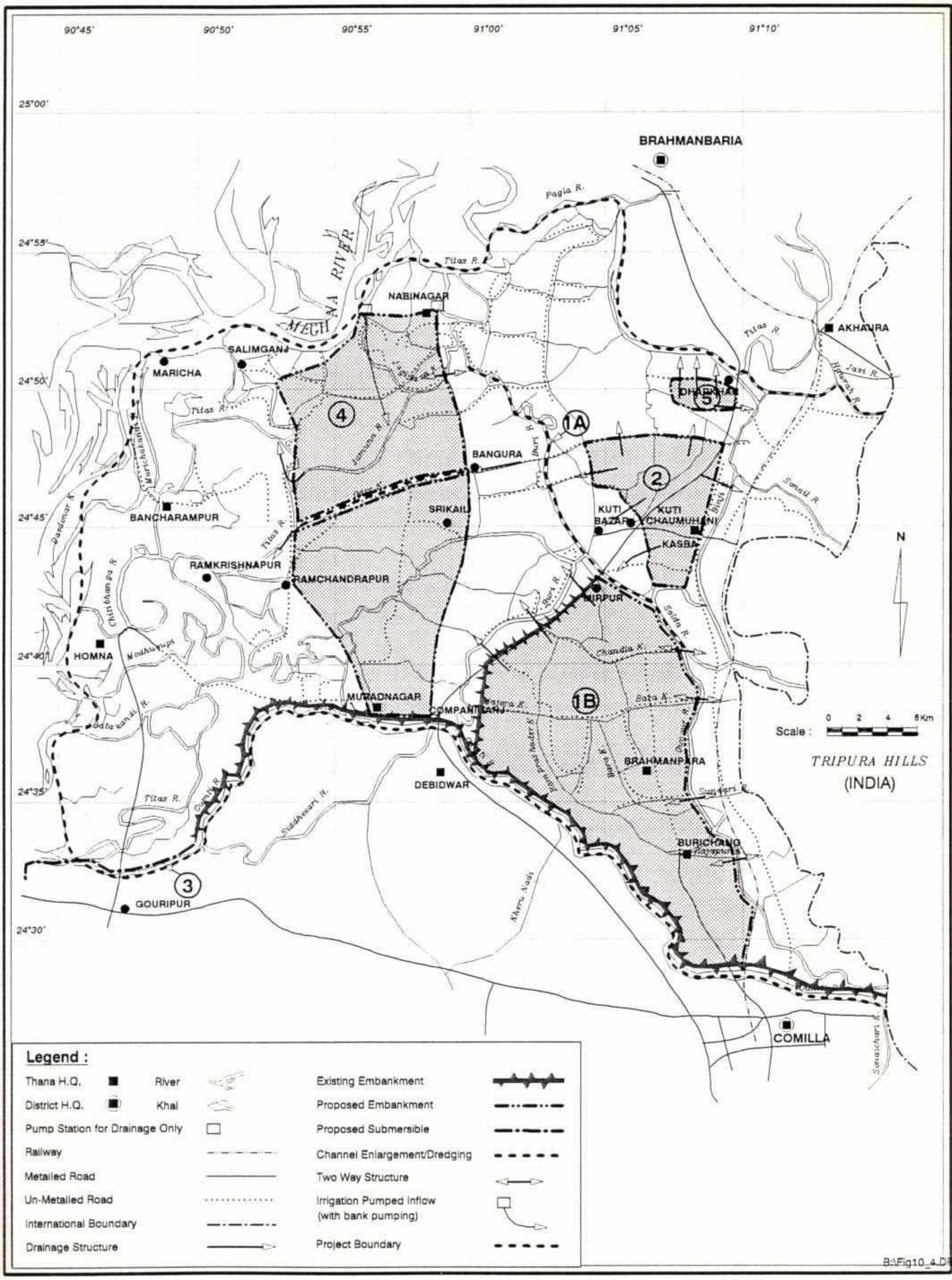
AREA	MPO Flood Phase (%)			
	F0	F1	F2	F3+F4
A1	28	53	19	0
A2	71	24	5	0
B1	20	31	44	5
B2	0	2	44	54
B3	35	22	24	19
B4	4	13	46	37
B5	20	35	31	14
C1	2	11	67	20
C2	7	17	61	15
C3	10	32	42	16
C4	3	28	27	42
C5	3	9	48	40
D1	2	7	31	60
D2	4	13	42	41

TABLE 10.2

Summary of Gumti Phase II Initial Design Options

	A1	A2	A3	A4	B1	C1	C2	C3	D1
Embankment on Ghungur left bank upstream of Buri Nadi confluence	X	X	X	X	X	X	X	X	X
Embankment of Buri Nadi right bank upstream of Ghungur confluence	X	X	X	X	X	X	X	X	X
Excavation in Ghungur upstream of Buri Nadi confluence		X	X		X	X	X	X	X
Excavation in Ghungur downstream of Buri Nadi confluence			X	X	X	X	X	X	X
Flow through Ghungur left embankment				X					
Embankment surrounding area B1					X	X	X	X	X
Embankment surrounding area B2					X	X	X	X	X
Embankment surrounding area C1						X	X	X	X
Embankment surrounding area C2						X	X	X	X
Excavation in Oder Khal							X	X	X
Pumped drainage from area C2								X	
Extension of Gumti right embankment to Meghna confluence									X

Figure 10.4
Initial Design Options



Zone A

As a result of design option simulations A1 to A4 it was concluded that the following were the best developments for Zone A:

- an embankment on the left bank of the Gunghur which only allows drainage from area A1
- an embankment on the right bank of the Buri Nadi which only allows drainage from area A1
- excavation of the bed high point upstream of the Buri Nadi confluence
- excavation of the bed high point downstream of the Buri Nadi confluence

These developments result in a significant reduction in the flooding depth in area A1. This is in part offset by a flooding depth on the right bank of the Gunghur which is slightly higher than presently occurs.

Zones B, C and D

As a result of design option simulation B1 it was concluded that the following developments were recommended for Zone B:

- Village roads will be upgraded to form a flood embankment surrounding Unit 5. Structures for rainfall-runoff drainage will be provided in the embankment.

- The ring road which encircles part of Unit 2 will be improved for full flood control with gated structures at the locations of existing bridges to facilitate rainfall-runoff drainage.

These developments result in a significant reduction in the flooding depth in poldered areas.

The construction of the embankments to create the poldered areas does not result in any rises in external water levels.

As a result of design option simulations C1 to C3 the following developments were put forward for Zone C:

- The part of this zone to the west of the Nabinagar - Muradnagar road and the North of the Oder Khal will be poldered. The polder will extend as far as the Meghna in the north. Structures will be provided on the Jamuna Khal at the western boundary of the polder and on the Jamuna Khal at the eastern boundary of the polder for controlling drainage.

- The part of this zone to the west of the Nabinagar - Muradnagar road and the south of the Oder Khal will be poldered. The polder will extend as far as the Gumti in the south. Drainage structures will be provided on the Jogidara, Arsi, Zia and Chapitala Khals under the Companiganj - Nabinagar road at the eastern boundary of the polder. Structures are also provided at the outfalls of the Roachala, Arsi and the khal to the south of the Roachala, for controlled drainage.

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- The use of the irrigation pumps for pumped drainage could greatly reduce the flooding depth in the northern poldered area of Zone C.

These developments result in a reduction in flood levels in the poldered areas.

Model simulation D1 showed that the extension of the Gumti right embankment results in a reduction in flood depth in the area adjacent to the river; this reduction occurs in the pre - and early monsoon seasons.

10.6.2 Final Design Option Simulations

A scheme which included all the above features formed the basis for the final design option simulations. This simulation did not included pumped drainage from the poldered area in the northern part of Zone C. The final design option simulation was run for the full 25 year period between 1965 and 1989 and complete post-processing analysis was carried out on the model results.

The simulated developments result in a reduction in flooding depth in all the poldered areas. The changes in the polders in Zone B and the southern polder in Zone C are significant. The improvements in the polder in Zone A and the northern polder in Zone C are much smaller. The improvements in the northern polder of Zone C could be greatly enhanced by pumped drainage.

Conditions in the un-poldered areas of Zones A, B and C are made worse by the proposed developments. Conditions in the southern part of Zone D are improved slightly by the extension of the Gumti right embankment; those in the northern part of Zone D are unchanged.

It was observed in the Without Project simulation that flow from the south-east of the area passes through the drainage channels in the southern part of Zone C to the Meghna throughout the wet season. Once the external rivers rise in May and June, flow passes through this area from the Meghna in the vicinity of Nabinagar to the Meghna a short distance upstream of Daudkandi.

The polder in the southern part of Zone C blocks this flow path and results in the negative impacts in the un-poldered parts of Zones A, B and C, and a reduction of improvement in the poldered part of Zone A.

The improvements in flooding conditions in the southern part of Zone C are at the expense of a worsening situation in the areas upstream, since the embankment blocks flow from these areas. This, together with the fact that the southern part of Zone C is very important for fish production, led to the conclusion that the polder in the southern part of Zone C should not be included as one of the recommended developments for the Gumti Phase II area.

Based on the results of the final design option simulation, it was concluded that all the developments included in this simulation should be included in the With Project simulation with the exception of the polder in the southern part of Zone C. It was decided that the With Project simulation should test the situation where pumped irrigation was not included in the northern part of Zone C; initial design option C3 indicated the benefits that could be gained from pumped drainage in this area.

10.7 The Model of Recommended Interventions

The key components of the formulated development plan were modelled in the final design option simulation with the exception of the polder in the southern part of Zone C. It was decided that the With Project simulation should not include pumped drainage from the polder in the northern part of Zone C; initial design option C3 indicated the benefits that could be gained from pumped drainage in this area. Figure 10.5 presents the modelled developments for the Gumti Phase II area categorised into "Interventions".

The excavation in the Nalia (Intervention 1A) improved the pre-monsoon situation in the area. However, despite the excavation of the channel upstream of the Buri Nadi confluence, the elimination of spills along the left bank of the Nalia (Gunghur section) has resulted in a rise in peak water level in the region to the east of the Gunghur River. With no flow allowed through the structures in the embankment, the peak 1987 and 1988 water levels was shown to rise approximately 30 cm. However, if flow was allowed through the structures, then the rise reduced to 20 cm. A check was also carried out by further excavating the Nalia of 20 cm, but this only reduced the water levels by 3 to 4 cm.

The preliminary economic analysis indicated that assuming the advent of force mode tubewells, the Zone C scheme (Intervention 4) scheme was not likely to be economically viable. A 25 year run was therefore carried out without this option in place. The resulting water levels outside the Zone C embankment were very much the same as with the scheme in place. This was to be expected Jogidara took the additional discharge which previously went down the re-excavated Oder khal. The water level at the junction of the Oder khal and Nalia River remained very stable in all three options. The analyses were carried out on this final run.

Figures 10.6 and 10.7 illustrate the without project and with project depths by flood phase. Apart from the area to the east of the Gunghur, the project brings only benefits.

The flow patterns are changed very little by the proposed developments. The reversal in flow direction between the pre-monsoon and monsoon seasons in the Nalia, downstream of the Buri Nadi confluence, still occurs with the recommended developments in place.

The flood phases for the Gumti Phase II area, under With Project conditions, are presented in Table 10.3. In brackets in this table are the corresponding figures for Without Project conditions. These are the results for the decade with deepest flooding. For comparison, the difference for the Zone C embanked zone (area C2) includes pumped drainage.

In areas A1 (Intervention 1B), B1 (Intervention 2) and B2 (Intervention 5) which have been poldered, there is a significant reduction in the depth of flooding. The impact has been greatest in area B1 where the area flooded to depths of F2 or greater has been reduced from 49 % to 7 %.

In area A2 the percentage of the area flooded to depths of F2 or greater has been increased from 5 % to 18 %. This is as a result of the elimination of spills on the left bank of the Nalia into area A1.

Figure 10.5
Layout of Modelled Developments

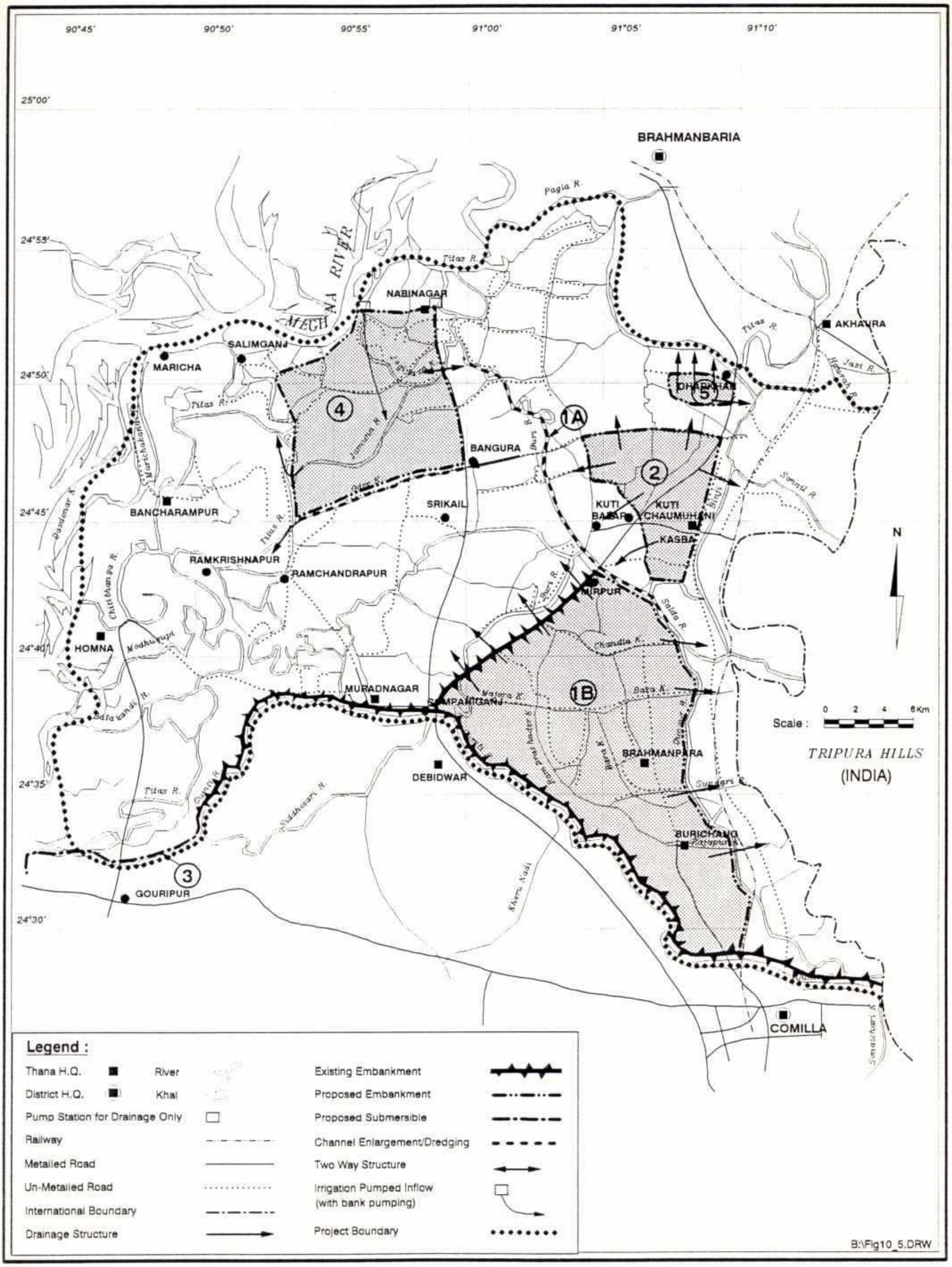

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Figure 10.6

Without Project 1 in 5 Year Peak Flood Phasing

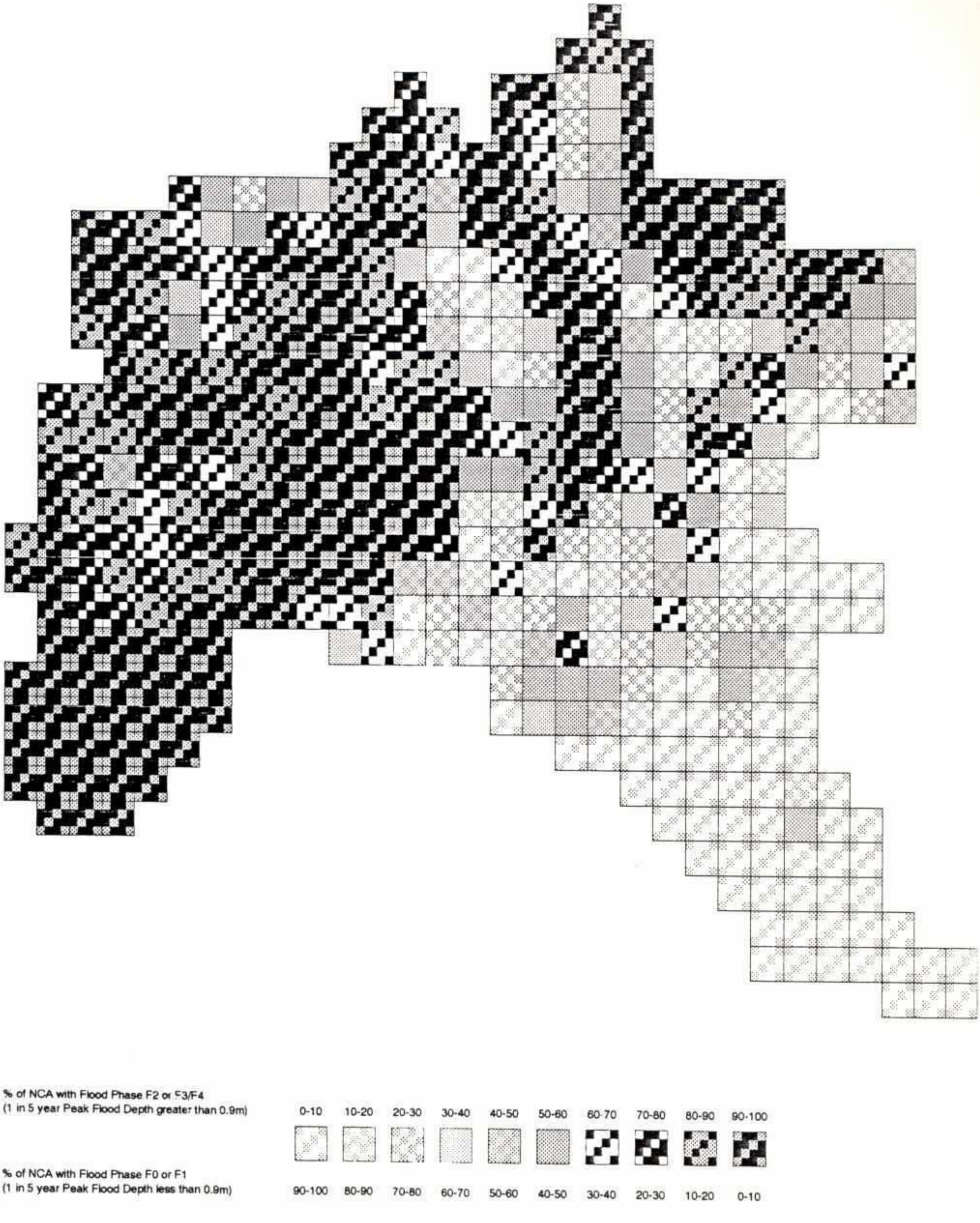

Figure 10.7

With Project 1 in 5 Year Peak Flood Phasing

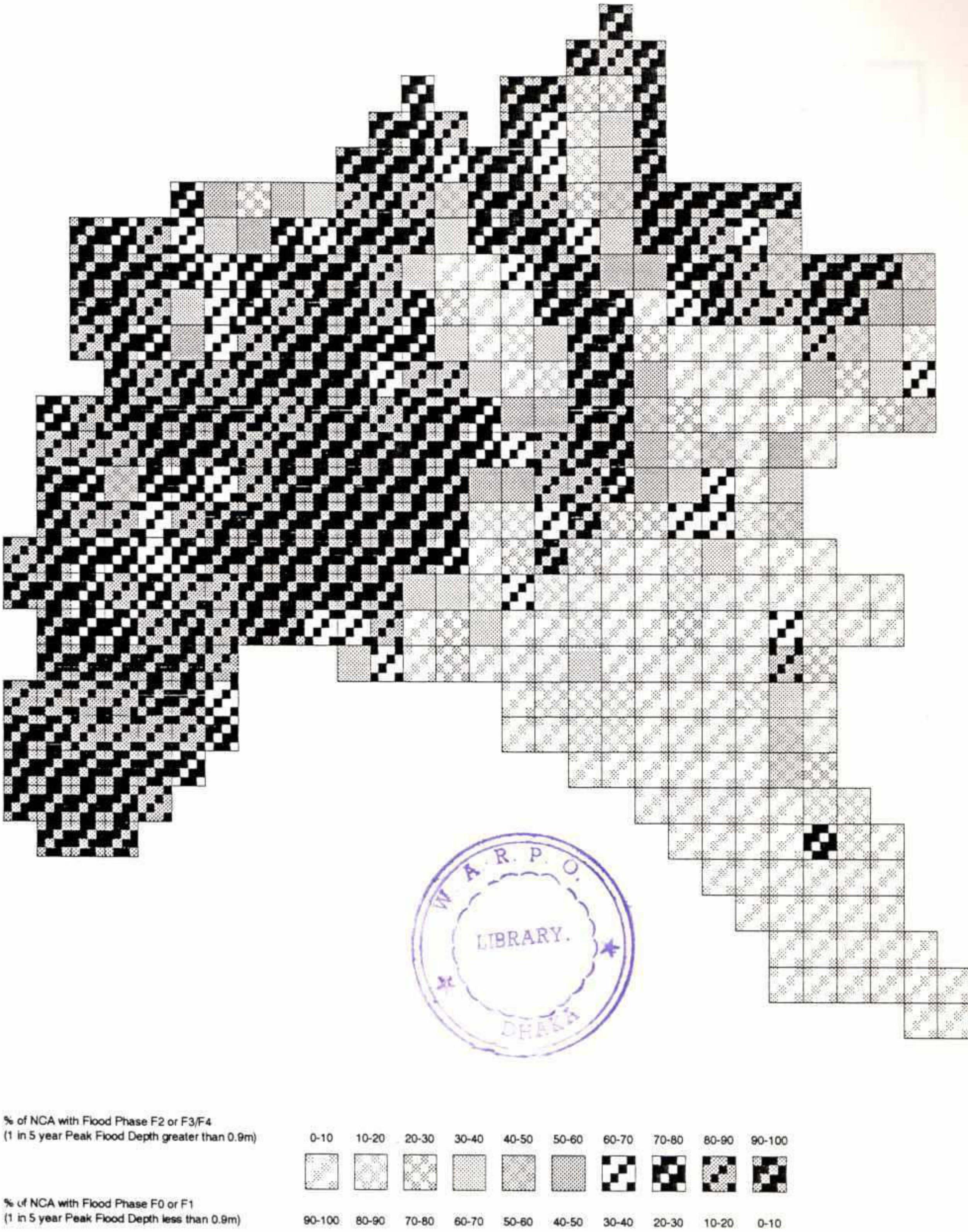

TABLE 10.3

Recommended Development Flood Phases for Gumti Phase II Area

AREA	MPO Flood Phase %			
	F0	F1	F2	F3+F4
A1	46 (28)	47 (53)	6 (19)	0 (0)
A2	60 (71)	22 (24)	18 (5)	0 (0)
B1	59 (20)	34 (31)	7 (44)	0 (5)
B2	3 (0)	29 (2)	48 (44)	20 (54)
B3	33 (35)	22 (22)	26 (24)	19 (19)
B4	4 (4)	14 (13)	46 (46)	36 (37)
B5	19 (20)	35 (35)	31 (31)	15 (14)
C1	2 (2)	12 (11)	68 (67)	18 (20)
C2 (pumped)	73 (7)	21 (17)	6 (61)	0 (15)
C3	12 (10)	36 (32)	39 (42)	13 (16)
C4	5 (3)	29 (28)	25 (27)	41 (42)
C5	3 (3)	9 (9)	51 (48)	37 (40)
D1	2 (2)	7 (7)	31 (31)	60 (60)
D2	4 (4)	13 (13)	42 (42)	41 (41)

Note: Bracketed values are without project

In the previous model option including the Zone C embankment, the poldered area C2 (Intervention 4) has only a small reduction in the amount of deeply flooded land in the absence of pumped drainage. Model simulations indicate that the percentage of land flooded to a depth of F2 or greater in this area could be reduced to 6 % by pumping at the fitted capacity of the irrigation pumps in the north of the area.

In area D1 the situation has improved slightly in the pre-monsoon period as a result of the extension of the Gumti right embankment (Intervention 3). However, this is not shown by Table 10.3 as the values relate to peak flood depth, when the submersible embankment will have been overtopped.

In the other analysis areas the situation is little changed from the Without Project conditions. Flood control options elsewhere in Bangladesh are unlikely to affect the impact of the recommended developments.

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10.8 FCD and FCDI Options

A number of flood control studies have been carried out previously in the Gumti Phase II area. The most recent of these, the Gumti Phase II Sub-Project Feasibility Study, which was carried out by Bureau of Consulting Engineers Ltd (Bangladesh) in association with Sir William Halcrow and Partners Ltd (UK), produced three options for development. The flood control and drainage (FCD) option and the recommended flood control, drainage and irrigation (FCDI) Alternative A option were simulated in the hydrodynamic model.

FCD Developments (Strategy (d))

Flood conditions are improved in all of the post-processing areas of the Gumti Phase II study area as a result of the FCD developments; in many of the areas the changes are small.

The greatest improvements are in the north Buri Nadi block which is on the right bank of the Nalia and extends as far as the Bijni.

FCDI Developments (Strategy (e))

In all of the Gumti Phase II post-processing areas the results from the FCDI option give less deeply flooded land than both existing conditions and also the FCD option. In the eastern part of the area the improvements over the FCD option are small whilst in the northern and western parts, which are mainly affected by the pumping, the improvements are more pronounced. In the western part of the area significantly more than 50 % of the land area remains flooded to depths of F2 or more despite the pump stations operating for many months of the year.

10.9 Conclusions and Recommendations

Hydrodynamic modelling of the Gumti Phase II area has brought the complex hydraulic regime into an analytical framework. It has proved to be an invaluable tool with which to assess and understand present flooding problems and to assess the impacts of measures to alleviate these problems.

The primary conclusions of the hydraulic modelling are described above. Further detailed hydrodynamic modelling should be carried out at the detailed design stage; the boundary conditions for these models should be provided by the most appropriate hydrodynamic model available at the time.

At the detailed design stage the hydrodynamic model should be updated using the latest hydrometric and topographic information. To obtain the maximum benefits the model should be linked to a digital elevation model.

Linking the model output results to other post-processing programs has enabled the models to be used in a much wider context than that of simply predicting water levels and discharges within the modelled river reaches and drainage channels. Further work should be undertaken on these applications.

More detailed analysis should be carried out, at the design stage, to quantify, as far as possible, the morphological changes which may be induced by projects in the Gumti Phase II area.

Further work should also be carried out in optimising the benefits of Zone A. This can be done by using compartments within the protected portion of the zone. By altering management strategies for drainage between compartments, the optimum dispersion of rain water and controlled inflow from the Gunghur River may be ascertained. As this work will require optimisation of management procedures instead of pure modelling from hydrological inputs, MIKE11 will not be suitable for the task.

11 Options for Development

11.1 General

The basic objectives of any proposed development in the area is one for economic improvements. This encompasses the maximization of the net present value of aggregate of consumption benefits and employment generation. With the current Government policy of attempting to reduce public sector expenditure, the encouragement of investment by the private sector becomes an important criterion.

The project area has been divided into different zones, as shown in Figure 9.1, each of which has a characteristic set of problems and hence potential development solutions. Because of these varied characteristics, it is considered important to approach the study in this context rather than to treat the area as a whole. There are interventions which will affect more than one zone, but this is easily accommodated within the analysis approach.

The planning steps taken in order to arrive at a set of interventions were extensive and are described in Annex I, Section I.6. The final set of proposed interventions are illustrated together in Figure 11.1. These interventions were tested using the MIKE 11 hydraulic model, to see their effect on agriculture and the environment. The model runs are discussed in Annex B.

11.2 No Project Development (Strategy (a))

There are three main arguments why there should be no project agricultural developments in the Gumti Phase II project area.

The first is that the project area is one of the highest floodplain fish production areas in Bangladesh. This means that any attempt to polder off any portion of the existing floodplain will involve heavy fishery losses.

The second is that there is a heavy sediment load coming annually into the east of the area from the Tripura hills, in India. This makes annual maintenance of khal excavation in the area expensive.

The third reason is that despite gas and salinity constraints, it is technically feasible to irrigate the entire net cultivable area to ensure winter crops, including boro, using tubewell technology. Therefore schemes which require two stage pumped irrigation are unlikely to be economic.

However, it should also be noted that the population density has increased significantly in the area and additional food and employment is greatly required. People's participation meetings highlighted many specific problems in each part of the project area and also gave possible solutions to these problems.

It was therefore concluded that despite the constraints of fisheries, sedimentation and the natural growth in "without project" irrigation, agricultural development was still important in the area. However, a viable scheme would have to be sympathetic to environmental considerations and should specifically address local water related problems.

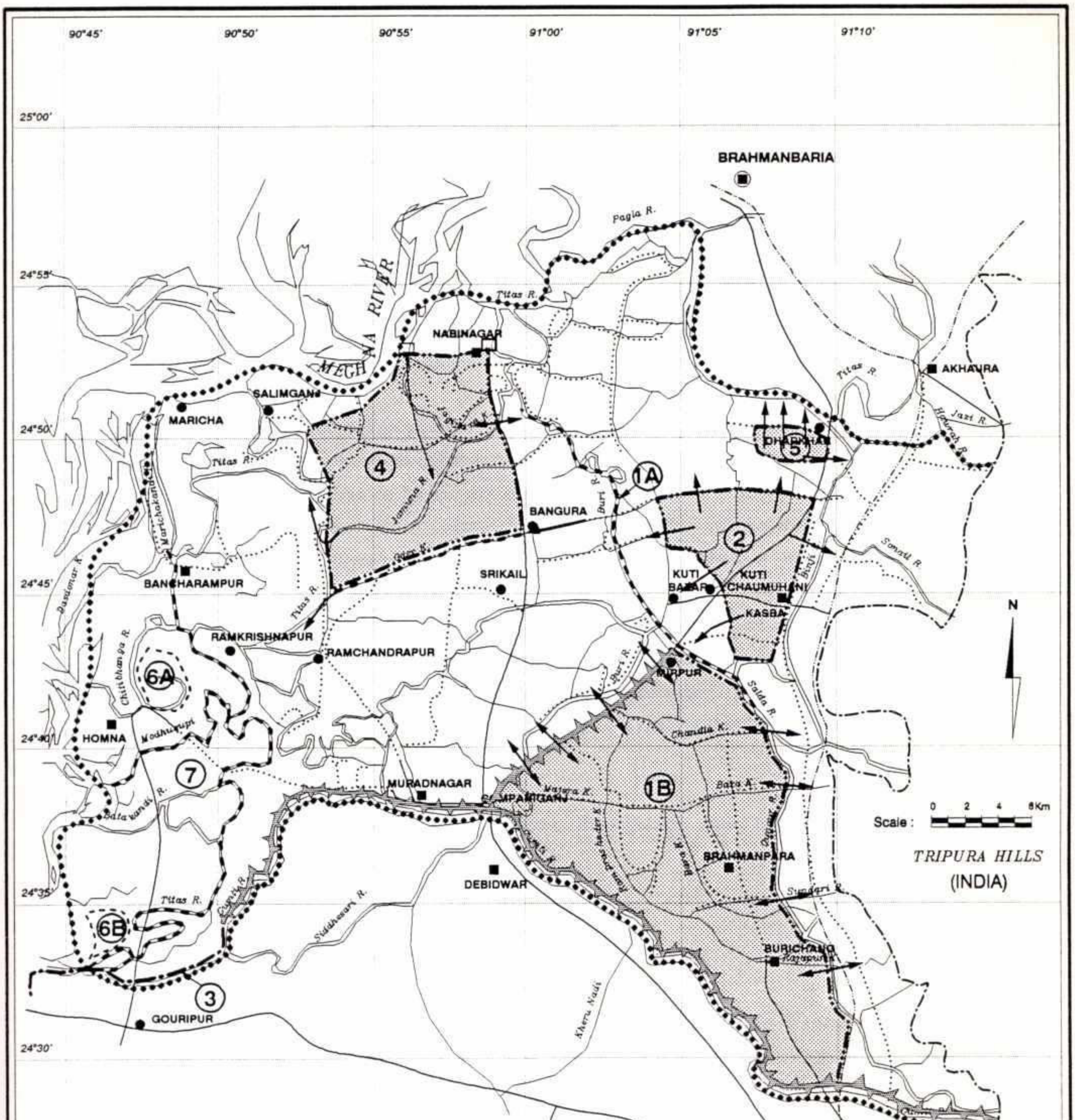

Figure 11.1
Layout of Interventions

11.3 Basic and Intermediate Flood Response Project (Strategies (b) and (c))

11.3.1 The Zone A Interventions

The initial model run showed that the peak water level in the unprotected area, to the east of Gunghur River, rose significantly when the Gunghur left embankment was in place. Further runs showed that if controlled discharge (40% of peak flow) was allowed into the protected area then this would reduce the additional rise but would also adversely affect the agricultural benefits caused by the embankment.

However, excavation of the Salda and Buri Nadi showed a considerable mitigation. With no discharge entering the protected area of Zone A, the peak (1987 and 1988) water levels showed an increase of only 30 cm. If a very severe flood did occur and the villages in the unprotected were being threatened, then opening Gunghur embankment gates would further reduce the water level by 10 cm. As the villages in the area are not particularly flood prone at the moment, it is unlikely that the additional rise will cause significant problems.

The model showed that in consequence of the rise in water levels, the flood phasing in the unprotected area is a little worse, this is further discussed in Section 10. However, it should be noted that the increase of water level is limited to the peak monsoon period and area of dis-benefits is very much smaller than the benefitted area, to the west of the Gunghur River. However, because the additional excavation has such a significant effect on pre-monsoon flows, there appears to be no additional damage to the boro crop in the unprotected area.

In addition to the Gunghur left bank, the proposal for Zone A included a left embankment along the Salda River, up to the Comilla-Sylhet road. In order to protect the whole zone from monsoon floods, it was also proposed to seal the Comilla-Sylhet road to form the north-west boundary. Four regulators will replace road structures so that the area may be effectively drained. Also, the khals within the protected area leading to the regulators are to be re-excavated.

In order to minimise khal and floodplain fisheries losses, the regulators under the Comilla-Sylhet road will be fish friendly.

11.3.2 The Zone B Interventions

Figure 11.1 shows that two embankment schemes have been considered in Zone B, a small scheme in the north (Intervention 5) and a larger one in the south (Intervention 2). Both schemes use existing roads to the maximum possible extent.

Model runs showed that very little agricultural benefit was achieved in Intervention 5. This was because the topography of the area was relatively low and it could not release the pre-monsoon rainfall adequately under gravity. However, large improvements were shown in Intervention 2. The drainage of the area was also much improved by the proposed excavation in the Buri Nadi.

The required excavation of the Buri Nadi River (Intervention IA) will also have an additional benefit. At present, in a 1 in 5 dry year, LLP irrigation can take place in the Buri Nadi to 5 km south of Nabinagar. However, with the proposed excavation, an additional 14 km length will have full supply during a 1 in 5 dry

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year. This will therefore supply an additional 2800 Ha which can be served by LLP.

The Interventions in Zone B and Zone A are therefore linked by their common need for re-excavation in the Buri River. Because of this, they are to be considered as one scheme (Scheme A) in the economic analysis.

11.3.3 The Zone C Interventions

The initial proposal for Zone C was to have two embanked schemes either side of the Oder Khal. Each with pumped irrigation supply to the khal and river network. A distribution canal, along the line of borrow pits for the Muradnagar-Nabinagar road, was to be excavated. Also, re-excavation was required in the existing khals.

The hydraulic model runs showed that in the present situation, pre-monsoon flow generated in the Tripura hills flowed into the Buri Nadi, which conveyed it north into the Titas River, by Nabinagar. When the monsoon arrived, water levels in the Titas backed up, with the rise of the Meghna levels. Instead of going north, the direction of flow changed to the west, passing through the khal and floodplain system north of Muradnagar to discharge into the Meghna between Homna and Daudkandi.

By effectively blocking this route with the southern Zone C embankment scheme, the water was restricted to flowing through the Oder khal. This caused congestion which had an adverse effect on the area to the east of the Muradnagar-Nabinagar road, including drainage from the schemes in Zones A and B.

These adverse effects meant that the southern embankment had to be abandoned. Model runs without the southern embankment, but with the khal excavation, brought the water levels back to the without project situation.

The proposed intervention for Zone C therefore consists of an embankment for the northern area (Intervention 4). In addition, 8 cumecs of pumped irrigation will be provided to the northern area and 14 cumecs for irrigation to the southern area. The southern area will not have any flood control. Both of the pump stations will be reversible and both pump stations will be used for pumped drainage of the northern embankment. Because the full 22 cumec capacity will be used for the 10460 ha protected area, the percentage of F0 land will increase from 7% to 73%, which will give a very large rise in the amount of T aman which could be grown. The disadvantage, of course will be the destructive effect to the floodplain fisheries in the area.

11.3.4 The Zone D Interventions

Khal Re-excavation

The most effective intervention for the Gumti Phase II area is re-excavation of khals in Zone D (Intervention 7). This intervention can be carried out with no negative effects. This is because fisheries will incur no floodplain losses but will achieve some gains. Also, drainage of the area will be improved. Maintenance costs will not be so high because of the sediment content of the Meghna is relatively low.

The proposed locations for khal re-excavation are given in Figure 11.1. At present, about 4000 ha can be irrigated by LLP during a 1 in 5 dry year. This value will increase to approximately 14000 ha with the recommended re-excavation. It should be noted that farmers are generally willing to invest in LLPs even if the guaranteed availability is less than a 1 in 5 year return period. The present and future areas are therefore likely to be greater than 4000 ha and 14000 ha, respectively, with a greater element of risk involved.

At present, JICA is carrying out khal re-excavation in the area, however, the scale of their proposed work is small compared to the proposed requirements.

Submersible Embankment Schemes

Two submersible embankment schemes were identified and are indicated in Figure 11.1 as Intervention 6A and 6B.

i) Dari Char Area to the north east of Homna (Intervention 6A).

This area was chosen as ground levels are low, indicating that HYV boro damage would occur in the pre-monsoon period. Also, the area may effectively be encircled by road developments proposed under the JICA/LGED rural improvement programme. A single drainage regulator would be able to control the inflow/outflow regime.

ii) Motopi Area just to the north west of Gouripur (Intervention 6B).

Again, in this area, ground levels are low, indicating that HYV boro damage would occur in the pre-monsoon period. A single drainage regulator would be able to control the inflow/outflow regime.

It was concluded that it was not possible to include a fish gate into the design. This was because any viable fish gate would let an unacceptable amount of water into the protected area before the boro crop could be harvested. The submersible embankment schemes were therefore considered to incur heavy fish losses (50%) because of lack of access to fish and spawn in the months of April and May. This value is consistent with the losses incurred in the existing Satdona beel scheme.

A further disadvantage of the concept was that when water is allowed into the protected area, the rate of rise of water level was much higher (10 cm per day) than the normal Meghna level rise (5 cm per day). This means that if B aman is to grow, a faster growing but inferior yielding variety will be required. The effect of these embankment schemes are analysed in detail in Annex I, Appendix I.V.

In order to properly assess the benefit of the scheme, the Agriculturalist visited the two areas in question. The farmers stated that they did not generally incur damage to their boro crop, as they tended to plant very early. The crop could therefore be harvested early, prior to natural flooding. The farmers also stated that they did not wish to risk growing the B aman crop as water levels were very high and also B aman was often incompatible with the boro crop.

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These arguments and the analysis formed the conclusion that at present it was not cost effective to provide submersible embankment schemes in Zone D. It must be noted, however, that this situation could change.

FAP 6 are presently considering interventions which could affect the timing of Meghna floods in the Gumti Phase II project area. Unfortunately, the FAP 6 "with Project" Modelling results are not yet ready, so the downstream effect is not yet known. If the time of flood is brought forward, then the boro crops in the submersible embankment areas will suffer damage. In this case, the submersible embankment schemes should be taken up as mitigation schemes for FAP 6.

Extension to Gumti North Embankment (Intervention 3)

Local people, during the course of the study, expressed a strong desire for protection against River Gumti pre-monsoon flash flooding, on the northern side, downstream of the existing embankment.

A dwarf embankment should therefore be constructed between the existing embankment on the north side of Gumti River and Gouripur. The purpose of this embankment is to prevent flash floods from affecting the boro crops of the area between the Gouripur-Homna road and the River Gumti. Two flushing sluices have been included to maintain present irrigation supplies. A small (submersible) embankment has been selected as it is not considered worthwhile to protect the area against monsoon floods, when high monsoon water levels will come from the Meghna River anyway. After the month of June, the Meghna related water levels will rise in the Gumti and Titas Rivers, so the embankment will be submerged.

In addition to protecting the area from flash flooding in the boro season, the embankment will also prevent sand from coming into the area, thereby reducing the required maintenance cost for re-excavation the Lower Titas River in the area. Extension of the embankment from Gouripur to the River Meghna was considered, but this would have to include a large structure at the Lower Titas outfall to the River Gumti, which would be very expensive. The computer model is not sophisticated enough to accurately predict the effect this extension will have on the area downstream of Gouripur. However, the area is already effected by flash floods and the Matia and Lower Titas beds are being excavated, which will improved drainage in the area. Should the situation show that despite the improved drainage, boro crops are being regularly damaged, then the Southern area submersible embankment scheme could be incorporated.

11.3.5 Recommended Phasing

The proposed Interventions which have been considered under basic and intermediate flood response projects have been grouped together as proposed "Schemes" as follows:

Scheme A

Construction of works in Zone A, including Interventions 1A, 1B as follows:

- the River Gunghur/Salda embankment with 4 nr regulators
- the Comilla to Sylhet road heightening, closure of 16 conveyance structures and provision of 4 nr fish friendly regulators.
- internal khal re-excavation for drainage of the 23,850 ha area
- external re-excavation of part of the Gunghur, Salda and Buri Nadi Rivers

Construction of works in Zone B, including Intervention 2 as follows:

- upgrading local roads to full embankment height and providing 6 nr regulators
- internal khal excavation for drainage of the 5,820 ha area
- external re-excavation in part of the Buri Nadi

Although the Zone A and B portions of the scheme appear to be independent, they are in fact linked by the excavation of the Nalia River (Salda and Buri Nadi).

Scheme B

Construction of works in Zone D, including Intervention 3 as follows:

- submersible embankment extension to River Gumti right embankment up to Gouripur
- provision of 2 nr flushing regulators

Scheme C

Construction of works in Zone D, including Intervention 7 as follows:

- re-excavation of khals for LLP operation and drainage affecting approximately 14,000 ha

Scheme D

Construction in Zone C, including Intervention 4 as follows:

- full embankment of the 10,460 ha area to the north of Oder khal
- re-excavation of rivers and khals for LLP irrigation over the (gross) area of 22350 ha
- construction of 2 nr pump stations (7.56 cumec and 14.62 cumec)
- construction of 10 nr regulators
- construction of administrative buildings

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Scheme E

Construction of works in Zone D, including Intervention 6 as follows:

- submersible embankment to the 1,060 ha area north-west of Gouripur
- drainage regulator
- brick mattress spillway

- submersible embankment to the 1,560 ha area north-east of Homna
- drainage regulator
- brick mattress spillway

Scheme A is independent from any other schemes. The protected area in Zone A will prevent flash flood damage as soon as the Gunghur/Salda embankment is in place. However, unacceptable flood levels will occur to the east of Gunghur River with the embankment in place, unless the Buri Nadi and Salda excavation is carried out. These works should therefore be carried out first, and simultaneously.

To maximise the beneficial effect of the scheme, the Zone B embankment is assumed to be constructed at the same time as the Zone A embankment.

Although Scheme B and Scheme C effectively stand alone, it should be noted that Scheme C includes khal excavation which will mitigate any adverse flooding downstream of Gouripur. However, Scheme B will also reduce khal maintenance requirements in the Lower Titas River. It is therefore recommended that detailed design for Schemes A, B and C should be carried out at once and implementation should begin as soon as possible. The implementation schedule is given in Section 13.

The viability of Scheme D will depend on the success of force mode tubewell technology in the area. This will be included in the NMIDP project, which started in 1993. It is therefore recommended to wait for their findings before making the decision whether or not to implement the scheme.

Under the present conditions, Scheme E is not viable. However, if FAP 6 implementation alters the flood timing, then submersible embankments in these pockets of low land may be required. This cannot be ascertained until FAP 6 have completed their "with project" model runs.

11.4 Full Flood Control and Drainage

11.4.1 General

The Consultants for the 1990 report went into considerable detail when considering the engineering aspects of the FCD and FCDI schemes. As such, it has not been considered worthwhile to attempt to fine tune the proposal, so the scheme analysed, using our methodology, is the same scheme proposed in the 1990 Report.

11.4.2 The Flood Protection and Drainage Scheme (Strategy (d))

Figure 11.2 shows the full Flood Control and Drainage (FCD) system. The scheme consists of a main perimeter embankment, the Salda/Buri Nadi double embankment, the Gunghur and Bijni left embankments and 12 nr drainage regulators. Most of the regulators are arranged to act as flushing sluices to admit irrigation water during the dry season. There will also be a flushing sluice in the extreme north-east of the project area.

The area is divided into the following 3 main polders:

- The south and west block of 103,019 ha, gross
- The north-east block of 24,082 ha, gross
- The Bijni block of 10,529 ha, gross

The major flows into the area, from the Indian border, have been routed to the relevant drainage regulators by way of enlarged drainage channels. Since the enclosure of the Buri-Salda channel has disrupted the normal drainage pattern in the Buri area, two side drains from Kuti to the Nabinagar regulators are included in this alternative.

The South and West Block

Approximately 13,300 ha of Indian territory drains into the area. The drainage water from this area is collected by the Gunghur River. Four gaps in the Gunghur left embankment discharge the water into the Chandla Khal, Bara Khal, Sundari Nadi and the Ramprashader khal. These khals will be enlarged to carry the drainage water. In addition, parts of the Buri Nadi, Arsi Nadi and Zia khal will also be enlarged to the point where they discharge into the Lower Titas River. From these points, the pre and post monsoon flows will be discharged through the regulator and lock at Homna and regulators at Mirpur, Lalpur, Batakandi and on the Matia River.

The Northern part of the block will drain to Homna or Muktarampur via the Titas and Chitibhanga Rivers or to Nabinagar West regulator via the Jamuna and Jogidara Rivers.

The North Buri Block

Small drainage regulators are provided at Shibnagar, Nar Ghat and Chandai Ghat, but the major part of the drainage will be by way of the large Nabinagar East regulator. The only channel excavated to help drain this area will be the east side drain of the Buri Nadi.

The Bijni Block

This block is part of a drainage catchment of nearly 30,000 ha, 18,000 of which are in India. A major drainage regulator is therefore required at the mouth of the Bijni River, where it crosses the main embankment and close to the river's confluence with the Titas.

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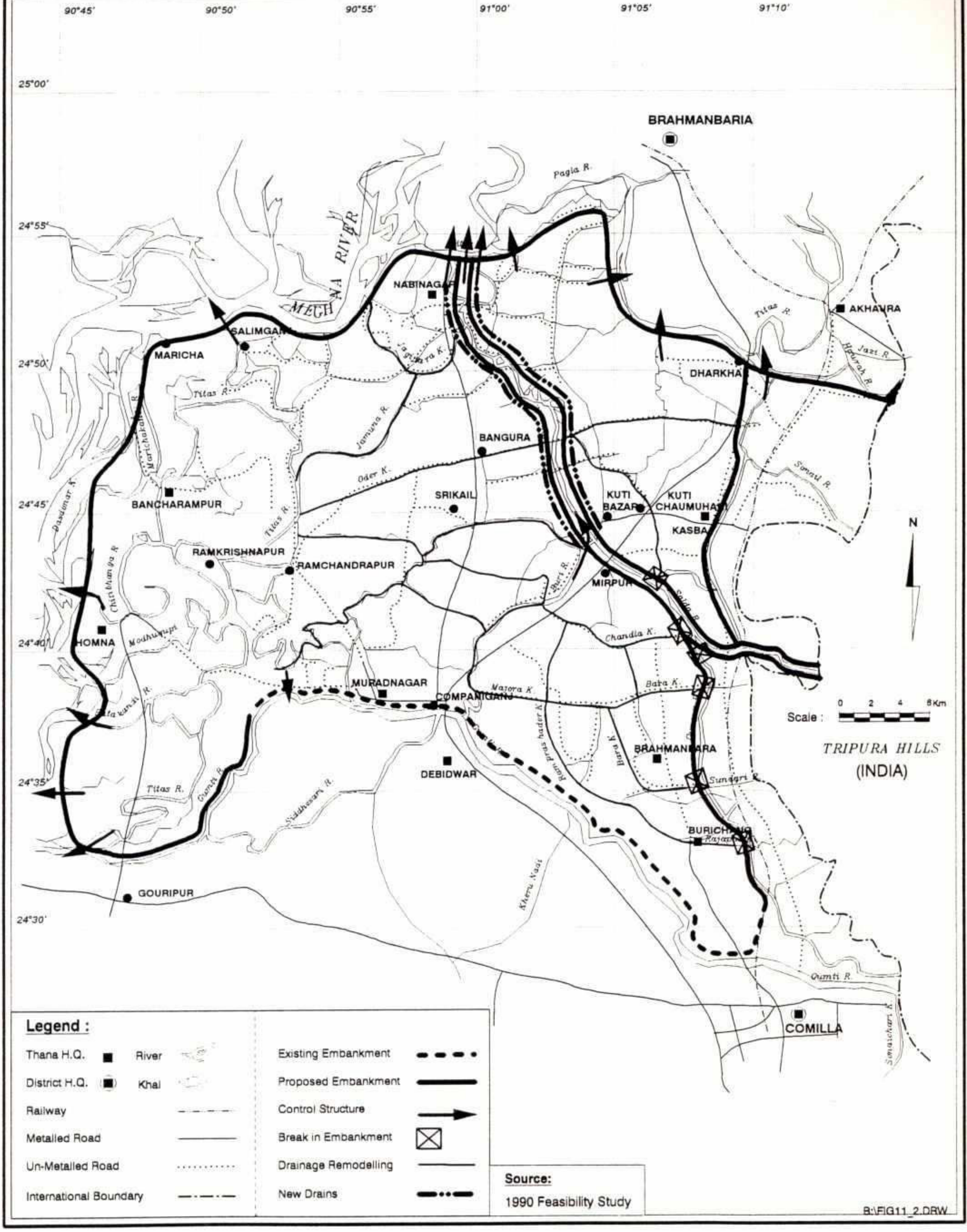
Figure 11.2

Map of Strategy (d)



Irrigation

The source of irrigation in the FCD case will be from tubewells or surface water admitted by flushing sluices. In addition, a very limited amount of water may be stored by closing the regulator at Nabinagar on the Buri Nadi. This stored water may be used by farmers near the embankments with LLP's pumping over the embankment.

As discussed in Section 2 and Annex C, the effect of polderizing the area will not have a major effect on groundwater. Assuming adoption of force mode tubewells, groundwater will be able to supply the area not covered by LLPs. The area covered by LLPs is assumed to be the same for "project with" and "project without" conditions. From our surveys and AST data, this amounts to 22,500 ha.

Transport

The relatively high water levels inside the polder during the monsoon mean that there is little point in road construction in the western half of the area. However, the existing Gouripur to Homna road will be usable and it is proposed to link this road to the main embankment at the Homna regulator with a metalled road. A short metalled road will link the launch ghat on the Titas with Nabinagar town.

There is no intention to provide more roads, although the remaining lengths of the main embankment, the Salda-Buri embankments and the Gunghur and Bijni left embankments will be wide enough to carry light traffic.

Because of the widening of the drainage channels, it will be necessary to provide new bridges on the Companiganj to Nabinagar road at the crossings of the Chapitala khal, the Zia khal and the Arsi Nadi. Access bridges will also be provided along the bank of the southern arm of the Buri Nadi where these cross the Majora khal, Chandla khal and Chapitala khal.

Since no road works are envisaged within the western area, it is important to maintain the existing waterway links. The 1990 Report water traffic surveys showed that the majority of the inward and outward boat traffic was on the Chitibhanga near Homna. In consequence, it was decided to include a double navigation lock with the regulator at Homna.

11.4.3 The Flood Control, Drainage and Irrigation (FCDI) Scheme (Strategy (e))

Figure 11.3 illustrates the proposed FCDI scheme. Again, the scheme is unaltered from the FCDI Alternative A proposed in the 1990 Report.

Flood Control

The flood control works consist of the main perimeter embankment, the Salda/ Buri double embankment, the Gunghur and Bijni Rivers left embankments and 9 drainage regulators and flushing sluices.

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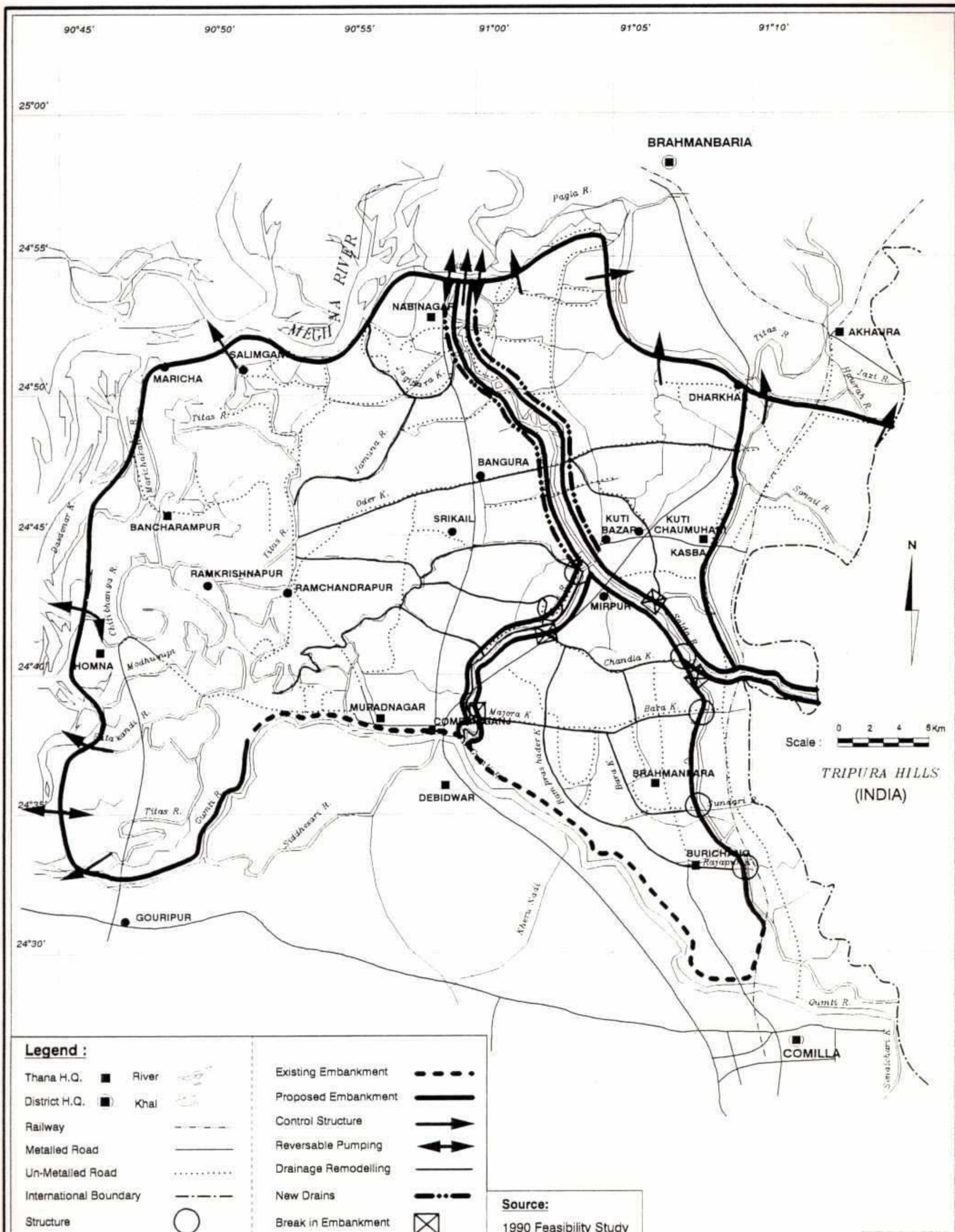
Figure 11.3
Map of Strategy (e)



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Drainage

The area is divided into the same three main polders as the FCD option. The south and west area is further divided by the embankments on the southern section of the Buri Nadi.

The south and west block is enclosed by the Indian border to the west, the River Gumti to the south, the Meghna to the west, the Titas to the north and the Buri Salda channel. The drainage of this area, and the 13,300 ha in India, is collected in the Gunghur River. The Gunghur will normally drain through check structures on the Chandla khal, Bara khal, Sundari Nadi and Ramprashader khal. These four channels will be enlarged, as will the Majora Nadi which will convey the flow, with the Chandla khal, to the Buri Nadi. Parts of the Buri Nadi channel will be enlarged to transfer these inflows to the Chapitala khal and Zia khal.

The Chapitala, Zia, Arsi, Roachala will also be re-excavated to convey the flow to the Lower Titas and Chitibhanga Rivers, eventually to be drained via the Homna pump station on the Chitibhanga. The northern part of the area will drain either to Homna or Nabinagar West pumping station, via the western side drain, parallel to Buri Nadi, or Jogidara khal.

The south-west corner is to be drained via the Matia and a reversible pump station at Mohanpur.

In addition to the three pump stations at Mohanpur, Homna and Nabinagar West, there are three drainage regulators at the junction of Lower Titas and Gumti Rivers, the Batakandi River and at Muktarampur on the Lower Titas to the north. While these regulators may assist local drainage during the pre-monsoon period, it is not expected that they will have much effect on the overall water level in the polder.

The North Buri Nadi block is enclosed by the perimeter embankment to the north, the Bijni left embankment to the east and the Salda/ Buri Nadi right embankment to the south and west. The major khal network in the area will be enlarged and improved and will drain north-west to the Nabinagar East pump station.

The Bijni block is bounded by the perimeter embankment to the north, the Indian border to the east and the Bijni left embankment to the south and west.

The block is drained north into the Titas, involving a large regulator in the perimeter embankment where the Bijni River crosses the embankment alignment. Excavation to the Bijni River is also proposed.

Irrigation

Irrigation supplies are provided by a combination of four main pumping stations and tubewells. The 1990 Report hydraulic model assumed the following capacities:

Mohanpur	4.5 cumecs
Homna	50.0 cumecs
Nabinagar West	25.0 cumecs
Nabinagar East	12.5 cumecs

In order to compare like with like, this report has assumed the same capacities. The axial flow pumps are assumed to be powered by electricity and in all cases are reversible.

The Mohanpur pump station supplies the area in the south-west corner of the project area.

The Homna pump station pumps from the Meghna into the Chitibhanga River and thence into the network of khals and beels of the Lower Titas River. This irrigation network includes a system of relift pumps.

The Nabinagar East and West pump stations pump water into the embanked Buri Nadi channel. The combined irrigation flows of both the east and west pumping stations at Nabinagar are distributed by this channel and the relift pumping stations at Bijni and Gunghur. There are therefore six combined irrigation outlets (aqueducts) on the Buri Nadi, which transfer irrigation water to the drainage system over the low level drains which run parallel to the Buri Nadi. A large irrigation structure at Kuti controls flows into the southern arm of the Buri Nadi, while a similar outlet controls the flow into the Rajar khal.

On the Gunghur, in addition to the four large drainage control structures, which will also control irrigation flows, there are five small irrigation offtakes to supply local areas adjacent to the embankment. Three similar structures distribute irrigation water to the North Buri Nadi block from the Bijni.

The main pump stations are designed to operate for 24 hours a day during peak demand. However, it is assumed that the relift pumps and LLPs will only pump for 16 hours a day. In consequence, water will be stored in the lower Titas and the Buri Nadi. This will have minimal effect on the Lower Titas but will generate water level increases of between 0.3 and 0.4 m in the Buri/Salda channel, which is confined. This will not threaten overtopping but will make operation more complicated.

In addition to the four main pumping stations, there are five relift pump stations. They are located as follows:

Arsi PS - 4 cumec capacity, situated on the Arsi Nadi commanding the area drained by the Arsi Nadi, Zia khal and Chapitala khal.

Oder Khal PS - 4 cumec capacity, situated on the Oder khal commanding the area drained by the Oder khal.

Jamuna PS - 12 cumec capacity, situated on the Jamuna River commanding the area drained by the Jamuna and Jogidara khals.

Bijni PS - 12 cumec capacity, situated on the right bank of the Salda River commanding the Bijni and North Buri Nadi blocks.

Gunghur PS - 9 cumec capacity, situated on the left bank of the Salda, opposite the Bijni PS, commanding the areas either side of the Gunghur River.

In addition to the pump stations and their associated structures, there are a large number of other irrigation structures controlling the flows and levels of irrigation water supplies, such as irrigation offtakes, inlets and check structures. These, as well as other details of the scheme are discussed in the 1990 Report.

All these pumping stations and control structures are intended to supply water to the existing of khals within the area. Water will then be relifted to the fields by LLPs, owned and operated by the farmers.

12 Impact Assessment

12.1 Introduction

12.1.1 Aims and Objectives

Environmental Impact Assessment for proposed development programmes attempts to place the considered interventions within a context of environmentally sound and sustainable development. The aim of the environmental component to the Gumti Phase II study was to provide a broad and integrated view of the likely implications of proposed interventions, so that these could be used as one criteria for judging if it was worth taking these to more detailed further study. A comparative assessment (including looking at a predicted without project situation) was carried out for a wide range of water and land development strategies being considered for the area. As a result of this assessment, recommendations were made as to the detailed interventions that were favoured, on broad environmental grounds, for further study. An assessment was then carried out for these and conclusions drawn from the analysis which allowed recommendations to be made as to which of the interventions should be studied to greater detail in the next phase of the work.

12.1.2 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 that was considered important was drawn up as a result of the early baseline assessment work in the study area. The predicted outcomes of interventions include a wide range of issues and these can be rated in terms of perceived and policy priorities. The likely nature and severity of impact, both positive and negative, needs to be considered in terms of which particular social groups of people will be effected, where and when. The impacts can be judged in relative terms and, if the data exists or can be collected, quantified and if appropriate valued, either in relative or economic terms. However many of the impacts are difficult to quantity let alone value and in any case they need to be judged against policy priorities, both nationally and regionally, along with an indication as to how these are to be interpreted locally.

12.1.3 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 in Figure 1.1. The study area was defined by a previous feasibility study which had a limited environmental component. It is bounded by the Gumti River in the south, which has been embanked for a considerable length of time, the Meghna main low flow channel in the west, the Titas River in the north and the Indian border in the east. The study area detailed map is shown in Figure 12.1.

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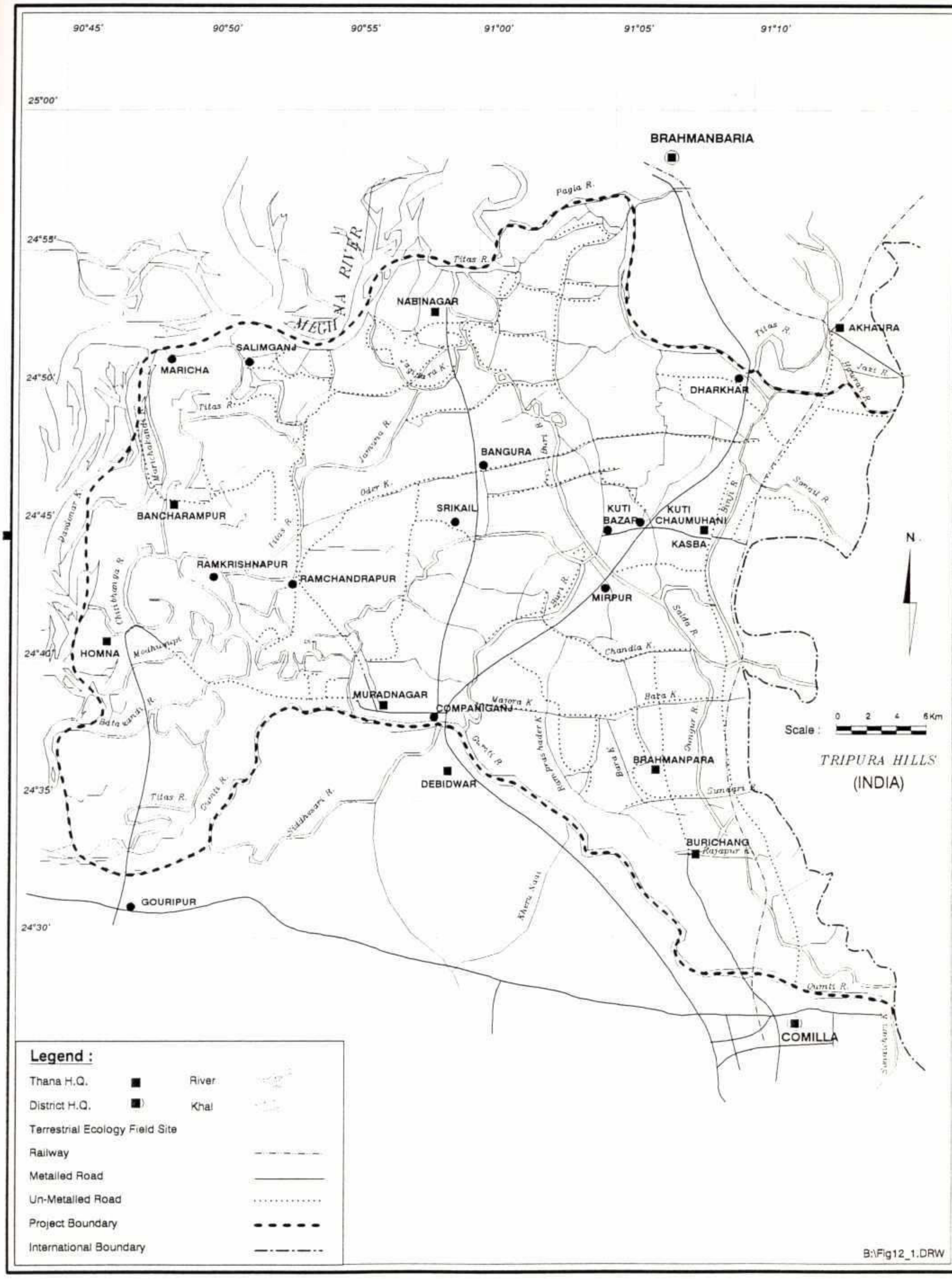
Figure 12.1
Project Area Base Map



12.1.4 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 basic 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 Environmental 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 Gumti Phase II 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 is thus essentially a scoping of feasible intervention possibilities with some analysis to allow a recommendation as to the most appropriate one to be taken forward for further detailed study.

12.1.5 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
* 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
* Health and Nutrition

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 most of it was done before the range of interventions to be considered for study was defined. This data shortfall could have been addressed to some degree if the 1991 BBS data for the area had been made available, but unfortunately it was not. For any future work it is essential that this data is made available.

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12.1.6 People's Participation

There was a significant people's participation component in the study which carried out a three stage set of visits to four villages from each of the four zones. This allowed an 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 enormous diversity of issues in the area and the requirement for highly site specific interventions. Overall, the participation work indicated that large scale embanking of the whole study area, as proposed by the previous study, was not favoured. The main flooding problem that was identified was flash flooding from the Indian hills in the east and not annual flooding from the Meghna River. The latter was perceived to be a regular "normal" occurrence for which nearly all homesteads are flood proofed on raised mounds for up to a 1 in 20 year flood event. It also transpired that the fisheries losses in the newly closed off submersible embankment areas in the western part of the study area have already resulted in fisheries losses of around 50% within 18 months of their construction.

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 H.2 of Annex H of this report. The basis for differentiation of these aspects are the four planning zones shown in Figure 9.1, delineated using a range of criteria including agro-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 thirty modelling cells which cover the study area. This then used the best topographic data that could be sensibly handled 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. There was an interactive process for the selected Strategy (c) (a complex set of diverse small scale interventions) by which each configuration of small scale multiple interventions was analysed and subsequently modified with the aim of minimizing any serious induced impacts, particularly increased upstream flooding and downstream backing up of water and/or drainage congestion. The modified interventions were then re-modelled to see if the modifications were successful in addressing the previously identified problematic impacts. The modelled outputs for the 1 in 2 year flood of the present situation are shown in Section 4 (Figure 4.2 for a rising flood and Figure 4.3 for a falling flood). The mapped outputs from the model were supported by field observation and reporting.

The mapped outputs show that the area floods first from the east, due to flash flooding from the Indian hills. The consequences of this show on the 1 in 2 year model output as flooding at the western end of the River Gumti right bank flood plain where the embankment stops before it reaches the Meghna River. This flooding is thus effectively the downstream impact of confining the Gumti River, a process that was started sometime before the year 1660. The Gumti flash flooding would appear to be an annual occurrence whilst the flash flooding from the hills north of this seems to be less common, probably because it is not concentrated in a confined channel. This was not very apparent on the 1 in 2 year model outputs but was very clear on the 1 in 5 year work. During the pre-monsoon, it shows flow to the north-west along the Gunghur and Salda Rivers. However, in the monsoon, when the River Titas levels rise, the River Gunghur flow meets the south bound Buri Nadi flow and both flows are conveyed to the Meghna River in the west. If the flash floods are severe (as was the case in April/May 1993) then this causes flow to go westwards from the Indian hills into the Zone A area. The main Meghna River is the last to rise, by which time much of the eastern part of the area has already been flooded and rainfall has filled all the depressions in the area. A major conclusion from the modelling results of the present situation indicated that there is surprisingly little difference in the extent of peak flooding for a "normal" and a high "normal" flood, the major difference being the duration. In any 1 in 2 "normal" or higher year, nearly all the study area goes under water by at least 0.30 m. Flooding extent and timing for the area appear to be determined by the water level in the main Meghna River channel in the south-west corner of the study area and the scope for changing the situation by engineering interventions would seem to be very restricted due to this and the high amounts of rainfall that occur in the area. The rising flood data has been compiled onto Figure 4.2 and the falling flood map in Figure 4.3.

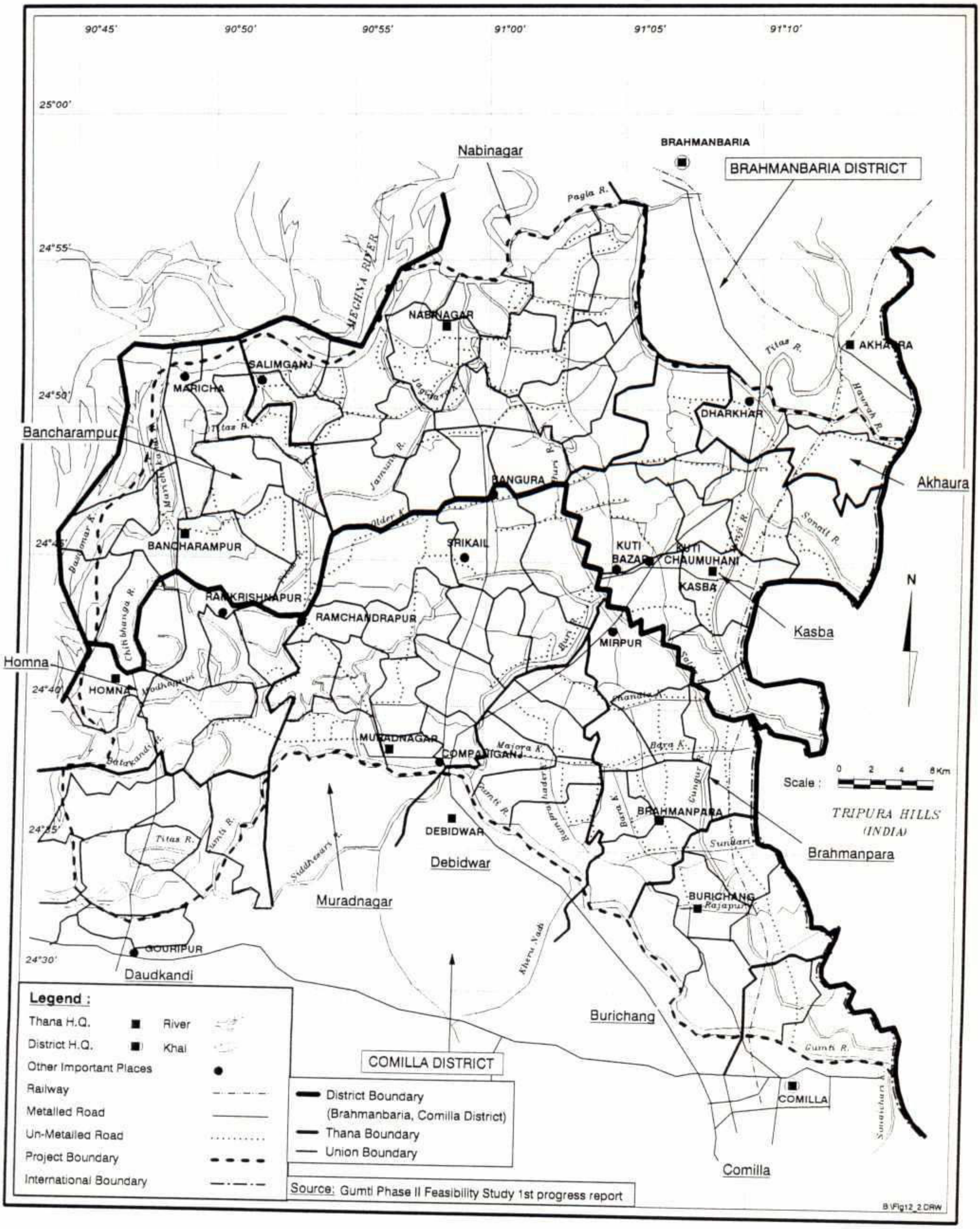
Other natural environmental issues considered include water quality, which is covered in Section 6.3 of this report. Main river erosion and accretion patterns were derived from time series Landsat imagery over the last 20 years. For land resources, the situation with regard to soils has already been outlined in Section 3.2 of this report. Attempts to obtain the existing surface soil chemistry data for the area were unsuccessful, so national standards for agricultural use were adopted. 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.

12.2.2 The Human Environment

The most notable feature is the very high population density and the long length of time that the area has been settled (from 350 BC at least, with formal written records existing from the 6th Century AD). The history of settlement in the area has been given in Section 6.6.1 along with an indication of known archaeological sites and landscape considerations. Formal political administration 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 12.2 and are based upon the BBS Small Area Atlas data and Police Station Maps which in turn are based upon the 1917 survey maps of the area reproduced in the Government Gazetteers. There is significant differentiation in population density across the area, although the only presently available data is for 1981 and is shown in Figure 5.1. Population density ranges from 500 persons/km^2 as the lowest with 1750 persons/km^2 the greatest. Up to 60% of households are landless (owning below 0.02 ha) and these are distributed in Zone D, northern areas of Zone C and the urban fringe of Comilla in Zone A. The lowest proportions are in Zone D where the figure is generally up to 19% which is surprisingly low for an area of Bangladesh that has such intensive agriculture. The proportion of households in 1981 with agriculture as their main activities is shown in Figure 5.5 and is

Figure 12.2

Administrative Boundaries (District, Thana and Union)



highly concentrated in the south eastern Zone D area, parts of Zone B and the north and southern edges of Zone C. Literacy rates for 1981 are shown in Figure 5.2 and are generally low in the western part of the study area, being below 20% in most places except in Zone D where they rise to 35%. For all this type of data it is imperative to have the 1991 BBS data as soon as possible so that it can be mapped, as for 1981, and then trend mapping produced to see the change in the last 10 years.

It is impossible to map land use in a formalised way in much of Bangladesh, due to its complexity in both seasonal and special terms. Even attempts to do this using detailed SPOT multi-spectral satellite imagery down to 1:25 000 have failed to produce usable information and if anything have confused the situation still further. Instead a conceptual model is required which combines the agro-ecological zones with flood timing and depth to the seasonal cropping calendar.

The level of capture fishing activity in the study is very high indeed, being one of the most productive areas in the country with an estimated annual catch of 26 800 t. The fish systems are shown in Figure 12.3 and illustrate the wide spatial variation in these. Overall, 56% of households are dependent upon capture fishing, 19% as a form of cash income and the others for directly consumed animal protein source. Again the spatial variation in this is very great, with 66% of the population in the western zone directly dependent to varying degrees on fisheries, falling to 18% in the south-east of the zone.

The picture with regard to health and nutrition has been briefly outlined in Section 6.5 and is given in detail in Appendix H.IV of Annex H of this report. The situation for domestic water supply has been given in Section 6.3 and mapped in Figure 5.3. Transport access through the area is highly variable, both spatially and seasonally. The road network is on embankments and these have implications for effects on flood patterns. The waterborne navigation system is extensive but there was sufficient time only to use the existing data on large traffic, whereas the impact issues are likely to require consideration of localised, small scale movement.

12.3 Development Proposals and Impact Assessment Methodology

12.3.1 Development Options and Strategies

The drawing up of a preliminary range of intervention strategies was carried out and given in the Second Progress Report. This included five differing degrees and types of intervention and they were broadly appraised relative to each other from an integrated environmental perspective. This then allowed environmental considerations to be borne in mind when drawing up an agreed intervention strategy for the area which was then studied in greater detail leading to recommendations being made as to which components of this were thought to be beneficial in overall terms.

Five possible broad policy strategies, labelled (a)-(e) (based on the TOR item 4) with (a) being a without intervention option, were drawn up for comparative consideration. Strategy (c) was a mixed strategy which took into consideration the great diversity of the study area, looking at different interventions in the various planning zones based upon proposed interventions suggested in the people's participation exercise. Strategies (d) and (e) were those suggested in the 1990 Report.

This first stage impact analysis thus considered a comparative assessment of these five possibilities on a

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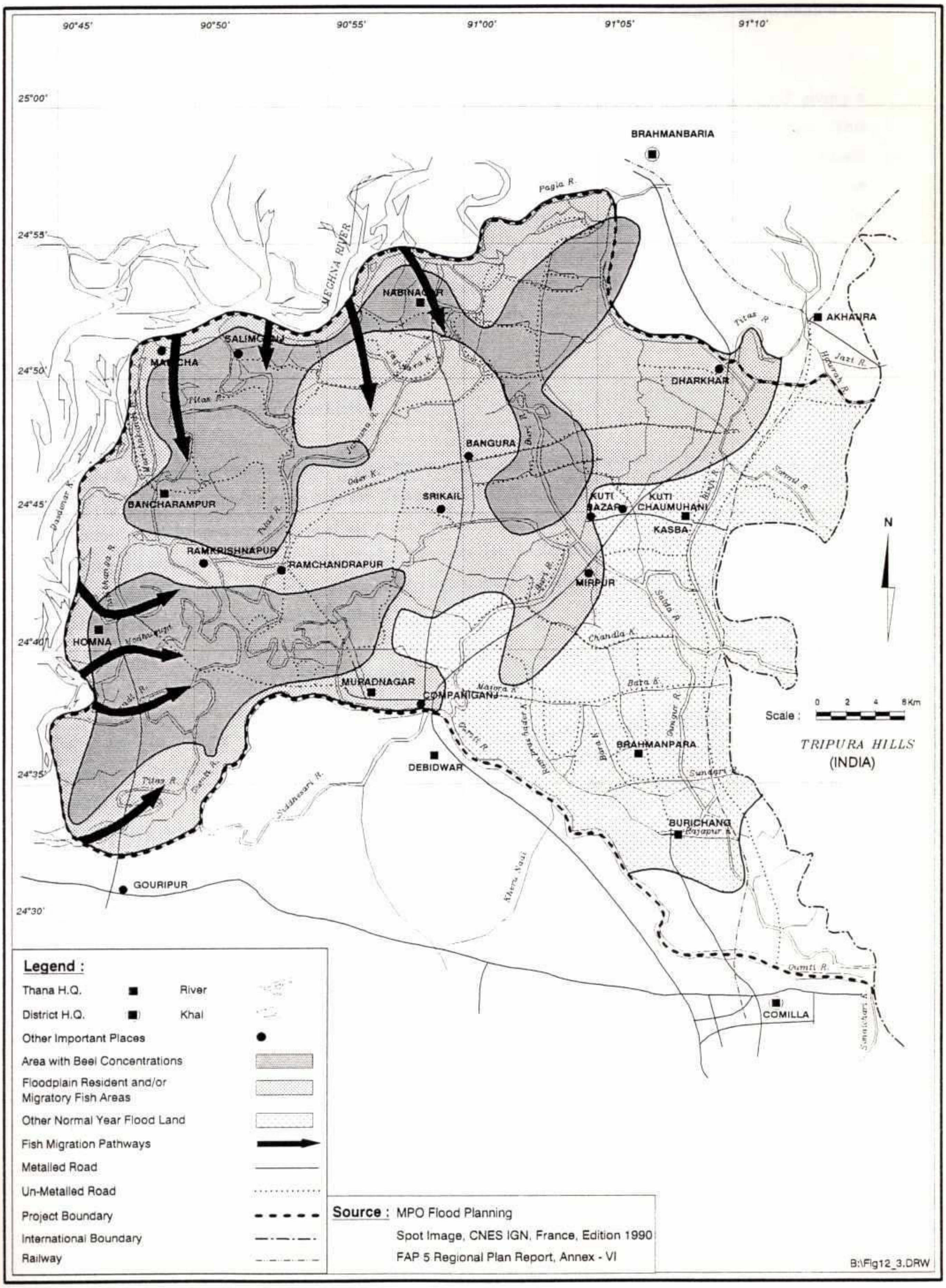
Figure 12.3
Fish Systems



conceptual basis, mainly to identify the likely broad positive and negative impacts of each strategy as an aid to drawing up a mixed or integrated programme of proposed interventions for study to the feasibility stage. The aim was to identify those geographical areas where the benefits can be maximised and the dis-benefits minimized for a particular broad strategy.

A brief description of each Strategy is given below and a ranking matrix has been constructed giving a comparison of the likely outcome of each strategy for each of the major identified environmental issues. This is shown on Table 12.1. These have been sub-divided into those concerning the natural environment, the human environment and considerations external to the project area but effected by or influencing it. In addition an indication is given of the likely priority issues, both from a detached technical perspective and also from the point of view of local people, these being gained from the people's participation exercise. For those issues which are considered to have serious negative impacts, an indication is given as to the possibilities for mitigation (i.e. if it is technically feasible) and also some idea of the likely costs.

Broad Intervention Strategies Considered

It should be recognised that the range of possible strategies that were considered are not incremental, they are essentially mutually exclusive of each other. The exception is Strategy (a), the Without Project situation, which by definition will happen irrespective of any project intervention. In addition there are elements of each strategy which can be separated and mixed with others. However this would further complicate the analysis which was aimed at providing indicators of positive and negative impacts of broad strategies to guide decision taking as to relevant interventions in Specific locations.

Strategy (a) - The Without Project Situation

This is the "do nothing" possibility for which the background situation is assumed to be the continuation of present environmental roads. This is notoriously difficult to predict for the natural environment and the maximum period for which this can normally sensibly be done is 6 years. The presently planned and implementing interventions include the recent construction and operation of two controlled flooding/submersible embankment schemes in the north-west of the study area, khal excavation to assist drainage and upgrading of the present road network on improved embankments. All these have implications for water and land management in the area. These activities are assumed to be taking place irrespective of any proposed study intervention.

Strategy (b) - Flood Proofing, Flood Response and Improved Drainage

This strategy includes a range of flood proofing possibilities, along with a flood preparedness and response programme following the lines of FAPs 14, 23 and 11. The flood proofing strategy covers a range of possible interventions depending upon the requirements of local people and the nature of flood risk. Ideas include individual homestead raising, provision of communal flood refuges and multi-purpose use of existing and any proposed embankments for both temporary refuge and permanent settlement. However the appropriateness of this strategy for the study area is highly questionable as much of the area appears to already be flood proofed to a 1 in 20 year return period and deaths from drowning due to river flooding seem to be negligible. It was however thought worthwhile to review present flood warning and disaster management procedures, particularly the situation with regard to the provision of pollution free water supplies and sanitation during flood periods, in addition to the need for securing storage of emergency seed grain. An additional component of this strategy is a larger scale khal excavation programme to ease drainage congestion and provide water storage during the dry season for surface irrigation. It could also include provision of a surface irrigation water promotion component in those areas where the without project groundwater development uptake is constrained by water quality.

TABLE 12.1

Comparative Impact Ranking Matrix for Strategies (a)-(e) Assuming No Mitigation

ISSUES	P	LP	NOW	(a)	(b)	(c)	(d)	(e)	MP	MC
THE STUDY AREA NATURAL ENVIRONMENT										
Hydrology										
Surface										
Flood Damage Land & Crops		*	0	0	0	+3	+1	+2		
Drainage Problems	*	*	0	0	0	+1	-2	-1		
Surface Water Availability	*	*	0	-1	-1	+2	-1	+1		
Groundwater Irrigation		*	0	0	0	+1	-1	+1		
Domestic Water Supply	*	*	0	+1	+1	+1	+1	+1		
Erosion										
Meghna			0	0	0	0	+1	+1		
Cross Drainage			0	0	0	0	-1	-1		
Sedimentation										
Meghna			0	0	0	0	0	0		
Side Drainage	*	*	0	-1	-1	+1	-2	-2		
Within Project Area										
Clogging/Smothering			0	-1	+1	+3	+2	+2		
Soil Fertility			0	-1	-1	-2	-2	-2		
Navigation		*	0	-1	-1	-2	-3	-3		
Water Quality										
Domestic Water Quality			0	0	0	-1	-1	-1		
Agriculture Water Quality			0	0	0	-1	-1	-1		
Land Resources										
Soil										
Quality/Chemistry			0	-1	-1	-2	-2	-2		
Waterlogging			0	+1	+1	+2	+1	+2		
Erosion			0	0	0	0	0	0		

ISSUES	P	LP	NOW	(a)	(b)	(c)	(d)	(e)	MP	MC
Ecology										
Flora			0	-1	-1	-1	-2	-2		
Fauna			0	-1	-1	-1	-2	-2		
Fish	*		0	-1	-1	-2	-6	-6	N	
Economic Livelihoods										
Risk			0	+1	+2	+3	0	+1		
Settlement			0	+1	+2	+2	+2	+2		
Land Tenure										
Scarcity			0	-1	-1	-2	-2	-2		
Agricultural Land Values			0	+1	+1	+2	+2	+2		
Common Resource Rights										
Fish	*	*	0	-1	-1	-2	-6	-6	VD	
Fuelwood			0	-1	-1	-2	-2	-2		
Grazing			0	-1	-1	-2	-2	-2		
Fodder			0	-1	-1	-2	-2	-2		
Agricultural Output			0	+1	+2	+3	+3	+3		
Fishing ("Professional")	*	*	0	-1	-1	-2	-6	-6	PO	CO
Forestry and Fuelwood			0	-1	-1	-2	-2	-2		
Livestock			0	-1	-1	-2	-2	-2		
Wage Paid Employment	*	*	0	+1	+1	+2	+2	+2		
Industry			0	+1	+1	+2	+2	+2		
Drinking Water Availability	*	*	0	+1	+2	+1	0	+1		
Human Health	*									
Waterborne Diseases	*									
Diarrhoea	*	*	0	-1	+1	-2	-1	-2		
Cholera	*		0	-1	+1	-2	-1	-2		
Insect Borne Diseases										
Malaria			0	-1	-1	-1	-1	-1		
Kala-azar			0	0	0	0	-1	-1		
Drinking Water Quality	*	*	0	0	+1	0	0	-1		
Sanitation			0	-1	+2	-1	-1	-1		
Nutrition	*		0	-1	-1	-2	-6	-6	VD	
Mental Health			0	-1	+2	+1	0	0		
Access and Transport Infrastructure										
Waterborne										
Meghna			0	-1	-1	-1	-1	-1		
Side Rivers		*	0	-1	-1	-2	-2	-2		
Within Project Area			0	-1	-1	-2	-4	-5	PO	
Railway			0	0	0	+1	+1	+1		

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ISSUES	P	LP	NOW	(a)	(b)	(c)	(d)	(e)	MP	MC
Road			0	0	+1	+2	+2	+2		
Archaeology and Cultural Sites			0	0	0	0	-1	-1		
-DOWNSTREAM CONSTRAINTS										
Meghna River Water Levels	*		0	+1	+1	+1	-1	-1		
-DOWNSTREAM IMPACTS										
Knock-on Flooding			0	0	0	0	+1	+1		
-UPSTREAM CONSTRAINTS										
Increased FAP 6 Flooding	?		0	?	?	?	?	?		
Indian Dams on Upper Meghna	?		0	+1	+1	0	+1	0		
Gumti River Hydro Dam			0	+1	+1	+1	+1	+1		
Upstream Sediment Inflow	*		0	-1	-1	+1	+1	+1		
ECONOMIC ASSESSMENT			0	0	-	+4	-3	-3		

LEGEND

RANKING OF IMPACT

-6 Severe Irreversible Negative Impact
-5 Highly Negative Impact
-4 Significant Negative Impact
-3 Moderate Negative Impact
-2 Slight Negative Impact
-1 Very Slight Negative Impact
0 Present Baseline Situation and No Change
+1 Very Slight Positive Impact
+2 Slight Positive Impact
+3 Moderate Positive Impact
+4 Significant Positive Impact
+5 Very Significant Positive Impact
+6 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
(a) = Without Project
(b) = Flood Proofing
(c) = Controlled Flooding
(d) = Polder + GW Irrigation
(e) = Polder + Surface Irrigation
MP = Mitigation Possible?
MC = Mitigation Costly?
(+1) = A Constraint not an Impact
* = Major Issues
F = In Times of Flood
LF = In Low Flows
PF = In Peak Floods
? = Insufficient Data to Assess

NOTE: The predicted impacts are assumed to be those some six years after completion of construction of the proposed interventions.

Strategy (c) - A Mixed Programme of controlled Flooding and Small Scale Polderization using Submersible and Non-Submersible Embankments and Improved Drainage

The elements of this strategy include the rehabilitation and rationalisation of existing embankments (particularly road embankments) and construction of some new ones, including submersibles, to allow flooding to be controlled and managed. In general this would not entail the complete exclusion of river flood water, but rather the aim would be to delay the early river floods. This is the prime rationale of submersible embankments, along with the protection they offer from diminishing the effect of flash floods, particularly outside the peak flood times. These will also have long reinforced weirs set into them as well as gated control structures, to allow for a more managed control of water regimes. In addition a khal excavation programme would be carried out as for Strategy (b), aimed at improving drainage of flooding caused by local rainfall. There is also likely to be provision of a surface water source for irrigation.

Strategy (d) - Full Polderization, Drainage and Groundwater Irrigation

This Strategy, which was suggested in the 1990 feasibility study for the area, excludes all external river flooding into the protected area by construction of full embankments. In addition there would be provision of improved drainage by khal excavation and a targeted programme to promote the up-take of irrigation using groundwater sources.

Strategy (e) - Full Polderization, Drainage and Surface Water Irrigation

This strategy was also suggested in the previous feasibility study for the area. It also has the full embankment provision component aimed at excluding all external surface in-flow into the area. The same khal excavation programme is also proposed and this would be linked to promotion of surface irrigation by pumping water back into the drainage system during the dry season, rather than a promotion of groundwater irrigation provision. The pumps would be used for pumping floodwater out of the poldered areas in the monsoon season.

Phased Area Development

In addition to the above range of Strategies, consideration would also need to be given to the drawing up of a Phased Area Development Programme for the study area. In theory this could be applied to each Strategy, however it is apparent that some of the Strategies are better suited and adaptable to this approach than others. Central to this idea is the concept of sub-division of the area into water management units or compartments, based upon existing constraints to water flow in the area (road and railway embankments for example). This would allow an incremental approach to development and a far more flexible water management policy which would be more sensitive to local people priorities. This approach could also allow the adoption of different strategies in different locations leading to an integrated but mixed development intervention programme for the area.

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12.3.2 Preliminary Impact Assessment Matrix

The comparative impact assessment matrix for these strategies is given in Table 12.1. The present situation 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. Those issues that are considered, from a technical standpoint, to be priority ones in terms of policy objectives are indicated in the first column, whereas those which are of concern to local people are indicated in the second column. The definition of the rankings is given on the last page of the matrix. 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. The principal aim of the matrix is to identify what are the significant issues so that further studies can concentrate on these and not be wasted on relatively unimportant and peripheral aspects. 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 inadequate time and resources given to do the work.

Strategy (a) - Without Project Situation

The main positive impacts likely to occur in the next six years in a without project situation include some modest improvement in agricultural production due to continued increased up-take of irrigated cropping. In addition, provision of domestic water supply, minor drainage and roads is predicted to increase. These could all have modest potential for increasing wage paid labour opportunities and slightly reducing socio-economic risk to households. On the negative side, the overall slight trend in fisheries decline is likely to continue and perhaps increase slightly and the overall ecological status will continue to fall although it is presently high in the western part of the study area when compared to other parts of the region. There is likely to be increased artificial fertilizer use and without a targeted programme to combat it, waterborne disease and overall nutritional decline particularly of the poorer sections of the population is likely to continue increasing. Waterborne navigation is likely to continue its slow decline as the road network expands and is upgraded. There are complex external issues which at present have very uncertain outcomes and it is very difficult to judge these without a lot more investigation.

A lot of development activity is planned for the area irrespective of any proposed study intervention. Most of this is small scale but lacks co-ordination and there could be some conflicts created. It requires to be consolidated into an overall planning approach which integrates all the elements and includes an environmental perspective to avoid conflicts and unintended impacts. The recently completed submersible embankment schemes in Satdona and Chandal beels would seem to be an example of what can happen if this is not carried out. It would appear that these have caused immediate severe fish losses, as they were designed without the benefit of an understanding of the flooding patterns in the area and are probably an inappropriate concept for the study area and particularly for the only areas of permanent dry year beels around which they have been built. Any road building programmes need to consider their effects of the hydrology of the area and have rational crest heights and structure opening locations and sizes. Khal deepening would seem to offer potential benefits through dry season water provision (although little effect on drainage) and to fisheries by providing increased dry season habitats. This also corresponds with local peoples expressed desire for this as a relevant and useful intervention.

Strategy (b) - Flood Proofing, Preparedness and Improved Drainage

Unlike many other parts of Bangladesh the effectiveness of flood proofing as a strategy is likely to be very limited in the study area. This is mainly due to the fact that the local inhabitants have already adopted this to a 1 in 20 year flood level and the main river flooding is not considered a large threat to their socio-economic livelihood. The flooding which causes concern is early flash flooding from the Indian hills and whilst this can cause significant crop losses every few years it does not destroy many homesteads. The socially based aspects of an integrated flood proofing programme, such as income diversification along with health, education and other infrastructural building programme are likely to have significant benefits and tackle the very issues local people identified as being problematic and a priority for action. Similarly the additional khal and internal river deepening over that being carried out in the without project situation (Strategy (a)) is likely to provide some increased benefits with few, if any, dis-benefits except perhaps some need for disposal of excavated material. Even this, if well planned, can be turned into an asset. The major weakness of this strategy is that it does not solve the stated significant problem of early flash flooding from the Indian hills.

Strategy (c) - Submersible Embankments, Small Polders and Controlled Flooding

This strategy is likely to have significant benefits in controlling early flash flooding, particularly in the east of the study area. The main drainage deepening component will also help alleviate the induced flooding dis-benefits that this is likely to cause and also provide a solution, if only temporary, to the sedimentation problem. Overall this strategy has the possibility of actually tackling some of the issues raised by the needs assessment and offers the greatest degree of flexibility, being (unlike Strategy (d) and (e)) divisible and allowing very different types of intervention to be considered in the very diverse conditions found in the study area. It is likely to reduce risks to household socio-economic livelihood but justifying this in narrow economic terms through increased agricultural production could be difficult. There are likely to be fisheries losses in any embanked area and these could be significant but are unlikely to be as severe as Strategies (d) or (e). However it will need very complex and detailed assessments to carry out any meaningful fisheries impact work for this strategy. In summary, this Strategy would seem to allow what benefits that there are from water control to be selectively realised whilst avoiding serious dis-benefits, particularly to fisheries, by being very selective as to intervention areas.

Strategy (d) - Polderization, Drainage and Tubewell Irrigation

This strategy is likely to result in some increase in agricultural benefit but the potential for this is very limited as the hydraulic modelling shows that even with the total exclusion of all external in-flow of surface water, the extent of peak flooding still remains similar to the without project situation. In the 1 in 5 high "normal" situation there is even less difference in peak flood extent. However although the extent of floodplain is not greatly diminished, the fisheries system is likely to suffer overall losses of some 40% due to the effects of creating closed embankments around the whole study area which effect fish migration. The nutritional implications of this loss in fisheries could be severe, especially to occasional fishing households who are unlikely to be in a financial position to purchase replacement aquaculture fish even if it were available. The disruption to monsoon season navigation, even if some locks were provided is likely to be severe and replacement access provision would need an integrated embankment top road provision programme. There are also likely to be requirements for significant land acquisition leading to issues of compensation and resettlement. However if well planned these could provide some significant degree of mitigation.

In conclusion it would appear from the hydraulic modelling outputs that the basic concept of a polderization strategy for the whole study area is environmentally unsound. The dis-benefits to fisheries production are severe and resulting nutritional consequences could be very serious indeed. This is further compounded by the fact that the potential benefits to agriculture that the intervention is aimed at realising are restricted because there is so much rainfall that the extent of peak flooding is reduced by only a small amount. If anything, polderization restricts the rate of drainage outflow once the major constraint of water level in the Meghna main river channel is removed and in some areas creates slightly longer flood durations. All this is irrespective of the costs of construction and operation of the scheme.

Strategy (e) - Polderization, Drainage and Pumped Surface Irrigation

Strategy (e) has similar problems to Strategy (d) and would appear to be as equally unsound in environmental terms. It also has the further complication of depending upon pumps in an attempt to address the drainage problem that the scheme itself makes worse, as well as for providing irrigation benefits in the dry season. All these dis-benefits would seem to negate against its consideration irrespective of its economics which also reflect its likely poor performance.

Phased Area Development

Strategies (d) and (e) are essentially all or nothing interventions and are not easily devisable for phased intervention. On the other hand the basic philosophy of Strategy (c) would appear to be well suited to the concept of phased area development and is another reason for favouring its more detailed study over (d) or (e).

Conclusions and Recommendations for Detailed Proposed Detailed Interventions for Further Study

The comparison of the different strategies favours a flexible approach that can be made appropriate to a very diverse range of both natural and social environmental conditions and implemented down to very small geographical areas. Such a mixed strategy also has the advantage of allowing a wide range of local people's perceptions of their needs, aspirations and commitments to be incorporated into development planning.

A decision on an appropriate strategy needs to be taken in the context of policy aims, both national, regional and how these are to be interpreted at sub-regional level. There needs to be a clear statement of policy aims and objectives and also some multi-disciplinary decision making framework to appraise this. A reasonably firm idea as to the required nature of measures along with a commitment to setting up the necessary integrated multi-disciplinary institutional structure is needed to successfully plan and implement such complex and inter-related strategies. It had originally been expected that the four planning zones would be the smallest units down to which detailed interventions would be proposed for further detailed study. Whilst refining Strategy (c), it became apparent that smaller units than this would need to be considered if an appropriate strategy that minimized environmental dis-benefits was to be followed. Some preliminary economic criteria were also required so that interventions with major constraints to economic feasibility were avoided of selection for detailed study.

12.3.3 Proposed Detailed Interventions

As a result of the preliminary assessment the following detailed interventions were proposed for further study These were essentially drawn up as a result of the people's participation programme. These interventions are shown in Figure 11.1. It should be noted that some of these cross planning zone boundaries are considered to depend, or be conditional upon, others, both for mitigation of induced negative impacts and also for economic feasibility. They are summarised by reference number:

1A Khal and river deepening of the Buri/Salda River system environmentally justified in its own right but considered a conditional requirement of Intervention 1B.

1B Controlled flooding of the western part of Zone A. This allows limited managed in-flow into the area via 4 gated structures in the north-west which uses an existing road embankment as one side of the protected are and four in the east placed within a new embankment on the east bank of the Salda River.

2 A medium sized polder in Zone B using existing road embankments which prevents all surface water in-flow to the area.

3 Extension of the Gumti right bank embankment westwards to Gouripur.

4 An enclosed medium sized polder in the north of Zone C and part of Zone D. This includes complete exclusion of all surface water in-flow and also has monsoon pumped drainage and pumped dry season surface irrigation using deepened khals. In addition the construction of the southern embankment will allow the Oder khal to be enlarged. The provision of pumping also allows the unprotected area south of this to be irrigated using gravity surface means along deepened khals and drains.

5 A small polder in Zone B using remodelled existing road embankments and excluding all external surface flow into the area.

6A6B Submersible embankments in Zone D similar to those recently completed in the north-west part of the study area.

7 A major khal deepening programme throughout the study area but predominantly in the south of Zone D. In Zone A this is intended to allow the khals to remain full of water in the dry

season for surface irrigation to take place. In the unprotected part of Zone C this would be for dry season pumped irrigation conveyance. Throughout the rest of the study area this is intended to improve drainage.

12.3.4 Hydraulic Modelling of Detailed Interventions

The proposed detailed interventions that have been incorporated into the hydraulic model are shown in Figure 11.1. The effects on the rising and falling flood pattern for a 1 in 2 year if all seven interventions were constructed are shown in Figure 4.9 and 4.10 respectively. The differentials in flood extents for the with and without detailed interventions by each 10 day period were analysed. (They are shown in Annex H, Figures H.3.9 to H.3.17). The broad conclusion of this analysis is that Intervention 3 is partially effective in preventing the early flooding due to downstream impacts of previous upstream Gumti River embanking. Intervention 1B is effective in delaying flash flooding into the protected part of Zone A and throughout a normal year reduces the mean extent of flooding on the protected area by some 30%. The induced flooding effects of this on surrounding land are nearly all mitigated for by Intervention 1A. Intervention 2, the medium sized polder, results in an internal mean annual floodplain loss, whereas the Intervention 4 pumped polder is very effective indeed and most of the floodplain remains flooded to a depth of less than 0.30 m all year round. According to the model, Intervention 5 has little effect on the extent of 0.30 m flooding but this may be due to the insensitivity of the model, the small size of the polder and the coarseness of the contours. The interventions have in effect been optimised to ensure that there is very little increased extent of flooding within the project area as a result of them. Overall, the changes in floodplain extent as a result of the interventions are surprisingly small. For a 1 in 5 high normal flood there is even less difference.

12.3.5 Detailed Impact Assessment Matrix

The environmental rating matrix for each of the seven interventions is shown in Table 12.2. These are on a scale of +5 to -5 and like the strategy ranking matrix uses a six year period for impact assessment. It aims to give an indication of what are the important issues for each intervention so that more detailed and targeted data collection can be carried out. Like the previous matrix it is not weighted by priority, instead an indication is given of those issues which are felt to be important. The principal negative impacts identified in the matrix are discussed in order of overall severity in Section 12.4 below.

TABLE 12.2

Environmental Rating Matrix of Proposed Detailed Interventions

ISSUES	P	Interventions							MP	MC
		1	2	3	4	5	6	7		
THE NATURAL ENVIRONMENT										
Hydrology										
Surface										
Flooding Damage to Land	*	+5	+3	+4	+4	+2	+1	0		
Drainage Problems	*	+3	-1	0	+5	-1	-1	+2		
Surface-Water Availability		-3	-2	-1	+4	-1	0	+3		
Groundwater Irrigation		+4	+4	0	+2	+2	0	0		
Domestic Water Supply	*	-1	-1	0	+1	-1	0	+2		
Erosion										
Meghna		0	0	0	0	0	0	0		
Cross Drainage		0	0	0	0	0	0	0		
Sedimentation										
Meghna		0	0	0	0	0	0	0		
Side Drainage	*	+2	+1	+3	+2	+1	0	+4		
Within Project Area		+2	+1	+3	+2	+1	0	+4		
Clogging/Smothering		+3	+2	+2	+2	+2	+1	+3		
Soil Fertility		-1	-1	0	-2	-1	-1	-1		
Navigation	*	-2	-2	-2	-3	-2	-2	+3		
Water Quality										
Domestic Water Quality		-1	-1	0	-1	-1	-1	0		
Agriculture Water Quality		-1	-1	0	+1	-1	-1	+1		
Land Resources										
Soil										
Quality/Chemistry		-1	-1	0	-2	-1	-1	0		
Waterlogging		0	+1	+1	+2	+1	+2	+1		
Erosion		0	0	0	0	0	0	0		
Ecology										
Flora		-1	-1	0	-2	-1	-1	-2		
Fauna		-1	-1	-1	-2	-1	-1	-2		
Fish	*	-2	-4	0	-5	-4	-4	+3	N	
THE HUMAN ENVIRONMENT										
Economic Livelihoods										
Risk		+3	+2	+3	+3	+1	-2	+3		
Settlement		+2	+2	+3	+2	+1	+1	0		

ISSUES	P	Interventions							MP	MC
		1	2	3	4	5	6	7		
Land Tenure										
Scarcity		-1	-2	-2	-3	-2	-2	-2		
Land Values		+2	+2	+3	+3	+1	+1	+2		
Common Resource Rights										
Fish	*	-2	-4	0	-5	-4	-4	+2	VD	
Fuelwood		-2	-2	0	-3	-2	-1	-1		
Grazing		-2	-2	0	-3	-2	-1	-1		
Fodder		-2	-2	0	-3	-2	-1	-1		
Agricultural Output		+2	+4	+1	+5	+2	+2	+4		
Fishing ("Professional")	*	-2	-3	0	-5	-3	-4	+3	PO	CO
Forestry and Fuelwood		-2	-2	0	-3	-2	-1	-1		
Livestock		-2	-2	0	-3	-2	-1	-1		
Wage Paid Employment	*	+3	+3	0	+4	+3	+1	+5		
Industry		+2	+2	0	+3	+2	0	+2		
Drinking Water Availability	*	-1	-1	0	+2	-1	0	+2		
Human Health										
Waterborne Diseases										
Diarrhoea	*	-3	-2	-1	-2	-2	-1	-1		
Cholera	*	-3	-2	-1	-2	-2	-1	-1		
Insect Borne Diseases										
Malaria	*	0	0	0	-1	0	-1	-1		
Kala-azar		0	-1	0	0	-1	0	0		
Drinking Water Quality	*	0	0	0	-1	0	-1	0		
Sanitation		-1	-1	0	-1	-1	-1	-1		
Nutrition	*	-2	-4	0	-5	-4	-4	+2	VD	
Mental Health		+1	+1	+2	+1	+1	0	0		
Access and Transport Infrastructure										
Waterborne										
Meghna		0	0	-1	-1	0	-1	0		
Side Rivers	*	+1	-1	0	-1	-1	-1	+2		
Within Project Area		-3	-3	-3	-3	-3	-3	+3	PO	
Railway		+1	0	0	0	0	0	+1		
Road		+2	+2	+1	+2	+1	+1	0		
Archaeology and Cultural Sites		0	-1	0	0	0	0	0		
EXTERNAL FACTORS WITHIN STUDY AREA										
Upstream Back-up Flooding	*	-3	-3	0	-1	-3	-2	+3	MI	
Downstream Knock-on Flooding		-1	-1	-1	+1	-1	0	-2		

ISSUES	P	Interventions							MP	MC
		1	2	3	4	5	6	7		
EXTERNAL FACTORS OUTSIDE STUDY AREA										
UPSTREAM CONSTRAINTS										
Increased FAP 6 Flooding	?	0	0	0	?	0	?	?		
Indian Dams on Upper Meghna	?	0	0	0	?	0	?	?		
Gumti River Hydro Dam		+1	0	+3	0	0	0	0		
Upstream Sediment In-flow	*	+3	+2	+3	+1	+1	0	+3		
UPSTREAM IMPACTS										
Peak Back-Up Flooding		-1	-1	?	-1	-1	0	+2		
DOWNSTREAM CONSTRAINTS										
Meghna River Water Levels	*	+1	+1	-2	+5	+1	+1	0		
DOWNSTREAM IMPACTS										
Knock-on Flooding	*	-1	-1	-2	-1	-1	0	0		
ECONOMIC ASSESSMENT	+3	+3	+5	+1	-2	+5	-2			

LEGEND

RATING OF IMPACT

-5 Severe Irreversible Negative Impact
-4 Significant Negative Impact
-3 Moderate Negative Impact
-2 Slight Negative Impact
-1 Very Slight Negative Impact
0 Present Baseline Situation and No Change
+1 Very Slight Positive Impact
+2 Slight Positive Impact
+3 Moderate Positive Impact
+4 Significant Positive Impact
+5 Very Significant Positive Impact
MI = Mitigation is Addressed Intrinsically
VD = Mitigation Very Difficult
PO = Mitigation Possible
CO = Mitigation Costly
PC = Mitigation Prohibitively Costly
N = Mitigation Not Possible

ABBREVIATIONS /HEADINGS

P = Expert Priority Issues
1 = Intervention 1
2 = Intervention 2
3 = Intervention 3
4 = Intervention 4
5 = Intervention 5
6 = Intervention 6
7 = Intervention 7
MC = Mitigation Possible?
MC = Mitigation Costly?
(+1) = A Constraint not an Impact
* = Major Issues
F = In Times of Flood
LF = In Low Flows
PF = In Peak Floods
? = Insufficient Data to Assess

Note: The predicted impacts are assumed to be those some six years after completion of construction of the proposed interventions.

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12.4 Principal Negative Impacts for Detailed Proposed Interventions under Strategy (c)

12.4.1 Introduction

The resources made available to the study to address such a complex area and which have required a wide ranging review of possible intervention strategies and options, have proved inadequate to carry out anything like a full environmental assessment. Consequently it has been decided to concentrate on the most serious negative impacts with the aim of identifying these and where possible undertaking sufficient work to quantify and value the most serious issues. Considerable additional work would be required to bring the environmental component up to the level of a fully integrated assessment with full quantification, mitigation arrangements and an Environmental Management Plan.

12.4.2 Changes in Flood risk and Timing

The results of the hydraulic modelling with all the seven detailed interventions have been interpreted using the differential flood mapping in Section 12.2.4 above. The conclusion from this is that the reduction in area of floodplain due to the interventions is not very great, but it is likely that the most serious effect of the interventions, especially on the fisheries system, are likely as a result of the barrier effects of closed embankments upon fish migration.

12.4.3 Losses to Fisheries

The detailed work on fisheries assessment is given in Annex F of the report. The estimated losses for each of the 7 detailed interventions are given in Table 4.3 (page 4-10) and these have then been totalled and presented as an overall assessment for Strategy (c) in order to give a comparison to Strategies (d) and (e). The comparison of strategies is shown in Table 12.3 which gives estimates of overall percentage fisheries catch losses. These are 33% for both Strategy (d) and (e), the benefits of keeping some khals full of water in the dry season in (e) being off-set by greater barrier effects of the sub-divided polders. The comparative figure for overall loss due to all seven components of Strategy (c) being implemented is 11% and the individual detailed intervention changes are shown graphically by system in Figure 12.4. Overall, the predicted benefits from increased dry season water availability due to khal deepening can only mitigate for some 20% of the predicted floodplain losses.

The overall changes in fish production, including those from ponds over the first six years after construction is completed, are estimated to be 3122 t for Strategy (c), 9224 t for Strategy (d) and 9153 t for Strategy (e). This is assuming overall national trends of a 1.5% per annum decrease in all fisheries systems except ponds which have been predicted to rise by 4.5%. There is some evidence that these figures, which are based upon pre- FAP 17 checking of PRSS data, may not be appropriate, and especially not to the Gumti area. However in view of the lack of any other data there appears to be no choice but to use them and it does at least have the advantage of being consistent with the work carried out for the FAP 3.1 fisheries work. In any case the differentials are what is more important in doing such a comparative assessment and these are not greatly effected by this assumption.

The procedures for valuation of the fisheries resources are given in Annex F and have been incorporated into the financial analysis of each strategy and the individual detailed interventions for Strategy (c). These use cash valuation based on market price and it must be remembered that the fisheries work covers only the fish caught by full time and part time fishermen and excludes occasional fishermen who in some zones are far more numerous. This is especially the case in Zone D where 66% of the households catch fish occasionally for their own consumption. Even so, 40% of all households in the study area carry out occasional fishing and according to the nutritional studies this accounts for by far the greatest source of protein intake, being way above dhal and meat. In terms of livelihood loss, an average of 6% of households are full time fishermen and 12% are part time, i.e. they both catch fish for sale, part timers having a primary occupation that they rate as being a more valuable contribution to their economic livelihood.

TABLE 12.3

Change in Fish Production Estimates in Gumti Phase II Under the Strategies C, D and E Without Mitigation and Management

	Fishery System	NOW	% Total Catch	WO Year 6	% Total Catch	Strategy C Year 6	% Total Catch	Strategy D Year 6	% Total Catch	Strategy E Year 6	% Total Catch
		(MT)		(MT)		(MT)		(MT)		(MT)	
Zone A	Int Rivers/Khals	378	1.41	345	1.26	332	1.37	146	0.80	171	0.94
	Beels	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Floodplain	2 750	10.27	2 512	9.19	1 199	4.95	732	4.04	525	2.89
	Ponds*	3 133	11.70	4 080	14.92	4 080	16.85	4 080	22.52	4 080	22.44
Zone B	Int Rivers/Khals	314	1.17	287	1.05	331	1.37	72	0.40	108	0.59
	Beels	85	0.32	78	0.28	71	0.29	35	0.19	35	0.19
	Floodplain	3 021	11.28	2 759	10.09	2 187	9.03	1 210	6.68	1 210	6.65
	Ponds*	1 299	4.85	1 692	6.19	1 692	6.99	1 692	9.34	1 692	9.30
Zone C	Int Rivers/Khals	477	1.78	436	1.59	585	2.42	186	1.03	279	1.54
	Beels	758	2.83	692	2.53	660	2.73	394	2.17	394	2.16
	Floodplain	5 458	20.38	4 985	18.23	3 877	16.01	2 615	14.44	2 615	14.38
	Ponds*	2 300	8.59	2 995	10.96	2 995	12.37	2 995	16.54	2 995	16.47
Zone D	Int Rivers/Khals	477	1.78	436	1.59	603	2.49	248	1.37	373	2.05
	Beels	296	1.11	270	0.99	243	1.00	134	0.74	134	0.74
	Floodplain	5 372	20.06	4 906	17.95	4 496	18.57	2 711	14.97	2 711	14.91
	Ponds*	664	2.48	865	3.16	865	3.57	865	4.77	865	4.76
Total	Int Rivers/Khals	1 646	6.15	1 503	5.50	1 851	7.65	652	3.60	931	5.12
	Beels	1 139	4.25	1 040	3.81	974	4.02	562	3.10	562	3.09
	Floodplain	16 601	61.99	15 162	55.46	11 759	48.56	7 268	40.12	7 060	38.83
	Ponds*	7 396	27.62	9 632	35.23	9 631	39.77	9 631	53.17	9 631	52.96
Grand Total		26 782	100.00	27 337	100.00	24 215	100.00	18 113	100.00	18 184	100.00
Percentage Change				2.07		−11.42		−33.74		−33.48	

* Includes cultured ponds only

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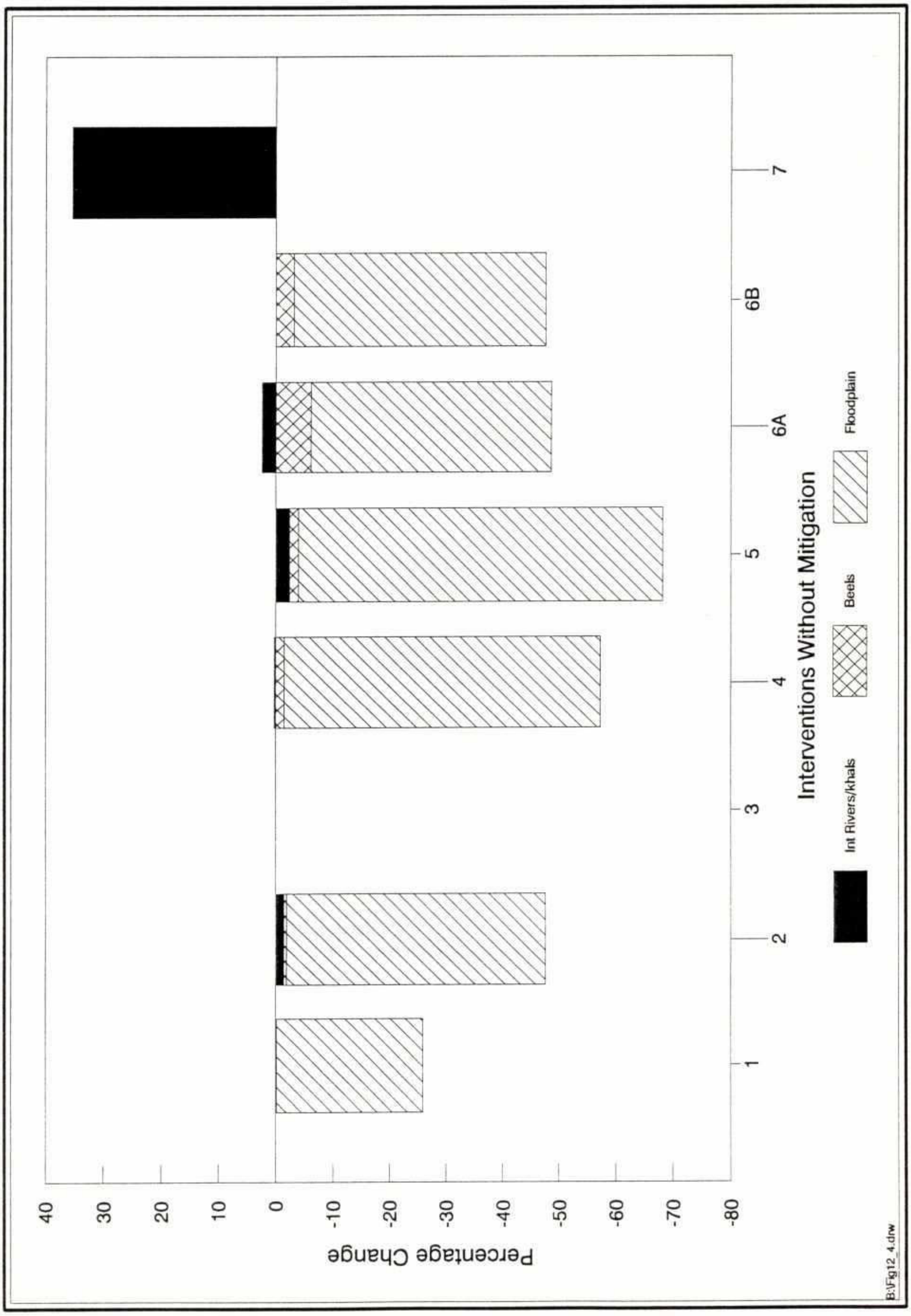
Figure 12.4

Estimated Fisheries Impacts of Strategy C in Gumti Phase II



In terms of the detailed interventions, there are severe losses to the common good fisheries resources in Interventions 2, 4, 5 and 6. These are likely to have serious local effects on occasional fishermen and will produce the significant reductions in the availability of animal protein, particularly to poorer households. The losses to professional fishermen are likely to be most significant in interventions 4 and 5.

12.4.4 Human Nutritional Consequences

As mentioned above, the loss of fisheries resources to occasional fishermen is likely to have serious localised problems in the vicinity of Interventions 2,4,5, and 6. The centre of the problem is that the present availability of "free good" fisheries resources will be restricted and the people losing out are unlikely to have the cash resources to substitute this with purchased fish. There are also likely to be problems of reduced supplies in the local markets resulting in possible inflation effects in fish prices depriving still further those households with limited cash resources.

12.4.5 Decline in Flora and Fauna

The assessment of the effects of the detailed interventions on the ecological system are given in detail in the Ecology Annex D. The natural fisheries system is likely to suffer the most serious problems, especially in the areas covered by Interventions 2,4,5, and 6. These result from habitat change and are notoriously 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 areas where it is proposed to seriously consider implementation of the detailed interventions. Construction impacts could be severe in some cases if not well managed. However, many can be avoided by careful planning and allowing regeneration to occur more quickly in those cases, such as khal deepening, where there may be some longer term benefits.

12.4.6 Possible Increase in Specific Waterborne Diseases

At present there are serious diarrhoeal disease problems in the dryer areas, such as Zone A, where the useful flushing effect of flooding is already limited. Conversely, in the western end of the study area there is widespread malaria though not of a serious type. There is a strong possibility that conditions in the post construction situation within embanked areas could increase the risk of diarrhoeal disease outbreaks. This is likely to be the case to varying degrees in all interventions. In those areas where there will be increased dry season water availability there is an increased risk of improved habitats for mosquitos which could cause an increased problem with malaria. This is particularly the case with interventions 4, 6 and 7 and any other component with khal deepening. This requires a detailed baseline data collection programme and subsequent monitoring to gain sufficient knowledge to tackle this issue.

12.4.7 Soil Fertility Issues

These issues have been outlined in Section 3 and apply to any area which is proposed to be drained or come under irrigation. It also requires a baseline data collection programme and access to the existing SRDI surface soil chemistry data.

12.4.8 Disruption to Waterborne Navigation

Any enclosed embanked area is likely to cause problems to wet season local waterborne navigation. No data has been collected that is appropriate to this issue, the information that is available relates only to main river traffic and is only relevant to addressing the issues in terms of Strategies (d) and (e). The use of remodelled polder embankments which are existing roads will go a long way to mitigating the problem of access, especially in the smaller polders. 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 analyses.

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12.4.9 Fuelwood, Grazing and Fodder

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 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 it. A crucial factor is the change in availability and quality of straw for cattle feed and the competition for this use as domestic fuel and building material. Fuelwood now appears to be 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. Promotion of social forestry on embankments can go some way to tackling this issue as can the use of power tillers, which would seem to relieve pressure on a stressed system.

12.4.10 Potable Water Issues

Study of the 1981 data has indicated that there is a severe problem with the low level of safe domestic water supply provision in the study area. The 1991 BBS data is not yet available so it has not been possible to produce trend data. However responses from the people's participation programme indicate that in 14 of the 16 studied villages there are still serious problems. In terms of local people's priorities it would seem that this issue is considered to be far more important than flood control or irrigation and drainage provision. It therefore begs the question as to the relative balance for funding of development priorities. The conclusion at present would seem to be that the scope for creating greatest immediate benefits to the area lies with improved domestic water supply provision and not flood control, drainage or irrigation programmes. However this needs to be verified using the 1991 BBS data when it becomes available.

12.4.11 External Impacts and Constraints

An indication of the likely external consultants and impacts to and from the interventions are shown in the matrix. However there is insufficient data to address these issues and overall there are too many unknown factors, especially the likely nature of FAP 6 upstream proposals. The downstream constraint of Meghna main channel water levels is the most crucial aspect of the hydrology of the area and when combined with the high levels of rainfall is the reason why large scale engineering interventions are ineffective as well as creating serious negative impacts.

12.4.12 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. The nature of the detailed interventions have been drawn up with these issues in mind with the aim of minimisation. This has been achieved by following existing embankment and road alignments, but even so Intervention 1B will require a land acquisition component. This has been costed in the economic analysis. Under World Bank Operational Directive 4.30 this could require a resettlement plan to be drawn up. More detailed work using low level air photography will be required to assess this. An inventory of assets along the proposed alignment will be required, followed by an assessment of likely livelihood loss to individual households. This will need to be done if the study is to be seriously considered for implementation.

Many of the resettlement issues can be tackled within the framework of multipurpose use of embankments leading to the development of liner settlements as has been proposed for the Coastal Embankment Rehabilitation Project (GERP). However this would need a strong commitment and resources for this by the implementing agency. The whole question of environmental considerations to contractors operations will need to be reviewed once there is a clearer idea as to the likely nature of the work and the construction technology that is to be used. The present review of the CERP Phase 1 construction issues will be valuable in doing this.

There are also likely to be significant socio-economic benefits offered by construction works, provided this is an intrinsic consideration in the planning of the construction programme. If appropriately phased, using labour intensive construction techniques, this could greatly increase the demand for wage paid labour at a time of the year and in locations where it is in short supply, particularly for specifically vulnerable social groups.

12.4.13 Hazard Risk and Sustainability

The whole question of physical sustainability of embankments, particularly those which carry flash floods from the Indian hills, needs to be carefully reviewed, particularly in the light of over 300 years experience with this on the Gumti River. There have been continuous failures of the Gumti embankment over at least the last 200 years. These have caused serious concentrated damage at such places of failure, probably for more so than if the embankment had not existed. This is made particularly serious in the case of the Gumti by the high levels of sedimentation which have resulted in the embankment heights having to be continuously raised to counteract river bed rise. The requirement for dredging the Salda and Buri Rivers will entail an open-ended programme of dredging and maintenance, which will necessitate continuous investment. At present there appears to be no institutional arrangement to raise capital from beneficiaries to do this.

It must also be pointed that the area is in a medium risk seismic zone, having experienced two severe events in the last 200 years. Such events have occurred during monsoon times when the river has been full and resulted in embankment failure due to liquefaction. Contemporary accounts of this indicated that this could be a severe, if statistically infrequent, occurrence and the consequences should not be underestimated.

There are a whole group of social impacts, particularly those at individual household level which have implications for risk levels to socio-economic livelihoods. Some of these are dealt with in the Social Impact Assessment in Section 5 of this report and in Annex G. Others, particularly those concerning livelihood loss to full-time and part-time fishermen and boat owners, operations and builders, have been mentioned above. The real difficulty is that it is impossible to assess these realistically at the moment as there is insufficient data made worse by the fact that the 1991 BBS census work is still unavailable. A major detailed social impact assessment component will be required in any follow-up work to the study.

A major issue in terms of economic sustainability is how any intervention programme is to be funded, be it a grant or a loan, and how this is to be paid back and what better alternative use this money could have put to. This needs to be considered at an early stage in planning and within the framework of national, regional and local economic planning and selection of priorities.

12.5 Impact Mitigation and Environmental Management Plan

12.5.1 Recommended Detailed Interventions

The preliminary economic analysis of the detailed interventions under Strategy (c) has included consideration of the major negative impact of fisheries resource loss. This has concluded that Interventions 4, 5, 6A and 6B are not presently viable, a major factor being that the agricultural benefits offered are either limited and/or can not overcome the likely losses to fisheries production to produce the economic return demanded by the funding agencies. Of the interventions which are considered to have an adequate rate of return, the most favoured of these by ranking using broad environmental grounds is:

7, 3, 1A, 1B, 2

Of these, Intervention number 2 (the medium sized polder in Zone B) is considered to have serious fisheries losses which require it to be carefully considered. However it also has a high potential for agricultural benefit and it thus comes down to a political decision as to if it is worth forgoing fisheries production for agricultural production in this particular area, although there may be places outside the study area where it is more justifiable to do this.

The multi-criteria analysis, which should include environmental mitigation and management planning, thus needs

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to be carried out only on these four interventions.

12.5.2 Impact Mitigation

The aim of impact mitigation is to design the interventions to be as environmentally friendly as possible by minimizing environmental dis-benefits and maximising benefits. In addition there should be targeted programmes to tackle specific negative impacts in defined places or amongst particular social groups. Another aspect is to design the operation of the intervention to allow identified environmental issues to be addressed. In the case of fisheries losses in Intervention 1B (controlled flooding to Zone A) some mitigation is possible depending upon the water management priorities for controlled flooding as opposed to recruitment of migratory fish species.

Mitigation considerations should also feature heavily in tackling construction issues, especially for Intervention 7 (khal deepening) and the extension of the Gumti right embankment. Of the four recommended Interventions the most serious negative impacts are likely to be in the medium sized polder in Zone B (Intervention 2). Unfortunately due to specific locational factors, particularly topography, and the philosophy of the intervention being an enclosed polder which excludes all external inflow, the possibilities for mitigation are very limited indeed. It is thus a straight policy decision as to the justification of promoting agricultural benefits with resulting fisheries losses.

12.5.3 Environmental Management Plan

It is not possible at the moment to even begin to draw up an Environmental Management Plan (EMP) for the intervention. This would not normally be considered justifiable until a firm commitment has been given to taking the recommended interventions to further study. The outline notes for a future work programme indicate what sort of data collection requirements are need to allow such an EMP to be drawn up.

12.5.4 Impact Timing

As explained previously, a 6 year period has been used for assessment of the likely impacts of the interventions as indicated on the matrices. For the medium and longer term impacts a baseline data collection and monitoring programme is needed. This would specifically need to address the issues of soil chemistry and structure change, medium and longer ecological impacts and also possible socio-economic issues that may arise.

12.5.5 Residual Impacts for recommended interventions

Table 12.4 gives a summary of the major negative environmental issues for the recommended interventions, quantification and valuation if presently possible and an indication of the mitigation possibilities. The residual impacts that are likely to be impossible or very difficult to mitigate for are shown in the final column. The most significant residual impact would seem to be the nutritional implications of fisheries losses to occasional fishermen, particularly for Intervention 2 in Zone B.

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TABLE 12.4

Residual Impacts for Recommended Aggregated Interventions 7, 3, 1A, 1B and 2

Principal Negative Impacts By Priority	Quantitification	Valuation	Mitigation Possibilities of Costs	Residual Impacts
Fisheries				
- Lost Cash Resource	- 1472 tones		- Some possible	- Some in 1B, Significant in 2
- Livelihood Losses	- 5% of households	- Possible	- Some possible	- Some
- Nutritional Consequences	- Not yet possible more data needed	- Possible but difficult	- Limited possibilities	- Significant for poor people
Increase in Waterborne Diseases	Not yet possible Monitoring data needed	Very difficult but possible	Possible	A little
Internal Navigation - Network and use - Livelihoods	- Not yet possible - Data needed	Possible but difficult	Partly possible	Some livelihood loss
Soil Fertility	Monitoring of data needed	Not yet possible	Management needed	Very little if careful
Decline in Flora and Fauna	Detailed basehead monitoring data needed	Not normally possible	Limited possibilities	Yes, depends on priorities
Fuelwood/Grazing/Fodder (Fertilizers, water quality)	Data needed	Possible but difficult	Possible	None

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12.6 Conclusions, Recommendations and Future Work Programme

12.6.1 Conclusions

The environmental component to the study has concentrated on providing a continuous environmental perspective to the evolution of appropriate and environmentally sensitive water and land development strategy planning for the area. This included consideration and re-evaluation of two alternative strategies proposed by the previous Feasibility Study along with a "do nothing" strategy with two intermediate levels of intervention of a flood-proofing based programme and a highly mixed, extensive but small scale approach. The latter was deemed to be the most appropriate to the area and was refined to address the issues identified by local people in the participation component of the study. This takes in the very varied conditions found throughout the study area and also recognises that large scale embanking of the area fails to address the issues of flood protection and drainage, the hydraulic model demonstrating that if anything such measures make the situation worse than they are at present.

The assessment of the seven major detailed interventions has shown that the levels of fisheries losses are such that they undermine what relatively limited agricultural benefits there are to be had by small scale polderization. There is potential for encouraging surface water irrigation by khal depending and this also has social benefits during the construction period provided implementation is tackled in a sensitive and labour intensive manner. There would seem to be direct benefits from extending the Gumti River right bank embankment as this should improve the long term problem of downstream aggravated flooding that partially embanking the river has caused for many years. The intervention of controlled flooding in Zone A addresses the problem of early flash flooding from the Indian hills but needs to be combined with downstream khal deepening if induced downstream and upstream flooding is to be avoided.

12.6.2 Recommendations

The following three interventions would seem to be justified in environmental terms and seem to offer significant benefits in order of priority:

* Intervention 7 - Khal deepening.

* Intervention 3 - Extension of Gumti right hand embankment.

* Intervention 1A and 1B - Deepening and remodelling of the Salda River and controlled flooding in part of Zone A.

However the economic analysis indicates that the latter pair of interventions (1A and 1B) are not economic unless their cost is shared by Intervention 2 (the larger of the exclusion polders in Zone B), as the latter has significant agricultural benefits. However this intervention has significant fisheries losses in this area, with socio-economic and nutritional loss implications, especially to occasional fishermen (37% of the population) and also to the 4% of full-time fishing households and some of the 6% of the part-time ones. It thus becomes a political decision whether the fisheries losses in the Intervention 2 area can be justified by the agricultural benefits along with the controlled flooding programme in part of Zone A and deepening of the Salda River system. Due to the fact that the economic analysis places so much store on the agricultural benefits of Intervention 2 in order to underpin Intervention 1A and 1B would demand a very powerful case indeed to demonstrate that the fisheries losses in Intervention 2 were unjustifiable. When presented in this manner there would seem to be a very strong case indeed for allowing Intervention 2 to go ahead even though the basic philosophy of promoting agricultural production at the expense of fisheries is regrettable within the Gumti area, which is so rich in fish. If it is wished to promote a policy of increasing agricultural production through increased irrigation and flood control provision, then the Gumti Phase II area is not a particularly suitable place to do this. This is irrespective of the question of environmental suitability, the economic losses to the fisheries resources amply demonstrate this to be the case. There are therefore likely to be more suitable places within Bangladesh to pursue this type of policy.

12.6.3 Future Work Programme

Data Collection Programme

Assuming that the recommended detailed interventions are to be followed up, then a highly specific programme and suitably phased programme of detailed data collection is required that addresses the issues raised in this preliminary environmental assessment. It needs to include the following components:

* Detailed fisheries assessment, especially in Zone A and the Intervention 2 area, the Gumti River outfall floodplain area and the khals and rivers to be deepened. This needs to include a baseline assessment of fish resources and socio-economic assessment of fishing households, both full-time, part-time and occasional.

* Nutrition surveys particularly in Zone A and the Intervention 2 flood plain areas.

* Waterborne disease vector study, especially for diarrhoeal diseases 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 fuelwood, grazing, fodder and rural energy balance survey.

* Studies of land acquisition requirements and formulation of an appropriate compensation and resettlement strategy with significant people's participation, to produce a resettlement plan under World Bank Operational Directive 4.30.

* A review of likely direct construction impacts bearing in mind the engineering design, nature or construction contract and 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.

* Water management criteria for controlled flooding in Intervention 1B

* Replacement protein production programme

* Professional Fishermen re-training

* Alternative fish production programme

* Health programme including water supply, sanitation and health education

* Boatmen re-training

* Road network improvements

* Soil management

* Flora and Fauna management for sustainable use including, homestead and embankment social forestry.

13 Implementation Proposals

13.1 Institutional Issues

13.1.1 General

As far as possible the aim should be to implement and manage the project through existing institutions and to strengthen and develop them as needed. Therefore it is expected that government agencies, such as BWDB, LGED, DAE and BRDB as well as the local government structure will be involved, as they are at present, in flood prevention work.

In addition, there will be a need to include, within the management structure, NGOs and others who can play a leading role in establishing and supporting continued people's participation. The most prominent NGO in the project area is Comilla Proshika Centre for Development. Project staff have liaised extensively with Comilla Proshika, as discussed in Annex G.

A separate FAP study (FAP 26) is underway to recommend institutional reform for water resources development projects. There are other programmes such as SSFCDI, EIP, SRP working on O&M. National Water Plan Phase II dealt with exercises to recommend responsibility of various GOB Agencies for different types and sizes of projects. FAP 13 and many other agencies identified that people's participation is very important for the successful implementation of a project. In this connection it was recommended that the public should be involved right from planning and design to implementation of a project. Recommendations were to involve the NGOs and the landless people in the project management.

Traditionally, great emphasis has been put on project committees to obtain the necessary interaction between different departments and institutions. By the time Gumti Phase II recommendations come to be implemented, useful experience will be available from FAP 20 on planning, implementation and management for projects of this type. Meanwhile, it is suggested that, where required, there should be a much smaller form of committee called the Project Coordination Committee (PCC).

The following institutions may be involved at different stages of development and at different levels in the project:

GOB	:	BWDB, LGED, DAE, IWTA, DOF, R&H, Forest Department
Local Government	:	Thana officials
Public representatives	:	Local MPs, Union Council Chairmen NGO's and landless people.

In order to secure efficient running of all stages of a project, direct participation of the beneficiaries is essential. They should be involved at all phases of development starting from planning and design. Accordingly, during the present feasibility study, the public, their representatives and the thana officials were duly consulted before formulation of different options for development. The BWDB, as the major GOB agency with the required technical skills and experience, is involved for the over all responsibility and monitoring of the project.

13.1.2 Pre-Design Stage

The future work programme covering environmental aspects is covered in Section 12.6.3. These works should be started at the outset and should carry on alongside the design of the schemes. The BWDB should be responsible for letting the contracts to Consultants.

The works detailed in Section 12.6.3 include land acquisition requirements. It is proposed that the cadastral land area surveys in the line of embankment construction should be carried out at the same time as the topographic surveys. The cadastral maps can then be handed to the land registration office for land ownership identification. Once the design is complete, then the full land requirement will be known and compensation paid. NGOs could be involved in land acquisition, which should be undertaken by the Land Acquisition Officer. The Land Acquisition Officer normally works under the Deputy Commissioner, but in this case will be under the Project Authority. Compensation given for the land to be acquired should be fair and the valuation of land should be done at current market prices. Compensation for land in village areas included an enhanced rate for land acquisition as well as 12,000 taka per family to meet reconstruction cost.

Geotechnical surveys should also be carried out at the same time as the topographical and cadastral surveys. These too will be contracts let by the BWDB.

13.1.3 Design Stage

The contract for scheme design will be let by BWDB. The Consultants should be ready to start work as soon as the results of the first surveys are ready.

As stated in Section 10, additional computer modelling will be required for optimisation at the design stage. It is therefore likely that the Surface Water Modelling Centre will be required to assist.

13.1.4 Implementation Stage

During the implementation phase there may be two levels of management. The project level committee (PCC) involving the local MPs, BWDB officials, district and thana officials and NGO's. A local professional (eg a teacher or a doctor) may also be invited. It should be noted that the MPs have been included as the GOB are presently considering a proposal that MPs should lead thana development activities.

The PCC have the full responsibility of the project management. As recommended by FAP 15, the committee could be chaired by a local MP, with the Executive Engineer, BWDB as Secretary. The Committee should monitor the over all progress of works and solve various bottlenecks towards the implementation of the project. Day to day works and other technical and financial responsibilities will remain with the Executive Engineer, BWDB as per the present practice. He will be the executive officer for the project. Representation of groups who could be adversely affected by the project or who are underprivileged (eg landless, fishermen or women) may be represented by NGOs.

Other GOB officials representing DAE, DOF, other thana level officials will also take part in monitoring the work, being members of the implementation committee. They may also be involved in the following in-depth activities:

(a) TNOs, NGOs and public representatives may be involved in forming local beneficiaries committees and motivating the people about the project, its benefit and nature of participation at different levels.

(b) BRDB may be involved in co-operative development and to arrange credit facilities.

(c) DAE will be involved mostly in the extension works in changing the cropping pattern and application of fertilizer and manure.

(d) The DOF may assess the impact of the project to fisheries and suggest improvements in mitigating those by different alternative measures.

(e) The Forest Department will be responsible for growth of tree plantation and selection of species for forestry on the embankments.

All the GOB officials and local representatives should be trained in their respective fields at the time of implementation so that they know about the project, its different components of development and the benefits well ahead of starting the O&M.

Major works and their implementation responsibilities are given below:

- Pump houses and hydraulic structures are to be constructed by contractor under the technical and administrative control of the executive engineer, BWDB.

- Drainage channels excavation and earth works in embankments turfing may be done manually as far as possible through LCS groups administered by NGOs or BRDB.

- Compaction of embankments and under water excavation should be done mechanically by contractors under the supervision of the BWDB.

- Tree plantation is to be organized by the Forest Department in consultation with the BWDB and R&H. NGOs and LCS could be involved.

- The BWDB/ Consultant design team will develop O&M manuals for the different infrastructure of the project.

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13.1.5 Operation and Maintenance Stage

The following major activities are involved during the O&M stage :

- Regular operation and maintenance of the infrastructure.

- Review of the operation manuals of the infrastructures especially pump stations and regulators.

- Collection of hydrological, socio-economic and fisheries data, analysis of the data collected and reviewed to monitor the correct operation of the project and to identify any changes or improvements needed.

- Extension and credit facilities.

- Training programmes.

The first two of the above being technical requirements should remain with the BWDB. The data collection should be carried out by the BWDB, BBS statistical officers and DOF.

The existing Design Directorate for the region should be involved in the ongoing review of design, for example if khals are under or over-sized. In case of different projects under the Directorate, a separate team headed by an experienced executive engineer should carry out the work. Adequate training for the executive engineer and his staff in this connection is important.

Maintenance of infrastructure includes:

- Pump Houses,
- Regulators,
- Embankments and
- Drainage/irrigation channels.

Maintenance of pump houses, buildings and regulators is a technical task which should be the responsibility of the BWDB. The Electro-mechanical works should be under the control of a Mechanical S.D.E. while the civil works may be looked after by the civil S.D.E.s, all under the control of the Comilla O & M circle.

Maintenance of embankments and drainage channels are of two types:

- regular maintenance and
- major/emergency maintenance

Work relating to regular maintenance may be given to the affected people, especially the landless. There are various recommendations about maintenance of the embankments and drainage channels in FAP 13, FAP 15 and others. The procedures adopted by the SRP is a good system which appears to be working well. Major and emergency maintenance works should be carried out by BWDB officials as per the present practice.

Units of farmers who are to pay for maintenance of the works, discussed in Section 13.4, should ensure adequate control of funds and quality of works, but through the award of maintenance contracts similar to those used by SRP.

The Project Coordination Committee (PCC) will continue during the O&M stage with full responsibility for mediation in any matter concerning O & M between staff, beneficiaries and other groups.

The Executive Engineer, O&M, BWDB will remain the executive officer of the project. Representatives from DAE, DOF and other thana officials will remain responsible for their relevant fields.

For operation of all the regulators, a local committee for each of the structures could be formed. The committee may be formed involving the chairman of a Union Council, NGOs, beneficiaries, BWDB Section Officer. The U.C. Chairman may be the chairman of the committee and the Section Officer, BWDB, the Secretary. The committee will work in consultation with the Executive Engineer and as per the operation manual. The committee will be accountable to the PCC.

13.2 Implementation Schedule

13.2.1 Schemes Recommended for Immediate Implementation

The five possible schemes for implementation are defined and discussed in section 11.3.5 (Scheme E is split into two separate submersible embankment schemes). Three of these schemes are recommended for immediate implementation. Their implementation schedule is given in Figure 13.1.

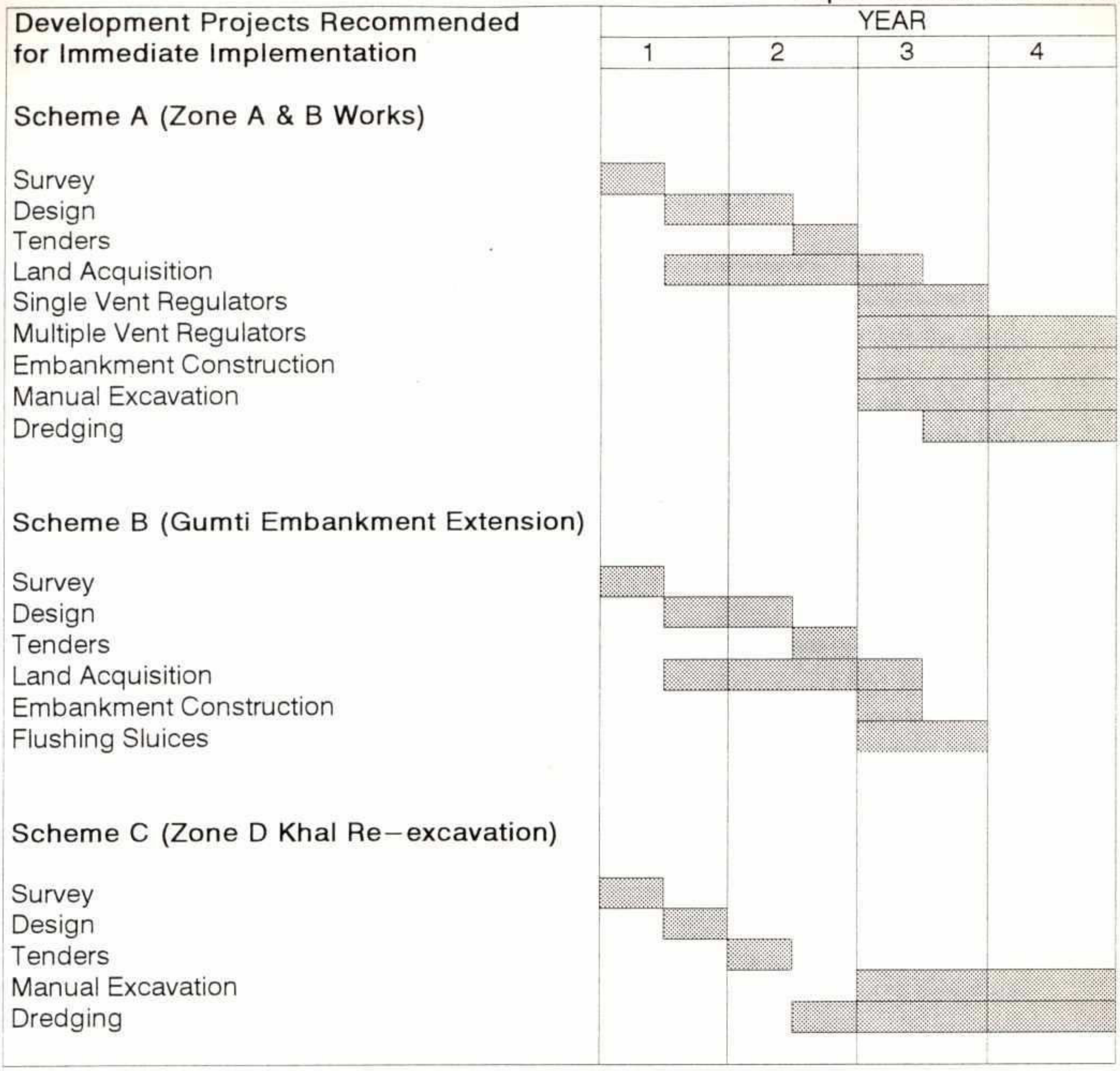
The beginning of each year is assumed to occur at the start of the dry season. The dry season is the only time when activities such as survey, foundation of structures and manual excavation may take place.

The design of Scheme A should include further model studies in order to optimise the excavation in the Salda and Buri Nadi Rivers along with the effects on the area to the east of the Gunghur River. In addition, the design should address the possible use of compartmentalisation in the Zone A protected area, to further optimise water distribution.

The design of Scheme B should also include a detailed sub model of the area, which will be able to accurately predict the effects of embanking the remainder of the Gumti River, towards the Meghna River.

It should be noted that JICA, with LGED and BRDB, are already carrying out khal excavation and supply of LLPs in the Homna and Daudkandi areas. Although the khals this project has selected do not include those planned for excavation by JICA, it is quite possible that JICA may wish to take up Scheme C under it's present project, or an extension to it.

Figure 13.1
Implementation Schedule



13.2.2 Schemes which May be Implemented at a Later Date

The remaining three schemes are not recommended for immediate implementation. This is because their viability is dependant on other factors, which can only be determined at a later date. Their implementation schedule is given in Figure 13.2.

Scheme D includes the irrigation schemes and embanked area in Zone C. The economic analysis has shown this scheme is not viable if force mode tubewell technology is taken up. This is logical, as the economic cost of two stage pumping with conveyance canals will be more than irrigation from force mode tubewells.

The National Minor Irrigation Project (NMIDP), which started in May, 1993, will address the viability of shallow force mode tubewells. Efforts should be made immediately to ensure that pilot projects should take place in Zone C of the project area. The scheme should then only start if and when NMIDP has concluded that force mode tubewells will not be taken up by farmers in the area. A further condition will be that the Government of Bangladesh has assessed the environmental situation and have decided that the area should be given to agricultural production as opposed to fish production.

Scheme E includes the two small submersible embankment schemes in Zone D. Under present conditions, farmers do not suffer damage to their boro crops as they plant very early. However, if FAP 6 interventions upstream of the Gumti project area extend the duration of the flood hydrograph, then farmers may face damage to their boro crops. It is therefore recommended to wait for the FAP 6 "With Project" computer model outputs. If there is a detrimental effect, Scheme E should be considered by FAP 6 as partial mitigation measures.

13.2.3 The 1990 Report Schemes

The 1990 Report assumed that their proposed schemes would be constructed in 2 phases of 4 years each. However, in order to maximise the benefits, the full FCD and FCDI schemes were assumed to be constructed in a single phase of 5 years.

13.3 Project Costs

The costs for the viable Schemes A, B, C and D are summarised in Tables 13.1 to 13.5. The revised costs for the 1990 Report FCD and FCDI schemes amount to approximately 6,198 million and 8,537 million Taka respectively. These costs are taken at 1992 prices. Cost for the additional environmental studies need to be carefully considered at this stage. Although design costs for topographic and cadastral survey and land acquisition have been included, the cost for fisheries surveys and additional environmental surveys will be additional to those shown on the project costs.

The cost estimates used in the economic analysis have been reduced to 1991 level, as directed in the FPCO Guidelines. The rates for the most important sections of construction, e.g. earthwork and dredging, were independently analysed, as discussed in Annex I. Dredging was assumed to be carried out by "mini dredgers", capable of shifting 65 m^3/hour.

Figure 13.2
Implementation Schedule

Development Projects Not Recommended for Immediate Implementation	YEAR 1	2	3	4	5
Scheme D (Zone C Works) (Year 1 starts if force mode tubewell technology is NOT taken up)					
Survey	■ (1st half)	■ (1st half)			
Design	■ (2nd half)	■			
Tenders		■ (2nd half)	■ (1st half)		
Land Acquisition	■ (2nd half)	■	■ (1st half)		
Regulators				■	■
Pump Stations			■	■	■
Embankment Construction			■	■	
Excavation			■	■	
Dredging			■	■	
Buildings			■		
Scheme E					
Zone D South Submersible (Year 1 starts if FAP 6 interventions alter the flood timing, causing damage to the boro crop)					
Survey	■ (1st half)				
Design	■ (2nd half)	■ (1st half)			
Tenders		■ (2nd half)			
Land Acquisition	■ (2nd half)	■	■ (1st half)		
Regulator			■		
Spillway			■		
Embankment Construction			■		
Zone D North Submersible (Year 1 starts if FAP 6 interventions alter the flood timing, causing damage to the boro crop)					
Survey	■ (1st half)				
Design	■ (2nd half)	■ (1st half)			
Tenders		■ (2nd half)			
Land Acquisition	■ (2nd half)	■	■ (1st half)		
Regulator			■		
Spillway			■		
Embankment Construction			■		

TABLE 13.1

Costs for Scheme A (Interventions 1A and 1B)

Zone A Capital Costs
Zone Area - 31 976 ha gross, 24 506 ha NCA
Protected Area - 23 400 ha gross, 17 933 ha NCA

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk ,000)
1.	Flood embankment				
	- Clearing, Grubbing & Stripping	sq.m	648,000	3	1,944
	- Channel Excav. and Formation of Emb. (Manual Excav./Mechanical Comp.)	cu.m	988,000	42	41,496
	- Turfing	sq.m	680,000	3	2,040
2.	Channel excavation & Spreading				
	- Manual (transport 50 m)	cu.m	2,230,000	28	62,440
	- Mini-Dredger (transport 500 m)	cu.m	688,000	50	34,400
3.	New regulators				
	1 - Vent 3.5m X 3.0m fish-friendly	Vent	2*1	8,500,000	17,000
	3 - Vent 3.5m X 3.0m fish-friendly	Vent	2*3	4,700,000	28,200
	1 - Vent 1.82m X 1.52m	Vent	4*1	2,000,000	8,000
4.	Buildings	Existing facilities at Comilla			
5.	Vehicles	Nr	1	1,000,000	1,000
6.	Land Acquisition				
	- Agricultural	ha	100	375,000	37,500
	- Homestead	ha	1.7	1,617,800	2,750
	Sub-Total				236,770
	Physical contingencies 15%				35,516
	Sub-Total including contingencies				272,286
	Engineering service cost 12%				32,674
	Total Project Cost				304,960

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TABLE 13.2

Costs for Scheme A (Intervention 2)

Zone B Capital Costs
Zone Area - 26 782 ha gross, 22 412 ha NCA
Protected Area - 5 000 ha gross, 4 184 ha NCA

Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk ,000)
1. Flood embankment				
- Clearing Grubbing & Stripping	sq.m	631,300	3	1,894
- Channel Excav. and Formation of Emb. (Manual Excav./Mechanical Comp.)	cu.m	713,650	42	29,973
- Turfing	sq.m	63,900	3	192
2. Channel excavation & Spreading				
- Manual (transport 50 m)	cu.m	90,500	28	2,534
3. New Drainage/Flushing Sluices				
2 - Vent 1.82m X 1.52m	Vent	1*2	1,700,000	3,400
1 - Vent 1.22m X 1.52m	Vent	2*1	1,600,000	3,200
1 - Vent 1.82m X 1.52m	Vent	3*1	2,000,000	6,000
4. Buildings	Existing facilities at Brahmanbaria			
5. Vehicles	Nr	1	1,000,000	1,000
6. Land Acquisition				
- Agricultural	ha	34.3	375,000	12,863
- Homestead	ha	0.61	1,617,800	987
Sub-Total				62,042
Physical contingencies 15%				9,306
Sub-Total including contingencies				71,349
Engineering service cost 12%				8,562
Total Cost for Intervention 2				79,910
Total Cost for Interventions 1A and 1B (from Table 13.1)				304,960
Overall Cost for Scheme A				**384,870**

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TABLE 13.3

Costs for Scheme B (Intervention 3)

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk 000)
1.	Submersible embankment (Gumti R. Bank)				
	- Clearing Grubbing & Stripping	sq.m	83 471	3	250
	- Channel Excav. and Formation of Emb. (Manual Excav./Mechanical Comp.)	cu.m	75 447	42	3 169
	- Turfing	sq.m	88 707	3	266
2.	Drainage/flushing sluices (Gumti R. Bank)				
	1 - Vent 1.82m X 1.52m	Vent	2*1	2 000 000	4 000
3.	Irrigation Inlet Structure (Gumti Right Emb.)				
	6 inch dia PVC Pipe with Dist. Box	Nr	15	50 000	750
4.	Buildings : Existing facilities	Nr	0	6 000	0
5.	Vehicles	Sum		500 000	500
6.	Land Acquisition				
	- Agricultural	ha	8.35	375 000	3 131
	- Homestead	ha	0	1 617 800	0
	Sub-Total				12 067
	Physical contingencies 15%				1 810
	Sub-Total including contingencies				13 877
	Engineering service cost				1 665
	Total Project Cost				**15 542**

TABLE 13.4

Costs for Scheme C (Intervention 7)

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk 000)
1.	Channel excavation & Spreading				
	- Manual excavation (transport 50 m)	cu.m	677 000	28	18 956
	- Mini-Dredger (transport 500 m)	cu.m	677 000	50	33 850
2.	Buildings : Existing facilities	Nr	0	6 000	0
3.	Vehicles	Sum		500 000	500
	Sub-Total				53 306
	Physical contingencies 15%				7 996
	Sub-Total including contingencies				61 302
	Engineering service cost				7 356
	Total Project Cost				68 658

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TABLE 13.5

Costs for Scheme D (Intervention 4)

Zone C Area	- 41 400 ha gross, 35 040 ha NCA
FCDI Area	- 10 459 ha gross, 8 852 ha NCA
Add. Irrig. Area	- 11 887 ha gross, 9820 ha NCA

	Description	Unit	Quantity	Unit Rate (Tk)	Cost (Tk ,000)
1.	Flood embankment				
	- Clearing Grubbing & Stripping	sq.m	593,890	3	1,782
	- Channel Excav. and Formation of Emb. (Manual Excav./Mechanical Comp.)	cu.m	1,219,943	42	51,238
	- Turfing	sq.m	807,500	3	2,423
2.	Channel excavation & Spreading				
	- Manual excavation (transport 50m)	cu.m	914,967	28	25,619
3.	New regulators				
	2 - Vent 3.5m X 3.0m fish-friendly + flume	Vent	1*2	7,000,000	14,000
	2 - Vent 2.0m X 3.0m check/navigation	Vent	5*2	600,000	6,000
	2 - Vent 1.82m X 1.52m check/head gate	Vent	1*2	550,000	1,100
	2 - Vent 3.5m X 3.0m fish-friendly	Vent	1*2	6,600,000	13,200
	1 - Vent 1.82m X 1.52m	Vent	3*1	2,000,000	6,000
	2 - Vent 1.82m X 1.52m chute drop	Vent	1*2	2,000,000	4,000
4.	Pump Stations				
	Nr 1 (Q = 3 @ 2.52 = 7.56 cu.m/sec)				
	Civil Works	sum		39,441,630	39,442
	Electrical & Mechanical Works	sum		41,271,600	41,272
	Nr 2 (Q = 4 @ 3.655 = 14.62 cu.m/sec)				
	Civil Works	sum		58,235,000	58,235
	Electrical & Mechanical Works	sum		91,637,671	91,638
5.	Buildings	sq.m	900	6,000	5,400
6.	Vehicles	Nr	4	1,000,000	4,000
7.	Land Acquisition				
	- Agricultural	ha	43.50	375,000	16,313
	- Homestead	ha	2.33	1,617,800	3,769
	Sub-Total				385,429
	Physical contingencies 15%				57,814
	Sub-Total including contingencies				443,243
	Engineering service cost 12%				53,189
	Total Project Cost				**496,432**

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13.4 Cost Recovery

The issue of cost recovery is extremely complex for the proposed developments. In Zone A, the major benefit of the embankment is flood protection, however, not all of Zone A will benefit. Also, the excavation works on the Salda and Buri Rivers are required for Zones A, B and part of C as well as the benefit of the LLP operators who will take irrigation water directly from it.

If Scheme D is taken up, the farmers in the protected area to the north will benefit not only from primary pump station water for their LLPs but also for pumped drainage, during the monsoon season. There will also be areas within the embankment perimeter which cannot be supplied by surface water but who will benefit from the pumped drainage and flood control.

In Zone D the situation will be simpler, as all the beneficiaries of the khal re-excavation will be in the same proximity as the required works, and will therefore identify with it.

The many attempts to impose water rates since 1963 when the first Water Rate Ordinance was enacted have met with difficulties. This has been due to the following reasons:

- no correlation between payments made by water users and the service they received
- water users were not properly consulted on the requirement and purpose of cost recovery
- water users were not encouraged to participate in project planning or cost assessment and collection activities of water rates
- inadequate project performance and service levels of O & M.

Amendments and new rules were therefore produced in 1990, which encouraged participation in assessment and collection activities. The payment of water rates is based on the level of O & M service received by the users.

The BWDB Systems Rehabilitation Project (SRP) is presently studying the aspect of cost recovery. They are in the late stages of a pilot project and the final report is expected to be submitted to the BWDB in the near future.

At present, the main considerations for successful cost recovery presented by SRP are as follows:

- Elicit participation at all levels of the project, so the target beneficiaries are convinced of the rationale and objectives of the project. It is crucial that beneficiaries are convinced that payment is justified and the rates are reasonable.
- The framework for beneficiary participation should be linked with O & M costs.

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- Beneficiaries should be organised to assure participation and representation. The project area should be divided into units, in the case of the LLP schemes, covering about 20 LLPs. A representative committee will be formed in each unit. Through this unit, the water users will voice their concerns to the PCC on which they could be represented by an NGO or through directly elected representatives concerning:

  - Review of the O & M budget and recommendation of the rate to be paid
  - Review of progress of water rate and identification of bottlenecks

The above procedure is mainly related to Water User Committees, for cost recovery of irrigation water. However, the key issue of including farmers into the process of O & M is just as relevant for flood protection and drainage schemes. At present, SRP pilot projects have been successful in recovering part of the costs for O & M. However, it is hoped in the near future that full O & M costs can be recovered and following this, parts of the capital costs.

Apart from the incremental approach adopted by SRP, the only practical methodology for cost recovery would be taxation. This tax could raised by one or more of the following:

- tax on farmer's inputs
- land drainage rates
- fuel tax

The most rational basis would be the application of a land drainage rate. However, there are difficulties regarding farmers who own land over which there is little or no change in depth of flooding.

This issue can only be addressed by the Government of Bangladesh on a national scale, however, the taxation could be carried out at a more local level, eg thana.

14 Operation & Maintenance

14.1 General

Effective operation and maintenance has been correctly identified as a major problem in achieving the expected benefits from flood control investments. The problems and recent developments have been fully addressed by the FAP 13 Study.

There are two major problems relating to the O & M of a water resources project. The first is the operation of the project, particularly its structures. The second relates to the maintenance of the major works, mainly khal re-excavation and embankments. In addition to these two fundamental requirements, monitoring and continued data collection should also be carried out. The data collected should be hydrological, socio-economic and environmental (including fisheries). This data will be extremely useful not only for Gumti Phase II but also for future similar projects.

The above problems are underlain by further questions, relating to institutional issues. Which agency or institution is to be responsible for O & M and how will the O & M be funded. The institutions for all phases of the work are discussed in Section 13.

14.2 Funds

Necessary funds for O&M of the project have to be realized from the beneficiaries. This however depends on the following:

- reliability of the project,
- public acceptance of the project and
- people's participation

To make the project reliable and acceptable to the public, O&M during the initial period after completion of the project may have to be carried out by the GOB (BWDB) as was conceived in FAP 13. FAP 13 recommended two years O&M after completion of a project. During the period the major drawbacks of the planning and design should also be rectified.

Involvement and motivation of the public during the planning, design and implementation stages will make it easier to make the project acceptable to them. Payments may be levied to realise adequate funds for O&M according to the findings of the BWDB Systems Rehabilitation Project. This is discussed in Section 13.

14.3 Specific O&M Requirements

Preparation of O&M manuals will be taken up during the design stage. A general outline for O&M of different infrastructure for the proposed projects are discussed below:

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14.3.1 **Zone A**

Embankments

The new embankments along the Gunghur and Salda may need more intensive care during the initial few years until the embankments are stabilized. No major erosion by wave action or current is anticipated. Normal turfing for protection is recommended. Improved varieties of grasses and other vegetation like dhancha and napier grass, which have additional benefits such as fuel and cattle feed should be used in consultation with the Forest Department. Trees may be grown on the berm and slopes, if they do not have any adverse effect on the stability of the embankment. Landless people should carry out this work wherever possible.

The modified reach of the R&H Highway, to the north-west of the scheme boundary, should also be maintained in similar way, in consultation with the R&H Department. The R&H Department should share part of the responsibility for maintenance.

Gunghur and Salda Rivers

Annual silt deposition in the Gunghur, especially at its outfall, and in the upper Salda may be significant. As reported by local people, silt clearance after four to five years may be required. This should, if possible, be done under Food For Works Programme. Annual maintenance in other reaches of the rivers should be normal and can be carried out by LCS under the supervision of the BWDB. However, maintenance in the lower Salda/Buri may need dredging as this work will be mostly underwater. This should be done by the BWDB directly as BIWTA are only responsible for dredging of Class 1 navigation routes.

Internal Drainage Channels

Normal maintenance of these channels will be required. This should be done by the fishermen to whom the channels may be leased by reaches. Special O&M should be carried out by the BWDB.

Regulators along Gunghur (4 nos)

These regulators are provided for controlled flooding within the polder and for flood by-pass during the catastrophic floods. A committee for each of the structures should be formed representing people of the area both inside and outside the embankment. GOB and BWDB officials at the local level will also be involved. A qualified person from the village nearest to the structure will be selected by the committee to operate the structure. Normal maintenance will be done by the BWDB but financed by the beneficiaries.

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Regulators Along the R&H Highway

There are 4 drainage regulators equipped with fish friendly gates. The gates are expected to remain open until June and will have free flow (weir flow). As the water level rises, the gates will be lifted so that the depth of flow over the gate will be adequate for fish movement. As with the Gunghur regulators,the structures will be operated by the local committee and maintained by the BWDB.

14.3.2 Zone B

O&M for embankments and structures are similar to those in Zone A.

14.3.3 Zone C

Interventions in Zone C involves major pump stations for irrigation/ drainage, embankments, irrigation/ drainage channels, buildings and structures.

Pump Houses, Buildings

These will be maintained and operated by the BWDB. An S.D.E. (Mechanical) will be in-charge of the pump house and the related warehouse. He will look after the operation and maintenance of the electromechanical parts of the pump houses. The SDE (Mechanical) will also look after the maintenance of the gates of all other regulators. Operation of the pump houses should be done as per the instruction of the project committee through the executive engineer.

Structures and Embankments

Similar to Zone A.

14.3.4 Zone D

Major work in Zone D are the irrigation/ drainage channels, flushing regulators and the submersible embankment along the right bank of the Gumti. O&M for the drainage channels and structures may be similar to those of Zone A in that the channels may need dredging. However, the rate of siltation in the area is much lower than near to the Indian border. Maintenance dredging will be the responsibility of the BWDB.

Submersible Embankments

Contrary to the other embankments, the submersible embankment along the Gumti will need special care, because it will be submerged every year. Therefore the responsibility for O&M should be with the BWDB. However, A committee should be formed at local level to carry out the day to day operation and maintenance. Petty works like earth filling and turfing should be done by LCS groups, formed by NGOs but under the supervision of the BWDB.

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14.4 O & M Costs

The costs for Operation and Maintenance were prepared according to the FPCO Guideline for Project Assessment. This cost includes the cost of:

- technical staff, department overheads, labour and materials
- operation and maintenance of vehicles and instruments
- estimate of annual repairs by contract
- periodic replacement of pumps, motors etc, subject to wear and tear
- cost of strengthening the government departments, e.g. extension systems

The maintenance costs of the schemes required for the Gumti phase II Project are taken as:

Embankments	6%
Drainage channels	6%
Structures	3%
Irrigation Structures	3%
Pump Stations (maintenance)	2%
Pump Stations (operation)	Sum
Vehicles	4%

The costs of annual re-excavation in the Salda and Buri Nadi Rivers is expected to be high. Calculations were carried out assuming an annual silt and sand load of approximately 110,000 tonnes per annum. This heavy requirement was however balanced with the far lower maintenance costs for khal re-excavation within the protected areas of Zone A and Zone B. Calculations showed that the combined re-excavation costs inside and outside the protected areas arrived at approximately 6%. This value was therefore adopted.

The operation of pump station costs were based on full irrigation requirements and 70 days (at 18 hours/day) of drainage pumping. The costs used were based on electricity supply at standard agricultural rates and amounted to approximately 3.4 million Taka a year.

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 Section 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.

Increased Agricultural Production

Gumti Phase II project area is richly endowed with groundwater resources and as a consequence the economic analysis has assumed (in most cases) that the only benefit which can be claimed from the provision of irrigation is the difference in cost between the exploitation of groundwater and the provision of surface water for low lift pumping out of khals.

The major 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 deepwater 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 deep water 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 (this study used the 1 in 5 wet year) 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

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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	0.67
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
	Main Crop	By-Product	Total	Labour	Draught	Seed	Irrig.	Fert.& Pest.	Total	Income
B Aus, local	12340	2000	14340	6106	2565	787		1131	11648	2692
B Aus, HYV	15425	1250	16675	6235	2565	787		1131	11790	4885
T Aus, local	15425	2500	17925	6665	2679	278		950	11629	6296
T Aus, HYV irri	22212	1800	24012	7783	2679	278	1436	2176	15787	8225
T Aus, HYV n-ir	19744	1600	21344	7611	2679	278		2176	14018	7326
Mixed aus/aman	17181	1150	18331	7108	2508	930		790	12470	5861
B Aman local dw	14069	942	15010	4761	2508	930		328	9380	5630
T Aman local dw	17928	1200	19128	5762	2280	493		728	10190	8938
T Aman, local	19422	2600	22022	6278	2280	493		1176	11250	10772
T Aman HYV irri	28760	1925	30685	7332	2451	336		2347	13712	16972
T Aman HYV n-ir	27266	1825	29091	7160	2451	336	1077	2347	14707	14383
Boro, local	18570	3000	21570	5160	1425	371	2205	673	10818	10752
Boro, HYV irrig	33426	2700	36126	9202	2565	278	4410	3157	21574	14552
Boro HYV p-irr.										
Wheat irrig.	16155	1125	17280	5461	2565	1404	2274	1580	14613	2667
Wheat unirrig.	12924	900	13824	4369	2565	1404		1125	10409	3415
Potato irrig.	62400	0	62400	8342	2508	10000	3111	6050	33012	29388
Potato unirrig.	41600	0	41600	7525	2508	10000		5550	28141	13459
Jute	14573	4218	18791	9224	2565	198		1243	14552	4239
Pulses: ave.	10129	956	11084	2150	1710	744		0	5065	6019
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	10859	1740	12599	4260	1566	693		1324	8626	3973
B Aus, HYV	13574	1088	14662	4350	1566	693		1324	8725	5936
T Aus, local	13574	2175	15749	4650	1636	244		1098	8391	7358
T Aus, HYV irri	22049	1566	23615	5430	1636	244		2603	10905	12711
T Aus, HYV n-ir	19599	1392	20991	5310	1636	244		2603	10773	10219
Mixed aus/aman	14087	1001	15088	4959	1531	763		959	9033	6055
B Aman local dw	11535	819	12354	3322	1531	763		352	6563	5791
T Aman local dw	14700	1044	15744	4020	1392	404		856	7340	8404
T Aman, local	15924	2262	18186	4380	1392	404		1402	8336	9850
T Aman HYV irri	23580	1675	25255	5115	1496	276		2686	10531	14725
T Aman HYV n-ir	22356	1588	23943	4995	1496	276		2686	10399	13545
Boro, local	15550	2610	18160	3600	870	311		755	6090	12070
Boro, HYV irrig	27989	2349	30338	6420	1566	233		3754	13171	17168
Boro HYV p-irr.										
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.	8301	831	9133	1500	1044	647		0	3511	5622
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 GUMTI

	Total area of sampled plots in farmer surveys		Percent weight		Market price		Yield
	ha.	%			Tk/kg 1991	Tk/kg 1992	t/ha
Keshari (lathyrus)	7.27	41.6%	43.4%		12.63	12.31	0.70
Masur (lentil)	5.28	30.2%	31.5%		20.48	21.89	0.50
Chola (chick pea)	0.22	1.3%					
Mung (greem gram)	0.00	0.0%					
Mash (black gram)	4.19	24.0%	25.0%		12.11	14.57	0.70
Barbati (cowpea)	0.51	2.9%					
Other pulses	0.04	0.2%					
total	17.46	100.0%	100.0%	weighted ave.	14.98	15.90	0.64

for more than four consecutive days was deemed to result in failure and the area associated with such an event excluded from the "safely grown" total.

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

Estimates of annual expected losses are presented below:

Annual expectation of crop damage (%)

Crop Damage	Aus	B.Aman	T.Aman	Jute	Boro
Zone A	2.6	2.4	3.5	2.1	3
Zone B	3.3	2.5	2.4	0	3
Zone C	2.3	2.2	2.2	2.1	0
FCD	2.5	2.2	3.1	1.2	2.1
FCDI	2.5	2.2	3.1	1.2	2.1

Property (Damage in Tk/ha of NCA / Year in financial prices)

		Gov Property	Housing	Livestock	Fishponds	Total
Zone	A	24	66	13	76	178
	B	36	80	11	53	180
	C	55	90	13	76	234
FCD		81	84	11	47	224
FCDI		81	84	11	47	224

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 floodplains and in the duration of flooding

Reducing the area of floodplain 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 fishermen's 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.

Weighted average fish catch value per kg is reduced as follows when there is a :

100% reduction in high value fish	Tk 20.86 / kg
75% reduction in high value fish	Tk 21.91 / kg
50% reduction in high value fish	Tk 22.85 / kg

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 floodplain 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 fishermen's 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.

At economic prices, the net value of fish after deducting catching costs declines rapidly, as both catching costs increase and the proportion of high value fish is reduced.

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 Tk/kg	Economic Price Tk/kg	Catch per day kg	Net Value Tk/kg
24.5	21.32	3	10.92
24.5	21.32	2.5	8.92
22.85	19.88	2.5	7.40
21.91	19.06	2.5	6.58
20.86	18.15	2.5	5.75

15.3.2 Capital Costs

Capital costs are summarised in Section 13.3 of this main report..

15.4 Economic Evaluation

15.4.1 Zones A and B

Proposals for Zones A and B are for the construction of two embankments surrounding 17933 ha (NCA) in Zone A and 4182 ha in Zone B. Benefits are expected to include increased cropping of aman in the monsoon season, and a small increase in T aus areas, as well as the provision of flood protection. Capture fishery losses of 1831 tonnes are forecast.

This proposal is described in Section 11. The results of the economic analysis for Zones A and B are presented in Tables 15.3 to 15.10 which cover 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 result and sensitivity analysis

As can be seen in Tables 15.8 and 15.11 the project produces an IRR of 14.9%. The project returns are particularly sensitive to delays in either completion or the achievement of benefits. Given that a construction schedule of four years is proposed, it is not anticipated that these will occur.

Sensitivity to both fishery losses and reduced flood damage are similar. Inspection of the cash flow (Table 15.8) illustrates the relative importance of different costs and benefits. Incremental Crop income is the largest but is still only twice the fishery losses. In percentage terms the increase in crop income between the "with" and "without" situations is small, less than seven per cent. The importance of flood damage benefits, especially protection against flash floods is evident.

Implementation of the project should increase rice production by seven per cent. Employment is not increased significantly mainly because the increase in demand for agricultural labour is offset by the loss of employment in fisheries.

A multi criteria analysis which reviews the overall impact of the proposals for Zones A and B is presented in Annex H and in Section 12 of this volume. Apart from the impact on capture fisheries the project is not expected to generate any serious environmental degradation. It may increase flooding depths in the monsoon in the area to the east of the Zone A embankment by small amounts, although this will be counteracted to some extent by the improvement expected in the control of flash flooding through deepening and enlarging the Rivers Salda, and Buri Nadi.

15.4.2 Zone C.

This proposal is described in Section 11. The difficulty in analysing the proposed interventions in Zone C concern the rate and extent to which groundwater can be expected to be exploited in the "future without" project situation. This is because shallow tubewells are hampered by the presence of underground gas reserves which break suction in the pump when the gas passes through the system. Alternative force mode technology for either shallow or deep wells should overcome the problem but application of such technologies have been constrained by their cost and novelty (in the case of the shallow force mode tubewell). At economic prices both shallow and deep force mode wells are cheaper than the alternative of pumping water from the River Meghna into khals and out of khals onto the land with low lift pumps. A comparison of costs, based on the proposed pumping stations for Zone C, which are designed for an irrigation duty of 9800 ha has been made with both shallow and deep force mode tubewells, and the present value of providing one hectare of irrigation over 30 years at 12% calculated:

Pump station and LLPs	P (12%) per ha =	Tk. 30 180
Shallow force mode tubewell	P (12%) per ha =	Tk. 15 000
Deep tubewell	P (12%) per ha =	Tk. 17 800

(Present values assume the pump station takes four years to build and that investment in secondary pumping occurs in year 5. LLPs are 20 L/S, irrigating 10 ha with an operational life of 5 years. SFMTWs are 15 L/S, command 7.4 ha with an operational life of 10 years. DTWs are 30 L/S, irrigate 13.4 ha with an operational life of 10 years).

TABLE 15.3

Annual Total (Net) Income, and Cropped Area by Crop

economic prices

Economic prices ZONES A & B

Crop	Net Income (Tk/ha)	Year 1 Area (ha)	Total Income (Tk'000)	Future WO(1) Area (ha)	Total Income (Tk'000)	Future WO(2) Area (ha)	Total Income (Tk'000)	Future With(1) Area (ha)	Total Income (Tk'000)	Future With(2) Area (ha)	Total Income (Tk'000)
B Aus, local	3973	1967	7814	1215	4826	1215	4826	1215	4826	1215	4826
B Aus, HYV	5936	716	4249	718	4263	718	4263	718	4263	718	4263
T Aus, local	7358	1223	8996	536	3947	536	3947	536	3947	536	3947
T Aus, HYV irri	12711	1411	17937	1266	16098	1266	16098	1591	20227	1591	20227
T Aus, HYV n-ir	10219	4166	42569	3792	38746	3792	38746	4297	43907	4297	43907
Mixed aus/aman	6055	779	4715	779	4715	779	4715	950	5754	950	5754
B Aman local dw	5791	7278	42148	4479	25935	4479	25935	2935	16993	2935	16993
T Aman local dw	8404	3270	27476	3270	27476	3270	27476	3739	31419	3739	31419
T Aman, local	9850	9799	96524	9798	96515	9798	96515	6365	62701	6365	62701
T Aman HYV irri	14725	1505	22157	1505	22155	1505	22155	2073	30527	2073	30527
T Aman HYV n-ir	13545	8334	112883	8334	112875	8334	112875	14151	191671	14151	191671
Boro, local	12070	336	4058	336	4058	336	4058	336	4058	336	4058
Boro, HYV irrig	17168	30098	516708	34852	598333	34852	598333	34852	598333	34852	598333
Boro HYV p-irr.	-11389	0	0	0	0	0	0	0	0	0	0
Wheat irrig.	12095	815	9855	711	8602	711	8602	711	8602	711	8602
Wheat unirrig.	9143	3726	34064	2990	27333	2990	27333	2990	27333	2990	27333
Potato irrig.	28461	1070	30453	1070	30453	1070	30453	1070	30453	1070	30453
Potato unirrig.	11775	1000	11772	1000	11772	1000	11772	1000	11772	1000	11772
Jute	8985	1719	15448	1719	15448	1719	15448	1719	15448	1719	15448
Pulses: ave.	5622	1700	9559	1252	7039	1252	7039	1252	7039	1252	7039
Mustard	2269	5176	11745	4321	9805	4321	9805	4811	10917	4811	10917
Spices (chilli)	15847	382	6048	382	6048	382	6048	382	6048	382	6048
Veg. (brinjal)	13069	900	11768	900	11768	900	11768	900	11768	900	11768
Total		87369	1048945	85224	1088210	85224	1088210	88594	1148006	88594	1148006

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	Tk'000	tons	Future without (1) area	Tk'000	tons	Future without (2) area	Tk'000	tons
B Aus, local	2.46%	10443	23	239	46	14	147	28	14	147	28
B Aus, HYV	2.46%	12480	8	104	21	8	104	21	8	104	21
T Aus, local	2.46%	13651	14	194	36	6	85	16	6	85	16
T Aus, HYV irri	2.46%	20889	16	343	59	15	308	53	15	308	53
T Aus, HYV n-ir	2.46%	18298	48	886	155	44	807	141	44	807	141
Mixed aus/aman	2.28%	12829	8	108	19	8	108	19	8	108	19
B Aman local dw	2.28%	10713	78	839	148	48	516	91	48	516	91
T Aman local dw	2.28%	13909	35	489	84	35	489	84	35	489	84
T Aman, local	3.47%	16102	160	2583	417	160	2583	417	160	2583	417
T Aman HYV irri	3.47%	22623	25	557	95	25	557	95	25	557	95
T Aman HYV n-ir	3.47%	21344	136	2912	498	136	2912	498	136	2912	498
Boro, local	3.52%	16637	6	93	17	6	93	17	6	93	17
Boro, HYV irrig	3.52%	27046	500	13535	2702	579	15673	3129	579	15673	3129
Boro HYV p-irr.	3.00%	-2847	0	0	0	0	0	0	0	0	0
Jute	1.90%	16992	7	124	14	6	109	12	6	109	12
percent of area to which damage reduction applies		47.2% total	1067	23007	4310	1092	24491	4621	1092	24491	4621

* lost income is gross crop income less 25% of costs

TABLE 15.4

Labour Requirements and Paddy Production

ZONES A & B

	LABOUR REQUIREMENTS						PADDY PRODUCTION				
	Labour md/ha	Present Labour md ('000s)	FWO (1) Labour md ('000s)	FWO (2) Labour md ('000s)	FW (1) Labour md ('000s)	FW (2) Labour md ('000s)	Present tonnes	FWO (1) tonnes	FWO (2) tonnes	FW (1) tonnes	FW (2) tonnes
B Aus, local	142	279	172	172	172	172	3934	2429	2429	2429	2429
B Aus, HYV	145	104	104	104	104	104	1789	1795	1795	1795	1795
T Aus, local	155	190	83	83	83	83	3056	1341	1341	1341	1341
T Aus, HYV irri	181	255	229	229	288	288	5080	4559	4559	5729	5729
T Aus, HYV n-ir	177	737	671	671	761	761	13330	12133	12133	13749	13749
Mixed aus/aman	165	129	129	129	157	157	1791	1791	1791	2186	2186
B Aman local dw	111	806	496	496	325	325	13708	8435	8435	5527	5527
T Aman local dw	134	438	438	438	501	501	7847	7847	7847	8973	8973
T Aman, local	146	1431	1431	1431	929	929	25477	25475	25475	16550	16550
T Aman HYV irri	171	257	257	257	353	353	5793	5793	5793	7982	7982
T Aman HYV n-ir	167	1388	1388	1388	2356	2356	30420	30418	30418	51652	51652
Boro, local	120	40	40	40	40	40	1009	1009	1009	1009	1009
Boro, HYV irrig	214	6441	7458	7458	7458	7458	162528	188203	188203	188203	188203
Boro HYV p-irr.	160	0	0	0	0	0	0	0	0	0	0
Wheat irrig.	127	103	90	90	90	90					
Wheat unirrig.	102	379	304	304	304	304					
Potato irrig.	194	208	208	208	208	208					
Potato unirrig.	175	175	175	175	175	175					
Jute	215	369	369	369	369	369					
Pulses: ave.	50	85	63	63	63	63					
Mustard	58	298	248	248	277	277					
Spices (chilli)	157	60	60	60	60	60					
Veg. (brinjal)	270	243	243	243	243	243					
	Total	14413	14656	14656	15317	15317	275763	291227	291227	307124	307124

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Irrigation Phasing and Net Crop Income - Future Without

ZONES A & B

Year	Irrigated Area (ha) LLP	STW/SFN	DSSTW	DTW	Manual	Total	On-Farm Irrigation Cost (Tk'000)	Crop Income (1) (Tk'000)	Net Crop Income(2) (Tk'000)
1	6344	10217	188	11547	2325	30622	91070	1048945	957875
2	6344	10427	375	11670	2280	31097	92733	1053032	960300
3	6344	10637	563	11792	2235	31572	94396	1057120	962725
4	6344	10848	751	11915	2190	32048	96059	1061208	965150
5	6344	11058	938	12037	2146	32523	97722	1065296	967574
6	6344	11268	1126	12160	2101	32999	99385	1069384	969999
7	6344	11478	1314	12282	2056	33474	101048	1073472	972424
8	6344	11688	1501	12405	2011	33950	102711	1077560	974849
9	6344	11898	1689	12528	1966	34425	104374	1081647	977274
10 FWO 1	6344	12318	1877	12773	1877	35189	107020	1088210	981189
11	6344	12318	1877	12773	1877	35189	107020	1088210	981189
12	6344	12318	1877	12773	1877	35189	107020	1088210	981189
13	6344	12318	1877	12773	1877	35189	107020	1088210	981189
14	6344	12318	1877	12773	1877	35189	107020	1088210	981189
15	6344	12318	1877	12773	1877	35189	107020	1088210	981189
16	6344	12318	1877	12773	1877	35189	107020	1088210	981189
17	6344	12318	1877	12773	1877	35189	107020	1088210	981189
18	6344	12318	1877	12773	1877	35189	107020	1088210	981189
19	6344	12318	1877	12773	1877	35189	107020	1088210	981189
20	6344	12318	1877	12773	1877	35189	107020	1088210	981189
21	6344	12318	1877	12773	1877	35189	107020	1088210	981189
22	6344	12318	1877	12773	1877	35189	107020	1088210	981189
23	6344	12318	1877	12773	1877	35189	107020	1088210	981189
24	6344	12318	1877	12773	1877	35189	107020	1088210	981189
25	6344	12318	1877	12773	1877	35189	107020	1088210	981189
26	6344	12318	1877	12773	1877	35189	107020	1088210	981189
27	6344	12318	1877	12773	1877	35189	107020	1088210	981189
28	6344	12318	1877	12773	1877	35189	107020	1088210	981189
29	6344	12318	1877	12773	1877	35189	107020	1088210	981189
30 FW0 2	6344	12318	1877	12773	1877	35189	107020	1088210	981189

Note: (1) Net of costs other than on-farm irrigation
(2) Net of costs including on-farm irrigation

PV (12%), Tk Mn 7822

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Fisheries Losses

ZONES A & B

	Fish production		Financial Value per kg		Economic value net of catching Value per kg		Economic price net of catching Total value			financial prices Net of catching Total value	
	tons	tons	Tk.	Tk.	Tk.	Tk.	Tk'000	Tk'000	Tk'000	Tk'000	Tk'000
	FWO	FW	FWO	FW	FWO	FW	FWO	FW	FWO-FW	FWO	FW
year 1	3732	3732	24.50	24.50	10.92	10.92	40735	40735	0	41674	41674
2	3715	3715	24.50	24.50	10.92	10.92	40549	40549	0	41484	41484
3	3698	3698	24.50	24.50	10.92	10.92	40364	40364	0	41294	41294
4	3681	3681	24.50	24.50	10.92	10.92	40178	40178	0	41105	41105
5	3664	1816	24.50	24.50	10.92	5.67	39993	10293	29699	40915	20279
6	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826
7	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826
8	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826
9	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826
10	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826

	fin.	econ.
gear cost per day	10.00	8.70
labour cost per day	30.00	22.50

Fish labour use	present	FWO 1	FWO 2	FW 1	FW 2	
kg per day	3.0	3.0	3.0	2.5	2.5	
'000 days	1244	1216	1216	726	726	
TK per day	54	54	54	32	32	(fishermans total income per day less gear cost in financial prices)
	39	39	39	32	32	(excludes leaseholders' share ??)

Non-agricultural flood damage

value of reduction per ha	179 Tk/ha
@ economic prices	156 Tk/ha
damage reduction applies to	47% of NCA
Total damage reduction	3448 Tk'000

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TABLE 15.8

Project Cash Flows (1991 Economic Prices)

ZONES A & B (Million Taka)

Year	Benefits: Net Crop Income FWO	Benefits: Net Crop Income FW	Benefits: Incremental Crop Income	Benefits: Flood damage non-agr.	Benefits: Flood damage crop	Total Benefits	Costs: Capture Fisheries Losses	Costs: Capital Costs	Costs: O&M Costs	Total Costs	Net Incremental Benefits
1	958	958	0	0.0	0.0	0.0	0.0	8.9	0.0	8.9	-8.9
2	960	960	0	0.0	0.0	0.0	0.0	8.9	0.0	8.9	-8.9
3	963	963	0	0.0	0.0	0.0	0.0	104.1	0.0	104.1	-104.1
4	965	965	0	0.0	0.0	0.0	0.0	112.2	0.0	112.2	-112.2
5	968	980	12	3.9	24.5	40.8	29.5	0.0	7.5	37.0	3.8
6	970	995	25	4.0	24.5	53.0	29.5	0.0	7.5	37.0	16.0
7	972	1009	37	4.0	24.5	65.1	29.5	0.0	7.5	37.0	28.0
8	975	1024	49	4.1	24.5	77.3	29.5	0.0	7.5	37.0	40.2
9	977	1038	61	4.2	24.5	89.5	29.5	0.0	7.5	37.0	52.5
10	981	1043	62	4.4	24.5	90.8	29.5	0.0	7.5	37.0	53.8
11	981	1043	62	4.5	24.5	90.9	29.5		7.5	37.0	53.9
12	981	1043	62	4.6	24.5	91.0	29.5		7.5	37.0	54.0
13	981	1043	62	4.8	24.5	91.2	29.5		7.5	37.0	54.2
14	981	1043	62	4.9	24.5	91.3	29.5		7.5	37.0	54.3
15	981	1043	62	5.1	24.5	91.5	29.5		7.5	37.0	54.4
16	981	1043	62	5.2	24.5	91.6	29.5		7.5	37.0	54.6
17	981	1043	62	5.4	24.5	91.8	29.5		7.5	37.0	54.8
18	981	1043	62	5.5	24.5	91.9	29.5		7.5	37.0	54.9
19	981	1043	62	5.7	24.5	92.1	29.5		7.5	37.0	55.1
20	981	1043	62	5.9	24.5	92.3	29.5		7.5	37.0	55.3
21	981	1043	62	6.0	24.5	92.4	29.5		7.5	37.0	55.4
22	981	1043	62	6.2	24.5	92.6	29.5		7.5	37.0	55.6
23	981	1043	62	6.4	24.5	92.8	29.5		7.5	37.0	55.8
24	981	1043	62	6.6	24.5	93.0	29.5		7.5	37.0	56.0
25	981	1043	62	6.8	24.5	93.2	29.5		7.5	37.0	56.2
26	981	1043	62	7.0	24.5	93.4	29.5		7.5	37.0	56.4
27	981	1043	62	7.2	24.5	93.6	29.5		7.5	37.0	56.6
28	981	1043	62	7.4	24.5	93.8	29.5		7.5	37.0	56.8
29	981	1043	62	7.7	24.5	94.1	29.5		7.5	37.0	57.0
30	981	1043	62	7.9	24.5	94.3	29.5		7.5	37.0	57.3
Present Value @12%		8068	246	23.7	122.8	393.0	148.1	160.5	37.6	346.2	46.8
										EIRR (%)	14.86

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TABLE 15.9

Summary of Benefits

ZONES A & B	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	46.9	46.9	46.9	46.9	46.9	0	0
Irrigated Area	'000 hectares	30.5	35.2	35.2	35.2	35.2	0	0
Labour Requirement (ag & fish)	million man days	15.7	15.9	15.9	16.0	16.0	1	1
Paddy Production	'000 tonnes	276	291	291	307	307	5	5
Cropping Intensity (excl. orchard)	% NCA	186%	182%	182%	189%	189%	4	4
Irrigated area	% NCA	65%	75%	75%	75%	75%	0	0
Net Crop Income	million Taka	933	969	969	1,029	1,029	6	6
Net fishery income	million Taka	42	41	41	9	9		
Crop flood loss reduction	million Taka				28	28		
Non-agric. flood loss reduction	million Taka				5	10		

Notes:
Project Year 1: assumed 1994/95
Future Without (1): Future Without Project Conditions, 5 years after project would have been completed
Future Without (2): Future Without Project Conditions, Year 30
Future With (1): Future With Project Conditions, 5 years after project completion
Future With (2): Future With Project Conditions, Year 30
% Increment (1): % difference FW (1) over FWO (1)
% Increment (2): % difference FW (2) over FWO (2)
Flood losses refer to average annual losses that will be eliminated by the project.
Values in 1992 financial prices

TABLE 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	4.2%	2.6%	2.6%	2.6%	2.6%
B Aus, HYV	1.5%	1.5%	1.5%	1.5%	1.5%
T Aus, local	2.6%	1.1%	1.1%	1.1%	1.1%
T Aus, HYV irri	3.0%	2.7%	2.7%	3.4%	3.4%
T Aus, HYV n-ir	8.9%	8.1%	8.1%	9.2%	9.2%
Mixed aus/aman	1.7%	1.7%	1.7%	2.0%	2.0%
B Aman local dw	15.5%	9.5%	9.5%	6.3%	6.3%
T Aman local dw	7.0%	7.0%	7.0%	8.0%	8.0%
T Aman, local	20.9%	20.9%	20.9%	13.6%	13.6%
T Aman HYV irri	3.2%	3.2%	3.2%	4.4%	4.4%
T Aman HYV n-ir	17.8%	17.8%	17.8%	30.2%	30.2%
Boro, local	0.7%	0.7%	0.7%	0.7%	0.7%
Boro, HYV irrig	64.1%	74.3%	74.3%	74.3%	74.3%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.7%	1.5%	1.5%	1.5%	1.5%
Wheat unirrig.	7.9%	6.4%	6.4%	6.4%	6.4%
Potato irrig.	2.3%	2.3%	2.3%	2.3%	2.3%
Potato unirrig.	2.1%	2.1%	2.1%	2.1%	2.1%
Jute	3.7%	3.7%	3.7%	3.7%	3.7%
Pulses: ave.	3.6%	2.7%	2.7%	2.7%	2.7%
Mustard	11.0%	9.2%	9.2%	10.3%	10.3%
Spices (chilli)	0.8%	0.8%	0.8%	0.8%	0.8%
Veg. (brinjal)	1.9%	1.9%	1.9%	1.9%	1.9%
total	186.2%	181.6%	181.6%	188.8%	188.8%

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TABLE 15.11

Summary of Results and Sensitivity Analysis

ZONES A & B

Capital cost	234.1 Tk.m.	construction period	4 years
Annual O&M cost	7.5 Tk.m.	(economic prices)	

Net Present Value @12%	46.8 Taka million (economic prices)
Economic Internal Rate of Return	14.9 %

Sensitivity Analyses	Economic IRR (%)							
	Base	Change in Variable						Switching
Variable	Case	+10%	+25%	+50%	-10%	-25%	-50%	Value (%)
Capital Costs	14.9	13.8	12.3	10.5	16.1	18.5	24.4	29.15
O&M Costs	14.9	14.6	14.3	13.7	15.1	15.4	16.0	124.27
Fisheries Losses	14.9	14.0	12.6	10.3	15.7	17.0	19.2	31.58
Reduced flood losses	14.9	15.7	17.0	19.1	14.0	12.6	10.3	31.91
Total Benefits	14.9	17.1	20.2	24.9	12.5	8.4	-1.7	11.90
Incremental Net Crop Income	14.9	16.2	18.2	21.1	13.4	11.0	6.2	18.98
Delay in full benefits								
2 years	11.6							
4 years	10.1							
Delays in completion								
2 years	12.1							
4 years	10.8							

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Thus it may be concluded that if only irrigation is considered, exploiting groundwater will be cheaper, in economic prices at least. In financial prices the outcome is far less clearcut because:

1) electricity for irrigation is subsidised whereas gas oil is taxed

2) both shallow force mode and deep tubewells are expensive and it is likely that farmers would be reluctant to invest such large sums even if credit were easier to obtain than it is at present.

As a consequence it is by no means certain that investment in groundwater will occur without an official intervention to encourage its development (as for example the National Minor Irrigation Development Project). For these reasons three alternative analyses of Zone C proposals have been undertaken which are all based on different "without project" developments. Thus in each case the "future with" remains the construction of the northern polder, with irrigation supplies sufficient for 9800 ha supplied by surface water and pumped drainage of the polder in the wet season, while the "future without" comprises:

1) no further development of groundwater

2) a rapid development of groundwater such that 75% of NCA is irrigated by year 10 (with the balance of irrigation required in the "with project" also supplied by groundwater)

3) a slow development of groundwater such that 53% of NCA is irrigated by year 10 (40% is irrigated at present) and 75% by year 15.

The results of these analyses are presented in Tables 15.12 to 15.14.

With no "future without" groundwater development the proposal produces an IRR of 18%, benefitting from both increased irrigation areas and substantial drainage benefits within the polder (where F0 land increases from 7% to 73% NCA). With "future without" groundwater development the project loses its irrigation benefits and the IRR falls to less than 12%. As a result the scheme cannot be recommended for implementation until the practical applicability of shallow force mode tubewells is established or disproved. In the event of the latter, the scheme looks attractive as an economic investment even though there are substantial fisheries losses and environmental costs associated with its development.

15.4.3 Zone D

Two proposals for Zone D are evaluated here:

1) the re-excavation of khals to improve the irrigation supply (Intervention 7).

2) the extension of the River Gumti embankment to provide protection to areas currently prone to flash flooding (Intervention 3).

TABLE 15.12

Zone C(no further groundwater development)
Summary of Results and Sensitivity Analyses

Capital cost	323.3 Tk.m.	construction period	5 years
Annual O&M cost	25.9 Tk.m.	(economic prices)	

Net Present Value @12%	157.8 Taka million (economic prices)
Economic Internal Rate of Return	18.34 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	18.3	17.2	15.6	13.6	19.7	22.2	28.4	74.0
O&M Costs	18.3	17.9	17.2	16.1	18.8	19.4	20.5	136.6
Fisheries Losses	18.3	18.1	17.7	17.0	18.6	19.0	19.7	218.3
Reduced flood losses	18.3	18.4	18.5	18.7	18.3	18.2	18.0	572.2
Total Benefits	18.3	20.2	22.9	26.8	16.3	12.8	5.2	28.2
Incremental Net Crop Income	18.3	20.2	22.7	26.5	16.4	13.1	5.9	29.3
Delay in full benefits								
2 years	15.0							
4 years	13.5							
Delays in completion								
2 years	14.9							
4 years	13.3							

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TABLE 15.13

Zone C(10 year FWO groundwater development)
Summary of Results and Sensitivity Analyses

Capital cost	323.3 Tk.m.	construction period	5 years
Annual O&M cost	25.9 Tk.m.	(economic prices)	

Net Present Value @12%	-64.0 Taka million (economic prices)
Economic Internal Rate of Return	9.15 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	9.1	8.4	7.4	6.1	10.0	11.4	14.8	30.05
O&M Costs	9.1	8.6	7.8	6.3	9.7	10.5	11.7	55.44
Fisheries Losses	9.1	8.8	8.3	7.4	9.5	10.0	10.8	88.55
Reduced flood losses	9.1	9.2	9.3	9.5	9.1	8.9	8.7	372.24
Total Benefits	9.1	10.7	12.8	15.8	7.4	4.2	-5.2	19.01
Incremental Net Crop Income	9.1	10.6	12.6	15.5	7.5	4.5	-3.7	20.12
Delay in full benefits								
2 years	8.6							
4 years	7.5							
Delays in completion								
2 years	7.7							
4 years	6.9							

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TABLE 15.14

Zone C(15 year groundwater development)
Summary of Results and Sensitivity Analyses

Capital cost	327.1 Tk.m.	construction period	5 years
Annual O&M cost	25.9 Tk.m.	(economic prices)	

Net Present Value @12%	-17.7 Taka million (economic prices)
Economic Internal Rate of Return	11.16 %

Sensitivity Analyses		Economic IRR (%)						
	Base	Change in Variable						Switching
Variable	Case	+10%	+25%	+50%	-10%	-25%	-50%	Value (%)
Capital Costs	11.2	10.2	9.1	7.5	12.2	14.1	18.7	8.20
O&M Costs	11.2	10.6	9.7	8.2	11.7	12.5	13.8	15.31
Fisheries Losses	11.2	10.8	10.3	9.4	11.5	12.0	12.9	24.45
Reduced flood losses	11.2	11.2	11.4	11.6	11.1	10.9	10.7	97.54
Total Benefits	11.2	12.9	15.4	18.9	9.2	5.7	-4.2	4.58
Incremental Net Crop Income	11.2	12.9	15.2	18.6	9.3	6.0	-2.7	4.81
Delay in full benefits								
2 years	9.1							
4 years	8.1							
Delays in completion								
2 years	9.3							
4 years	8.3							

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Re-excavation of Khals

The re-excavation of Khals should increase the area able to be irrigated with low lift pumps by approximately 10 000 ha (See Section 11).

The analysis of this option has been based on a cost comparison between excavation and irrigation using LLPs and the alternative costs of development with shallow tubewells (STW). There is little doubt that farmers will invest in LLPs given the opportunity to do so but in order to test the sensitivity to under-utilisation of water, the area of new irrigation required to produce an IRR of 12% was also calculated.

The cash flow for this calculation is presented in Table J.6.13 of Annex J where it can be seen that with an increase of 10 000 ha the IRR = 28%. An IRR of 12% is obtained with an increase in irrigated area of 5200 ha, or just over half of what is expected.

Assumptions made for this analysis were:

1) LLPs and STWs are replaced every 5 years

2) LLPs command an area of 10 hectares, with a discharge of 20 l/s.

3) STWs command an area of 3.8 hectares with a discharge of 7 l/s.

Costs for LLPs and STWs are presented in Appendix J.1, of Annex J.

Extension of the River Gumti Embankment

The proposal is to construct a submersible embankment along the right bank of the Gumti in order to prevent flash flooding between January and June. The difficulty in analysing the proposal stems from a lack of knowledge in predicting the frequency and extent of flash floods, mainly arising from the fact that the previous extension was only completed two years ago so current conditions are not well defined.

In addition it is not known to what extent the current proposal will simply move the location of flooding downstream in exactly the some way as the previous extension has done. They are good reasons for supposing that the proximity of the end of the proposed embankment to the River Meghna will alleviate flash flooding very considerably as the low flows in the Meghna at this time should encourage the water to flow into the river rather than back up and cause flooding. The khal re-excavation programme should also assist in reducing flooding by greatly increasing the water holding capacity of the khals. An analysis was undertaken to determine the minimum annual area of boro which would need to be saved to make the scheme worthwhile. As the scheme is so cheap, this minimum area is only 65 hectares. Given that unofficial estimates of damage in 1993 exceed 1000 hectares it seems most unlikely that the proposal will not be worthwhile. Analysis of the areas flooded prior to the extension completed in 1991 suggest that about 300 hectares are damaged every three years. Inserting these figures (i.e. 100 ha per year) into the cash flow produces an IRR of 24%.

15.4.4 Full Area FCD and FCDI Proposals

A description of these proposals is given in Section 11.

Full Area FCD (Strategy (d)).

This strategy has been analysed on the basis of model projections for areas of crops which can be safely grown. Cropping patterns were derived for Zones A, B, C and D and are amalgamated for inclusion in the economic model. Groundwater development and irrigation coverage are assumed to be the same as for the other options i.e. 75% in Zones A, B and C and 60% in Zone D.

The economic analysis produced a negative rate of return. It remained negative when fishery losses were reduced to zero, mainly because the agricultural incremental benefits are extremely low, as brought about by severe internal drainage problems which limit improvements in the flood regime. The expected change in flood regimes is given below:

	Highland(F0)	Medium land(F1)	Low land (F2+)
Zone A			
Present	38%	43%	19%
FCD	54%	40%	6%
Zone B			
Present	20%	24%	56%
FCD	34%	23%	33%
Zone C			
Present	5%	21%	74%
FCD	12%	27%	61%
Zone D			
Present	3%	10%	87%
FCD	4	14%	82%
Total			
Present	14%	23%	63%
FCD	23%	27%	51%

At economic prices the project costs Tk 33 000 per hectare which is simply too high for the relatively modest improvements achieved.

FCDI (Strategy (e))

This strategy is analysed on the same basis as the FCD proposal with the difference that a far higher proportion of irrigation is supplied using LLPs (47%).

The project produces a slightly better IRR than the FCD proposal although it is still negative.

Flood regime changes are given below:

	High land(F0)	Medium land(F1)	Low land (F2+)
Present	14%	23%	63%
FCDI	33%	26%	42%
1990 Study	0 - 30 CM	30 - 60 CM	60 CM+
Present	21%	9%	70%
FCDI (104.5 cumecs)	89%	4%	7%

The discrepancy between the results presented here and in the 1990 study are explained in part by the differences in post project flooding regimes. Other important factors in explaining the differences are the yield increases assumed in the "future with" project over the future without project in the 1990 study and the far lower irrigation coverage assumed. In addition the 1990 study incorporated flood losses of 5% for monsoon crops in the "without project" analysis whereas the current study uses rather lower figures. These have been offset however by the inclusion in this analysis of non agricultural damage and flash flood damage to the boro crop. At economic prices, the project costs Tk 45 800 per cultivated hectare to construct, and Tk 1400 per hectare per year to operate. With this level of costs, benefits would have to be doubled to make the project worthwhile, which is roughly what would happen of the project had managed to convert nearly 90% of NCA to F0 as was envisaged by the 1990 study.

15.5 Financial Analyses

Financial Analysis of farm models has been restricted to Zones A and B, as these are the only major proposals recommended for immediate implementation.

Given the relatively small agricultural changes anticipated, many farmers are not expected to change their farming systems greatly. Many of those farming inside the proposed embankments are also unlikely to experience significant changes in flooding regimes although they will of course benefit from protection from floods. The major impact of the project will fall on those farmers whose land classification will be changed moving from medium land (F1) to highland (F0) or from low land (F2) to medium land (F1).

Farm models reflecting these changes are presented in Tables 15.15 and 15.16 for Zones A and B respectively. They are presented in Tk per hectare for farmers on HL (highland), ML (medium land) and LL (low land), in Tk per average farm size and in Tk/ha and Tk per average farm size for sharecroppers (as sharecropping is an activity restricted to small and medium farm sizes, only these sizes are included). Sharecropper returns are based on a 50.50 split of gross revenue on land rented (sharecropped) in, which constitutes half the area operated by such farmers.

Given the relatively small changes in flooding regimes which the project is expected to precipitate, most farmers will only benefit from flood protection. Farmers in areas where flooding regimes will be improved should benefit from opportunities to cultivate higher value varieties of T aman in the wet season. Given that high yielding varieties of T aman are already widely cultivated on high lands it seems likely that farmers will react positively to improved flooding regimes. As a very high proportion of farmers are owner occupiers (80%), disincentives arising from sharecropping arrangements which substantially increase the risks in growing high input crops are of little importance. Following detailed design, it will be possible to identity much more precisely which areas will benefit directly and a programme to encourage farmers to switch to HYV or LT aman could easily be devised by the extension service within its current budget. Even though the agricultural incremental benefits are not substantial it is obviously still very important that they are obtained if the project is to be worthwhile. The most useful factor in favour of the project is that changed flooding regimes often allow farmers to adopt what is probably the most preferred cropping pattern, boro followed by T aman. This 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 them.

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TABLE 15.15

ZONE A Farm Models

Returns per Ha at Financial Prices assuming no change in land type

	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	45313.77	39606.80	35547.50	36456.45	33700.99	29076.63	25823.40	26457.19	26153.19	22438.70	19771.96	21157.22
Future Without	46456.30	40302.38	35963.16	37021.34	34784.50	29787.61	26311.27	26979.01	27130.83	23058.07	20184.51	21488.77
Future With	49186.51	42930.65	38526.47	39759.71	35291.74	30450.06	27080.61	27839.09	29270.53	25011.37	22033.53	23263.62
FW less FWO	2730.211	2628.269	2563.308	2738.365	507.2383	662.4437	769.3394	860.0860	2139.699	1953.300	1849.023	1774.855

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	33700.99	29076.63	25823.40	26457.19	26153.19	22438.70	19771.96	21157.22
Future Without	34784.50	29787.61	26311.27	26979.01	27130.83	23058.07	20184.51	21488.77
Future With	49186.51	42930.65	38526.47	39759.71	35291.74	30450.06	27080.61	27839.09
FW less FWO	14402.01	13143.04	12215.19	12780.70	8160.903	7391.985	6896.102	6350.327

Returns per average farm size at Financial Prices assuming changes in land type

Farm size	0.15	0.6	1.5	3.9	0.15	0.6	1.5	3.9
Present	5055.149	17445.98	38735.10	103183.0	3922.978	13463.22	29657.94	82513.17
Future Without	5217.675	17872.56	39466.91	105218.1	4069.625	13834.84	30276.77	83806.20
Future With	7377.977	25758.39	57789.70	155062.8	5293.761	18270.03	40620.92	108572.4
FW less FWO	2160.301	7885.825	18322.79	49844.73	1224.135	4435.191	10344.15	24766.27

Sharecropper Returns per ha at Financial Prices no assuming changes in land type

	Small HL	Medium HL	Small ML	Medium ML	Small LL	Medium LL
Present	22302.21	18242.90	15755.63	12502.40	11860.61	8987.051
Future Without	22486.56	18147.34	15927.50	12451.17	11860.61	8987.051
Future With	25788.95	21384.76	17774.88	14405.44	14314.18	11336.34
FW less FWO	1981.428	4856.130	1108.424	2931.405	1472.145	3523.946

Sharecropper Returns per average farm size at Financial Prices no assuming changes in land type

	ML to HL 0.6	ML to HL 1.5	LL to ML 0.6	LL to ML 1.5
Present	9453.379	18753.60	7116.366	13480.57
Future Without	9556.504	18676.75	7116.366	13480.57
Future With	15473.37	32077.14	10664.92	21608.16
FW less FWO	5916.865	13400.39	3548.563	8127.583

TABLE 15.16

ZONE B Farm Models

Returns per Ha at Financial Prices assuming no change in land type

	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	34234.61	30170.59	27252.10	28110.50	30807.90	26901.58	24116.06	24796.74	25119.06	21554.19	19000.60	20399.08
Future Without	34903.62	30644.72	27624.00	28386.73	31650.64	27464.92	24519.33	25134.21	25512.48	21752.45	19095.66	20445.61
Future With	41022.01	35931.89	32318.49	33666.50	32088.88	27921.70	24991.57	25643.15	26491.78	22637.01	19926.66	21225.82
FW less FWO	6118.389	5287.168	4694.488	5279.769	438.2318	456.7767	472.2415	508.9314	979.2986	884.5547	831.0079	780.2092

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	30807.90	26901.58	24116.06	24796.74	25119.06	21554.19	19000.60	20399.08
Future Without	31650.64	27464.92	24519.33	25134.21	25512.48	21752.45	19095.66	20445.61
Future With	41022.01	35931.89	32318.49	33666.50	32088.88	27921.70	24991.57	25643.15
FW less FWO	9371.366	8466.972	7799.158	8532.282	6576.391	6169.245	5895.916	5197.540

Returns per average farm size at Financial Prices assuming changes in land type

	0.13	0.5	1.6	3.6	0.13	0.5	1.6	3.6
Present	4005.028	13450.79	38585.70	89268.27	3265.477	10777.09	30400.96	73436.69
Future Without	4114.584	13732.46	39230.93	90483.19	3316.623	10876.22	30553.05	73604.20
Future With	5332.862	17965.94	51709.58	121199.4	4171.554	13960.85	39986.52	92315.34
FW less FWO	1218.277	4233.486	12478.65	30716.21	854.9309	3084.622	9433.465	18711.14

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	17308.61	14390.12	15187.52	12402.00	11825.53	9168.741
Future Without	17479.88	14459.15	15411.47	12465.88	11825.53	9168.741
Future With	21219.46	17606.06	16339.46	13409.33	12894.30	10183.96
FW less FWO	3739.589	3146.909	927.9894	943.4542	1068.768	1015.221

Sharecropper Returns per average farm size at Financial Prices assuming changes in land type

	ML to HL 0.5	ML to HL 1.6	LL to ML 0.5	LL to ML 1.6
Present	7593.763	19843.20	5912.769	14669.98
Future Without	7705.737	19945.41	5912.769	14669.98
Future With	10609.73	28169.70	8169.732	21454.94
FW less FWO	2903.997	8224.288	2256.963	6784.955

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ANNEX A

AGREED TERMS OF REFERENCE

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THIRD FLOOD CONTROL AND DRAINAGE PROJECT, CREDIT 1591-BD

GUMTI PHASE II SUB-PROJECT

TERMS OF REFERENCE FOR REVISED FEASIBILITY STUDY

BACKGROUND

1. The Government of Bangladesh, in implementing the Third Flood Control and Drainage Project, financed under IDA Credit 1591-BD, undertook the preparation of feasibility study of Phase II of the Gumti Project. This study was to formulate a project that would mitigate the effects of periodic flooding and poor drainage in the project area, develop its irrigation potential and, alleviate any adverse effects of the Gumti Phase I Project on the adjoining Gumti Phase II area. The study report (hereinafter "the BWDB study"), submitted in March 1990, was accepted by the Bangladesh Water Development Board (BWDB) but not by IDA, who, inter alia, believe that less capital-intensive options should also have been investigated and evaluated. In addition, IDA considers that the study should be compatible with the framework and guidelines of the Flood Action Plan (FAP) and current IDA project preparation policy: this implies, inter alia, the need for an environmental impact assessment of the project and consideration of any diseconomies and their mitigation measures in the economic analysis. In order to continue its support of project preparation, IDA has requested that the feasibility study be revised and extended; accordingly, this Terms of Reference describes the tasks to be carried out by a qualified consulting firm with the financial support of a Japanese Grant Facility executed by the World Bank.

THE PROJECT AND ITS OBJECTIVES

2. The proposed gross project area of about 140,000 hectares (ha.) is bounded in the north by the Titas River, in west by the Upper Meghna River, in the south by the Gumti River and in the east by the Indian border. Parts of the area are prone to flooding and one third to one half of the area is currently irrigated by shallow and deep tubewells, low lift pumps and traditional water lifting devices. A revised feasibility study is to be prepared, to international donor agency standards, wherein additional technically and economically viable project alternatives are to be identified and evaluated as to their ability to fulfill regional development objectives in a cost-effective manner. The economic objectives of the project are maximization of the net present value of aggregate consumption benefits (net value added) and employment generation, with as large a private sector participation in project investment as possible. Fulfillment of these objectives should minimize any regressive effects on the poorer population's income and welfare and/or, adverse non-mitigable impacts on the physical environment.

DEVELOPMENT TARGETS AND ALTERNATIVES

3. The development options and interventions for meeting the project objectives should create conditions which would facilitate some, or all, of the following target economic and environmental improvements in the project area:

(a) Prevention of property damage and impoverishment due to major floods and, reduction of crop losses due to seasonal flooding;

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(b) Creation of improved water management and control conditions in the aman season to facilitate the transformation of areas normally under deep water broadcast rice to HYV or LIV transplanted rice cultivation;

(c) Increase of the area under boro and rabi cultivation by facilitating further groundwater development and surface irrigation by low lift pumps (LLPs);

(d) Development of pond fisheries and sustained, or improved, productivity and conservation of floodplain capture fisheries potential;

(e) Improvement of physical infrastructure (roads, navigation facilities, power supplies) needed to complement flood control and/or impoldering measures, or otherwise required for agricultural/economic development;

(f) Improvement of agricultural support services and agri-business infrastructure (extension, credit, markets, storage, post-harvest processing, communications, storage, markets, transport, etc) needed to sustain intensified and increased agricultural production.

4. The alternative interventions or development options to be considered by the consultants for achieving some, or all, of the above targets, are the following:

(a) "Without Project" Scenario: No flood response or control intervention, but implementation of current GOB development programs in crop production, livestock, pond and floodplain fisheries, minor irrigation, social services, off-farm employment and economic development and, including investments in physical infrastructure (roads, rural electrification, markets, etc) on higher lands. This option assumes that current trends in private sector investment response to existing conditions - particularly in installation of shallow tubewells (STWs) for boro irrigation - will continue. This case would also serve as the baseline environmental scenario assuming application of current GOB conservation, poverty alleviation and related programs.

(b) Basic Flood Response and Development: Reduction of non-agricultural damage from intermediate floods and adjustment to normal flooding by: (i) systematic flood-proofing of physical infrastructure (government buildings, roads, railways, communications, power, water supply facilities, etc); (ii) improved monsoon surface drainage by deepening of natural waterways (khals) and improvements in waterways and amphibious transport facilities; and (iii), GOB assistance for flood-proofing of private property, enterprises and deep tubewells (DTWs) in designated flood zone areas; (iv) appropriate local flood early warning arrangements and dissemination and, GOB assistance for related district and community flood preparedness. Deepening of khals and, possibly, deployment of large floating pumps at certain locations, may enable the LLP irrigated areas to be extended. This development option should include any extensions of the agricultural and economic development programs of the "Without Project" scenario facilitated by the flood response and irrigation interventions.

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(c) Intermediate Flood Response and Development: All Basic Flood Response components and agricultural/economic programs, supplemented by partial agricultural flood control due to: (i) **compartmentalization of selected shallowly flooded areas using submersible embankments and flow regulating** structures to protect boro and aus crops against early flooding only; (ii) improved internal drainage and related dry season water availability (possibly assisted by floating pumps). This option would require appropriate BWDB and beneficiary participation organization for O.& M. of flood and water control structures.

(d) Flood Control and Drainage (FCD) Polder: Flood control and gravity drainage of most, or all, of the project area (including deeply flooded areas) by major floodplain embankments and appurtenant regulators, flushing sluices, navigation locks and compartmentalization. This option would be similar to the FCD alternative of the BWDB study, except that the alternative of major embankment set-back along the Upper Meghna River - particularly in deeply flooded areas and at locations where major bank erosion hazards exist - would be also be evaluated; the BWDB study alternative of minimal set-back along a riparian alignment would include incremental investments in bank protection and river training works. Possibly, additional improvements in internal drainage for rapid conveyance of storm run-off to ponding areas at the major drainage outfalls would be included for better crop protection. The Intermediate Flood Response interventions should also be considered in this option for areas outside the embankments, together with the need for flood-proofing interventions within the polder. Irrigation and supporting agricultural interventions would be based on private LLPs, STWs and DTWs exploiting groundwater and, any surface water supply improvements (including floating pumps or stationary booster pumping stations serving deepened khals), facilitated by the polder. Complementary physical infrastructure (roads, rural electrification, etc) needed to enable attainment of the full agricultural and economic potential of the altered hydraulic environment should also be considered.

(e) Flood Control, Drainage and Irrigation (FCDI) Polder: The development concept would be similar to that of the FCD option above, except that major primary and secondary pumping stations would be used for irrigation water supply to LLPs and, monsoon season drainage of the polder via deepened khals and a secondary canal network - as proposed in the FCDI alternative of the BWDB study. Pumped irrigation water supply to the adjacent Gumti Phase I Project and an optimal cost-effective mix of public irrigation water supply and private groundwater development for both projects may also be considered. Any incremental investments in power generation and distribution facilities needed by the pumping stations, as well as interventions required to promote private investment in pond fisheries (facilitated by irrigation pumping), should be included in this option.

(f) Phased Development: A phased development option envisages a succession of increasing investments from Intermediate Flood Response through FCD to FCDI, or FCD to FCDI according to resource availability and implementation

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monitoring. Each successive phase would be dependent on the success of its predecessor in achieving farmer and public response targets, its production and flood control objectives, as well as the requisite level of management, beneficiary participation and minimal adverse environmental impact.

All the above options are to be compatible with the regional master plan findings and proposals of the on-going UNDP supported and IDA executed Southeast Region Water Resources Development Program study (hereinafter referred to as the "the Southeast study").

STUDY SCOPE

5. The consultant shall: (i) undertake detailed formulation of the development options under paras 4(a) to 4(c) and, any necessary modifications of the BWDB study alternatives [paras 4(d), (e) and (f)]; (ii) conduct all necessary feasibility level surveys, investigations and studies to evaluate their technical, economic and financial feasibility, implementability, sustainability, risks and environmental impact; (iii) formulate an implementation program (additional studies, estimated budgets, tendering/procurement framework, pre-requisite land acquisition needs, organizational, institutional and training proposals, etc) for the recommended option(s); (iv) prepare 35 copies of a final feasibility report. Maximum use of the data and designs of the previous BWDB feasibility study may be made, where applicable and compatible with this Terms of Reference, after their thorough review.

6. If development option components tend to be mutually exclusive, or, create adverse long term impacts - e.g. polders reduce floodplain fisheries or, induce extensive public and/or private investments create a potential risk of greater flood damage in the event of embankment failure - an optimal level of government intervention should be selected based on consideration of such diseconomies, possible mitigation measures and trade-offs. All project development program proposals shall be consistent with the current policies and programs of the Ministry of Agriculture (particularly its minor irrigation policies and programs), Inland Waterways Authority, Power Development Board and Ministries of Fisheries and Livestock, Environment and Forests, Local Government, Rural Development and Cooperatives. Existing and future upstream water resources and agricultural developments on national and international rivers affecting seasonal discharge and water quality in the project area shall be identified and, their possible impact on project proposals shall be allowed for in their formulation. Likewise, any project impacts on adjacent areas, such as increased flooding, reduced waterway transport potential, etc, shall also be considered.

7. The consultants shall also be cognizant of the on-going relevant studies of the Flood Action Plan by liaison and coordination with their respective consultants and the FPCO. The available findings and proposals of the following FAP studies are to be considered and applied where necessary: Meghna Left Bank Protection Project (FAP 9B); Flood Forecasting and Early Warning Project (FAP 10); Disaster Preparedness Program (FAP 11); FCD/I Agricultural Review (FAP 12); O.& M. Study (FAP 13); Flood Response Study (FAP 14); Land Acquisition and Resettlement Project (FAP 15); Environmental Study (FAP 16); Fisheries Study and Pilot Project (FAP 17); Compartmentalization Pilot Project (FAP 20); Flood-

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Proofing Pilot Project (FAP 23); and, Institutional Study (FAP 26). The consultants should also be cognizant of the floodplain component of the IDA supported Fisheries III Project and the findings of past reviews of FCD/I and minor irrigation projects, including the September 1990 MPO report entitled, "Historical Evaluation of Water Resources and Implications for the National Water Plan".

CONSULTANT'S TASKS AND ACTIVITIES

Mapping, Data Review, Surveys and Analysis of Existing Conditions

8. Mapping: The latest available large scale (preferably 1:10,000 scale) maps of the project area are to be compared with the BWDB maps used for the BWDB feasibility study and an assessment made as to their accuracy in representing the topography and significant landmarks of the project area; this should also include the absolute levels of the datum of the respective map series based on FAP work and the Southeast study. Area-Elevation curves of the three drainage units (West and South Block, North Buri Nadi Block and Bijni Block) identified by the BWDB study, are to be derived using the latest maps, compared to the curves in the latter study and an assessment made as to which curves and map sets best represent field reality and are to be used for this study. The datums of the key hydrological gages of the project area are also to be checked and sampled in light of the foregoing findings and those of the Southeast study and, an assessment made of any discrepancies for use of hydrological and flooding data in further planning.

9. Hydrology: Review the quality of climatological, rainfall and river level data used in the BWDB study in the light of data reviews and analyses carried out for the Southeast study. Similarly, review and assess the ten-day rainfall, rainfall-depth-duration, ten-day river level, ten-day river discharge, low flow and peak flood analyses and graphs of the BWDB study in relation to Southeast hydrological study findings and, assess their usefulness for planning in this study. If the Southeast study's flow simulation model did not include the project area, this model is to be applied and its results assessed accordingly. Only data and analyses found to be inadequate or inaccurate need be updated and repeated according to planning criteria and methodologies to be used in this study; satisfactory analyses may be used as required. The impact of existing and proposed Indian schemes and watershed management on the hydrology and water quality of common rivers flowing into the project area shall be assessed in the requisite simulation exercises.

10. Current Flooding and Inundation: Data and maps of the depth and extent of flooding of the project area (including the 1988 flood) and, the estimated frequency thereof, are to be reviewed and assessed in the light of data accuracy and the findings of regional simulations carried out by the Southeast study and the mapping review. A flood inundation analysis of the "Without Project" and "Basic Flood Response" options (i.e. without new flood control embankments), should be carried out with the Southeast study's regional hydrological simulation model to provide a baseline for the assessment of existing inundation patterns and their physical, economic and environmental impacts in subsequent analyses required by this TOR; this analysis may also aid in assessing the quality of

existing data and model calibration. Particular attention should be given to defining the hydrological boundary conditions of the simulation with regard to joint probabilities of high stages in the major project boundary rivers, rainfall, etc. Results should be shown on appropriate maps and charts in terms of MPO flood depth categories (F0-F4) for zoning of the area under normal and selected extreme flooding frequencies.

11. <u>River Morphology and Waterways</u>: The geomorphological/bank stability study of the Upper Meghna by the FAP 9B project and findings for bank stability in the vicinity of Manikanagar, should be reviewed and their implications for major embankment alignment and river training works assessed in terms of their implications for the FCD and FCDI options. The findings of a recent hydraulic and morphological study of confinement of the Gumti River by the Gumti Phase I project embankments should be reviewed for consistency with the hydrological data analysis specified in para 9 and, its morphological findings assessed in relation to planning of the FCD and FCDI options. Review available data on seasonal country boat traffic in project area waterways and conduct a traffic survey if necessary.

12. <u>Groundwater</u>: The groundwater findings of the BWDB and Southeast Studies for the project area are to be reviewed. Additional available observation well and tubewell pumping test data (eg. static water levels, specific yield and drawdown, transmissivity) are to be evaluated and mapped for assessment of the project area's developable groundwater potential. This assessment is to include: (i) hydrological, hydraulic and water quality characteristics of the aquifer derived from well and stream base-flow recession data; (ii) absolute and relative depth and fluctuation of seasonal water tables (levels), hydraulic gradients and flow directions; (iii) existing water balance, recharge areas and their safe annual yields; (iv) inventory of existing wells, well types and their annual withdrawals; (v) zoning of the aquifer for the maximum number of STWs and DTWs installable in each zone; and (vi) seasonal groundwater levels and gradients at fuel development and their implications for wetlands, stream base-flow, existing hand-pumps, wells, STWs.

13. <u>Land-use, Physical Infrastructure and Flooding</u>: Using aerial photos and other data sources, determine and map area of current land-use in the project area (cropped area, wastelands, wetlands, built-up areas, fishponds, etc). Using Upazila records and other secondary data sources, locate and map are existing major physical, commercial and social infrastructure (roads, bridges, power facilities and distribution lines, communications; major agri-business facilities, banks, port-offices, schools, hospitals etc.) Compile available data on road traffic counts,composition and volumes in the project area. Assess the vulnerability to flooding of infrastructure using previous flood records, field verification and findings of the analysis of current inundation patterns (see para 10). Determine customary flood-proofing of property (e.g. location of villages on "high" lands etc).

14. <u>Baseline Agriculture</u>: Review the findings of the BWDB and Southeast studies with regard to current agriculture and livestock in the project area. Undertake additional baseline surveys to supplement, complement or correct available data. These surveys should be based on flood phase zoning by average inundation patterns (see para 10), with the objective of determining existence

of any significant cropping pattern, farming system and farm structure differences between the various major flood phase zones and, areas of significant groundwater and/or LLP irrigation. The survey should determine the principal parameters relevant to agricultural planning and farm management including: (i) patterns of land ownership, tenure and fragmentation of holdings, (ii) livestock ownership and use patterns, herd composition and sources of fodder, (iii) irrigated and non-irrigated cropping patterns, calendars and intensity and, crop yields, (iv) labor inputs (family labor equivalents, hired labor); (v) use of agri-chemicals; (vi) credit sources and indebtedness; (vii) use of crop residues (e.g. rice straw and bran); (viii) seed inputs; (ix) irrigation regimes (period, hours of use) and commanded area of STWs, DTWs and LLPs; (x) use of traditional irrigation methods; (xi) proportion of crop consumed domestically; (xii) marketing methods and prices of marketable supplies; (xiii) patterns of ownership and access to minor irrigation equipment and, costs of operation and/or water; (xiv) patterns of risk aversion to crop inundation damage (e.g. cultivation of long stem rice varieties, ownership of "highland" plots, use of aus varieties, timing of planting etc); and (xv), patterns of production on "homestead" farmers (i.e. effectively landless with no field crops).

15. Baseline Fisheries Production: Determine the seasonal species composition (type and percentage) of subsistence and commercial pond, river and floodplain fisheries by a survey of markets and fishermen's catch at various locations in the project area; such a survey should be conducted during both the dry season and late monsoon periods. Particular attention is to be paid to fish species migrating temporarily into the floodplain from rivers as part of their life-cycle. Estimate the natural and pond fisheries productivity of the project area in general and, the deeply flooded areas in particular. Formulate a conceptual ecological model of the floodplain fish population in terms of biomass and trophic pyramids, nutrient cycles and food chains affecting population dynamics and its limiting factors (including fishing, depth and duration of flooding, etc). Assess the composition and productivity changes that could be induced by flood control (e.g. reduced inundation depths and prevention of seasonal migration) with reference to the above model; this assessment should also draw on previous surveys of FCDI fisheries impacts - such as that of the nearby Chandpur FCDI Project.

16. Baseline Physical Environment: Assess the existing conditions with respect to populations of rodents, reptiles and pests and the extent to which flood control may alter limitations to their proliferation. Determine if there are major point and non-point sources of water pollution by organic and non-organic effluents, and the extent to which they are neutralized by stream self-purification or "flushing" via natural drainage of the project area. Random seasonal water quality sampling, particularly for inorganic compounds attributable to fertilizers, is desirable. The soil survey of the BWDB study should also be reviewed and an assessment should be made of soil fertility and nutrient deficiencies in deeply flooded and highland areas by supplementary soil sampling if necessary. The possibility of flood control impact on soil fertility [illegible] deeply flooded areas should be assessed.

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17. Socio-Demographic Environment: Estimate the current urban and rural population of the project area including estimates of number of households, household size and composition of farming and non-farming families, age-sex distribution of population and labor force, occupations (farmers, landless laborers, fisherman, clerks, self-employed etc), unemployment and disguised unemployment levels. Estimate urban and rural natural population and migration growth rates and project population to the year 2030. Review available household income surveys and supplement, where necessary during the baseline agricultural survey (see para 14) to estimate the income distribution of the area's social groups (landless, small and large farmers, etc). Assess the population pressure on available cultivable area for the "Without Project" case at present and in the year 2030, given existing land tenure patterns and trends.

18. Baseline ("Without Project") Farm Structure Models: Prepare representative economic farm structure models for the "Without Project" case using the baseline agricultural survey data (see para 14). These models are to include, inter alia, the following possible farming structure characteristics (or combinations thereof) that are found to be significant: (i) small, medium and large farms; (ii) owner operated and sharecropping arrangements; (iii) irrigated using alternative minor irrigation equipment and water user arrangements (ownership of equipment, payment for water, etc); (iv) topography and depth of inundation (highland or lowland in category F1, F2, F3 or F4 etc); (v) draft animal availability (owned or hired); labor availability (family and hired labor). The net annual disposable income, return to labor and/or irrigation is to be computed using typical cropping patterns and inputs found for each farm structure type in each typical agro-hydrological zone (e.g. highland or lowland). Estimate the proportion of each farm structure type and calculate the current weighted average annual net potential economic output of the project area. Similarly, compute the potential agricultural production over a planning period of 30 years allowing for a scenario of adoption of innovations (increased amount of minor irrigation, cropping pattern changes etc).

19. Baseline ("Without Project") Flood Damage Estimates: Prepare an Area-Elevation - Damage curve for non-agricultural land uses (towns and physical infrastructure) subject to flooding using the land-use analysis (para 13); using the results of the inundation analysis (paras 10) estimate the agricultural Area-Elevation-Damage curve. Using current flooding probabilities, compute weighted average annual flood damages over the planning period allowing for the scenario of possible land use development and increasing damage potential.

ANALYSIS OF DEVELOPMENT ALTERNATIVES

20. Basic Flood Response: Undertake the following analyses:

(a) Formulate possible agricultural and non-agricultural flood proofing and flood response options and interventions required for this development option using, inter alia, the findings of FAP 14 and FAP 23. Formulate a preliminary implementation program for the above interventions including the nature of GOB assistance, etc. and, estimate the capital and other costs of public investment and private response concomitant with the proposed program.

(b) Undertake feasibility level planning and cost estimates of drainage (deepened khals etc) and potential irrigation improvements facilitated by this development options. Assess possible farmer responses according to the profitability of adoption of the innovations facilitated using the various farm model types. Accordingly, estimate the proportion of each farm type adopting the innovations and revised cropping pattern and, compute the project area's weighted annual average net economic output concomitant with the proposed implementation program. Cost estimates should include all public and private annual operations and maintenance costs.

(c) Revise the Area-Elevation-Damage curves to reflect proposed Basic Flood Response interventions and compute the weighted average annual agricultural and non-agricultural flood damages over the planning period using the methodology of para 19.

INTERMEDIATE FLOOD RESPONSE ALTERNATIVES

21. Undertake the following analyses:

(a) Select planning criteria and plan a network of drains, submersible embankments and appurtenant structures for the prevention of early flood damages to crops and undertake average overland flow simulations for this system. Undertake an inundations analysis for joint probabilities of early river flooding and high rainfall/runoff and determine the areas inundated in the F0-F4 flood depth categories; similarly undertake an inundation/drainage analysis for the monsoon period.

(b) Formulate possible engineering and agricultural intervention and implementation programs for agricultural intensification for the Intermediate Flood Response alternative and revise the farm models (para 18) to reflect possible farmer responses (e.g altered cropping pattern) to improved drainage irrigation and submersible embankments and the intervention programs. Determine their profitability for each farm model and, accordingly, estimate overall adoption rates for each farm model group. Compute the project area's potential weighted annual average net agricultural economic output concomitant with the proposed implementation program.

(c) Formulate the intervention program's operation and maintenance organizational framework, inclusive of beneficiary participation, Food-for-Work and other related poverty alleviation programs (e.g. landless women etc) that may be used for implementation. Estimate the time stream of capital operations and maintenance costs (in cash and kind) to government and the community (inclusive of personnel, equipment etc).

(d) Determine the impact of the submersible embankment system and non-agricultural flood response interventions on mitigation of the Area-Elevation damage curves using the results of the inundation analysis in (a) above. Compute the time stream of resultant annual weighted average flood damages (allowing for embankment damage and repair under severe flooding) using estimated flooding probabilities.

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FCD AND FCDI ALTERNATIVES

22. Undertake the following analyses for the FCD and FCDI alternatives (see paras 4(d), 4(e) and 4(f):

(a) Review the design criteria of the FCD and FCDI alternatives of the BWDB study with particular attention to: (i) consistency of irrigation criteria (consumptive use, commanded area of minor irrigation equipment and irrigation efficiencies etc.) with MPO Technical Memorandum No. 2 and No.3 recommendations; (ii) consistency of agricultural drainage criteria with those of volume VI of the MPO 1986 Interim Report; (iii) other design criteria used by FAP studies (including major embankments). Accordingly, select flood control, drainage and irrigation design criteria for both options. Determine polder outlet (regulators and pumps) capacities and drainage coefficients using storm sequences of 10 and 20 year return periods for critical agricultural calendar periods; modify regulator capacities to ensure their safety under pre-monsoon hydraulic head conditions in accordance with BWDB, or equivalent, design procedures. Review designs of embankments, river training works, locks etc and modify where necessary.

(b) Investigate alternative alignments of major embankments to minimize the necessity for river training/bank protection works and/or, adverse impact on capture fisheries in deeply flooded areas. Accordingly, where necessary, revise FCD and FCDI polder layouts and drainage systems to reflect the reduced protected area using approved maps (see para 8). Prepare Area-Elevation curves for each major outlet/inlet structure for the alternative embankment alignments and alter drainage structure capacity (if necessary) for alternative polder designs.

(c) Undertake inundation analyses for the various FCD and FCDI polder configurations - and selected drainage structure capacities - using ten-day monsoon season rainfall sequences of 2, 5, 10, 20 and 50 year return period, average and/or other boundary river level conditions; this analysis should be undertaken using the Southeast study flow simulation model or its equivalent. Determine the areas under each flood phase (F0, F1, etc) during critical periods of the agricultural calendar in general and, areas inundated in the F2-F4 categories in excess of three days in particular, and compare the various FCD and FCDI alternatives.

(d) Estimate the areas likely to be irrigated by private tubewells for both FCD and FCDI options. Review the design of irrigation water supply for the FCD and FCDI options (i.e. location and capacity of flushing sluices, reversible primary pumping stations and secondary lift pump units) based on LLP and STW boro irrigation and, determine the need for night storage or increased pumping capacity for the FCDI option. Determine whether khal density averages 1.5 km/200 ha for irrigation by the FCDI option and, if a supplementary network of canals is needed for areas not commanded by the surface water system. Outline the mode of operation of the FCDI irrigation system (including network diagrams, sample irrigation block layouts etc).

(e) Consider the possible cropping pattern changes, irrigation and other innovations likely to be adopted by the various farm model types and determine their profitability. Formulate an agricultural intervention support program to promote adoption of farming innovations facilitated by FCD and FCDI development. Estimate the proportion of farms in each group undertaking the changes and determine the weighted average net agricultural production under FCD and FCDI development over the planning period.

(f) Using the inundation analysis, rainfall probabilities and farm model results [paras 22(c) and (e)], estimate the weighted average annual crop damages over the planning period for the FCD and FCDI options; similarly, estimate the weighted annual average non-agricultural flood damages that may occur under the FCD and FCDI options over the planning period (including embankment failure events caused by major floods, etc).

(g) Review proposals for roads and navigation locks of the BWDB study in the light of waterways and road traffic statistics as well as projected agricultural output; formulate and evaluate necessary modifications. Determine nature and capacity of additional power generation and distribution infrastructure required for the pumping stations etc.

(h) Review BWDB study proposals for pond fisheries development and facilitation of fish migration through polder structures and review annual pond fisheries production estimates, structure modification costs and benefits, modifying and elaborating where necessary.

(i) Formulate a preliminary implementation program for all alternatives including agricultural interventions and related inputs (equipment, staff and materials). Review, update or modify capital cost estimates in foreign and local currencies for all FCD and FCDI project works allowing for ICB procurement; similarly, prepare annual expenditure schedules. Determine land acquisition requirements.

(j) Determine - and quantify in physical and economic terms if possible - any positive or adverse physical environment (e.g. capture fisheries) and social (e.g. changes in employment and income distribution - particularly of the landless poor and women) impacts of the FCD and FCDI alternatives. Formulate feasible interventions to mitigate adverse impacts and determine the time stream of quantifiable expenditures, losses and benefits.

(k) Review the findings of past assessments of FCD/FCDI project implementation and determine their implications for the proposed project alternatives.

ECONOMIC AND FINANCIAL ANALYSIS

23. Undertake a economic and financial analysis (internal rates of return, net present value of benefits) - including sensitivity analysis - of all development alternatives according to FAP/FPCO guidelines and procedures acceptable to IDA. The time stream of potential net benefits identified for each development

alternative should be reduced by the expected annual flood damage estimates and include any positive or negative quantifiable environmental impacts and mitigation measures. Select a recommended development alternative that best fulfills the project objectives.

PLAN OF OPERATIONS AND PROPOSED IMPLEMENTATION PROGRAM

24. Prepare feasibility level construction and phased implementation schedules, procurement and land acquisition plans for the recommended alternative and, proposals and TOR for additional surveys and investigations required for detailed design and preparation of tender documents.

25. Elaborate on the required organizational structure for project implementation, O.&M., cost recovery and community participation.

PERSONNEL INPUTS, STUDY DURATION AND REPORTING

26. A breakdown of suggested personnel inputs totalling 40 expatriate and 50 local staff man-months are shown in Table 1. These inputs are considered to be adequate for a joint venture of local and foreign consulting firms familiar with the region and currently working on similar projects. It should be noted that the architect and civil engineer are suggested primarily for data collection, formulation and assessment of non-structural flood control alternatives. Unallocated expert inputs are to be proposed by the consultant according to his perceived needs for fulfilling the requirements of this Terms of Reference.

27. The expected duration of the study is eleven calendar months. The draft final report should be submitted at the end of the ninth month after commencement of work; the tenth and eleventh months are allocated for the expatriate Team Leader's presence during review of the draft Final Report. The Final Report should be issued by the end of the eleventh month and incorporate all IDA and GOB comments on the draft Final Report. In addition, reporting requirements will consist of the following:

(a) An Inception Report submitted 3 weeks after commencement of work outlining any necessary conceptual and work program modifications of the original pre-contract proposal, as well as review of the BWDB study and a detailed baseline field surveys program.

(b) A First Progress Report submitted 3-4 months after work commencement. This report should include, inter alia, preliminary field survey results, general hydrological analysis, identification and formulation of development options and their component alternatives (including the "Without Project" case), design criteria and discussion of development and evaluation issues.

(c) A Second Progress Report submitted about 7 months after work commencement. This report should include baseline survey results, farm models, hydrological/engineering analysis of development alternatives, analysis of their environmental impact and formulation of mitigation options (if any).

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Table 1: Suggested Personnel Inputs

Personnel Discipline	Input (Man-Months)	
	Expatriate	Local
Team Leader/Water Resources Planner	11	
Senior Irrigation & Drainage Engineer	9	
Irrigation & Drainage Engineer		10
Design/Costing Engineer		6
Hydraulic Works Engineer	1	
Senior Agricultural Economist	6	
Agricultural Economist		8
Hydrogeologist	2	
Groundwater Engineer		3
Senior Hydrologist/Modeller	3	
Hydrologist/Modeller		5
Senior Agronomist	2	
Agronomist		3
Senior Fisheries Specialist	2	
Fisheries Specialist		3
Senior Environmentalist	1	
Environmentalist		1
Sociologist	1	3
Architect		3
Civil Engineer		3
Unallocated Experts	2	2
Total	40	50

STUDY BUDGET

28. The study budget cannot exceed the equivalent of US$850,000 in foreign and local currency. A detailed breakdown, based on the suggested personnel inputs is given below in Table 2. The final budget breakdown is to be determined by negotiation of the consultant's proposals to the World Bank. The estimates of survey, office and logistics expenses are indicative only, and should be desirably reduced in favor of greater personnel input if the study is housed in

the consultant's furnished project offices in Dhaka: i.e. these costs are charged on an incremental cost basis.

Table 2: Estimated Study Budget

		US Dollar Equivalent
Expatriate Consultants 40 m-m x $13,700/m-m		548,000
Local Consultants 50 m-m x $1,800/m-m		90,000
International Airfares 15 fares x $2,600		39,000
Expatriate Housing & Subsistence 40 m-m x $1,400/m-m		56,000
Office Rent and Operations		30,000
Personal Computers		12,000
Office Staff		24,000
Vehicle Hire and Operation		40,000
Report Reproduction		11,000
	Total	850,000