FAP-5

World Bank
Government of the People's Republic of Bangladesh

Gumti Phase II
Sub-Project Feasibility Study

FINAL REPORT

ANNEX H

ENVIRONMENTAL IMPACT ASSESSMENT

September, 1993

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

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GUMTI PHASE II SUB-PROJECT FEASIBILITY STUDY

ANNEX H- ENVIRONMENTAL IMPACT ASSESSMENT

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GLOSSARY

acre	-	0.4047ha
Aman	-	Early dry season paddy planted before or during the monsoon and harvested November-December
Aus	-	Early Monsoon paddy planted during March-April and harvested during June and July
B.Aman	-	Broadcast Deep-Water Aman Paddy
BARC	-	Bangladesh Agricultural Research Council
BBS	-	Bangladesh Bureau of Statistics
BCAS	-	Bangladesh Centre for Advanced Studies
Beel	-	Bangla term for an area of open water away from a river
Bigha	-	A unit of area measurement = 0.33acre or 0.14ha
Boro	-	Late dry season paddy transplanted in December-January and harvested April-May
BRAC	-	Bangladesh Rural Advancement Committee
BWDB	-	Bangladesh Water Development Board
Decimal	-	Unit of area equal to 0.01acre
DEM	-	Digital Elevation Model
District	-	A large administration unit under the authority of a Deputy Commissioner, now known as a Zila
DoE	-	Department of the Environment
DOF	-	Department of Fisheries
EIA	-	Environmental Impact Assessment
FAO	-	Food and Agriculture Organisation of the United Nations
FAP	-	Flood Action Plan
FCD/I	-	Flood Control, Drainage and Irrigation
FPCO	-	Flood Plan Co-ordination Organisation
FRSS	-	Fisheries Resource Survey System
GIS	-	Geographical Information System
GPA	-	Guidelines for Project Assessment (FPCO Guidelines for the Flood Action Plan)
ha	-	Hectares = 2.4711 acres
HYV	-	High Yielding Variety
IUCN	-	International Union for the Conservation of Nature
Jalmahal	-	Bangla term for Government leased fishing rights
kg	-	Kilogram = 1.11Sher
Khal	-	Bangla term for a drainage channel or canal either natural or man made
Kharif	-	Summer/Wet Season
MOEF	-	Ministry of Environment and Forest
Maund	-	A unit of weight = 37.5 Kilos
Mauza	-	A village revenue collection and cadastral mapped unit
MPO	-	Master Plan Organisation

NCS	-	National Conservation Strategy
NEMAP	-	National Environment Management Programme
NGO	-	Non Government Organisation
POE	-	Panel of Experts (of FPCO)
Rabi	-	Winter/Dry Season
Sher	-	A unit of weight = 1/40maund = 0.94kg
SPARRSO	-	Space Research & Remote Sensing Organisation
SPOT	-	System Pour Observation de la Terre
SRDI	-	Soil Research Development Institute
T.Aman	-	Transplanted Aman Paddy
Thana	-	A sub-division of a Zila or District
TK	-	Taka, Bangladesh Currency, 1 Pound Sterling = TK60 at May 1993
TM	-	Thematic Mapper
ton	-	An Imperial Ton = 1016kg
umoles	-	Micromoles, Unit of electro-conductivity, a measure of salinity
UN	-	United Nations
Union	-	Sub-division of a Thana or Upazila
Upazila	-	A subdivision of a Zila or District now known as a Thana
WHO	-	World Health Organisation
WO	-	Without, as in Without Project situation
Zila	-	A large administration unit formerly known as a District

FOREWORD

This Draft Environmental Impact Assessment Annex to the Gumti Phase II Feasibility Study Report was prepared by the Consultant Environmental Specialist. It was drawn up in May and June 1993 following a programmed input of 2 months spread over the period September 1992 to May 1993. In addition there were local specialist consultants in water quality, human health and nutrition. The expertise of other specialists working on the study was also used to cover the following disciplines (which have their own technical Annexes):

- Surface Hydrology
- Groundwater Hydrology
- Land and Soil Resources
- Aquatic and Terrestrial Ecology
- Sociology and Socio-Economics
- Agriculture and Agricultural Economics
- Fisheries
- Engineering

This Annex aims to provide an integrated environmental perspective to the study which assessed a wide range of possible water and land management interventions for the area, including a review of the previous 1990 Feasibility Study. The work has allowed an environmentally sound set of interventions to be proposed for further detailed study if the client should so wish, leading to a full EIA along the lines of the World Bank Operational Directive 4.01 and the FAP Environmental Guidelines.

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SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK PROGRAMME

SUMMARY

The aim of the environmental component of the study was to provide an integrated environmental perspective to the formulation of water and land management interventions for the defined study area. This included limited collection of environmental data for the area concerning water quality, aquatic and terrestrial flora and fauna, fisheries, health and nutrition. In addition there were other study components that tackled surface water and hydraulic modelling, groundwater, soil and land resources, socio-economics, agro-economics and infrastructure provision. There was also a significant public participation component to the study to assess what local people perceived to be the problems and issues that effect them and what are their priorities for intervention.

The broad results from this data collection work indicated that the study is very complex and diverse from the standpoint of natural resources and human use of these. The flooding pattern of the area was shown to be complex and variable in both direction and timing of flooding from year to year. Virtually all of the study area lies under water for at least two months in a "normal" year and in some areas up to eight months and a significant proportion of this results from local rainfall, not external flow into the area. The main constraint to drainage of this is the level of water in the main Meghna River channel. As a result most of the homesteads in the study area are already flood proofed above a 1 in 20 year flood and there is little loss of life from flooding. The main flood problem is flash flooding from the Indian hills which is unpredictable and can cause significant damage to standing crops depending upon its timing. Whilst there is some erosion and accretion in the main Meghna River channel this is minor, especially when compared to the other major rivers in Bangladesh.

The best available complete socio-economic data for the area was the 1981 BBS census which is now considered to be badly out of date. However, using this data in mapped form, the spatial variation in population density could be seen. The high levels of population density which have been prevalent in the area for some considerable time have resulted in intensive use of the natural resources of the area. The annual flooding regime also means that the area is one of the richest inland fisheries areas in the country and a significant proportion of the population are dependent upon the availability of this resource, both for cash income and also for most of their protein intake. The levels of water supply provision in the area recorded in 1981 were low, although this needs to be confirmed when the 1991 BBS data is made available. This appears to have contributed to the widespread problems with diarrhoeal diseases and many people expressed the opinion that adequate safe drinking water provision was a higher priority than flood control, drainage and irrigation.

The environmental perspective of the area allowed the previously proposed water and land management interventions for the area to be reviewed and also the drawing up of a strategy that addressed the expressed needs of local people and the environmental conditions in the area.

CONCLUSIONS

The environmental component to the study has concentrated on providing a continuous environmental perspective to the evolution of an appropriate and environmentally sensitive water and land development strategy plan for the area. This included consideration and re-evaluation of two alternative strategies proposed by the 1990 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 polderisation. There is potential for encouraging surface water irrigation by Khal deepening 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 finally solve the long term problem of downstream aggravated flooding that partially embanking the river has caused for many years. The intervention of controlled flooding in Zone A addresses the problem of early flash flooding from the Indian hills but needs to be combined with downstream Khal deepening if induced downstream and upstream flooding is to be avoided.

RECOMMENDATIONS

The following three interventions would seem to be justified in environmental terms and seem to offer significant benefits in order of priority:

- Intervention 7 - Khal deepening.
- Intervention 3 - extension of Gumti right bank embankment.
- Intervention 1A and 1B - Deepening and remodelling of the Salda river and controlled flooding in part of Zone A.

However the economic analysis indicates that the latter pair of interventions (1A and 1B) are not economic unless their cost is shared by Intervention 2 (the larger of the exclusion polders in Zone B), as the latter has significant agricultural benefits. However this intervention has significant fisheries losses in this area, with socio-economic and nutritional loss implications, especially to occasional fishermen (37% of the population) and also to the 4% of households dependent upon full-time fishing and some of the 6% who are part-time ones. It thus becomes a political decision as to if it is considered that the fisheries losses in the Intervention 2 area can be justified by the agricultural benefits in that area 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 it 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 seems to be very unwise within the Gumti area which is so rich in fisheries resources. If it is wished to promote a policy of increasing agricultural production through increased irrigation and flood control provision then the Gumti Phase II area is not a suitable place to do this. Irrespective of the question of environmental suitability, the economic losses to the fisheries resources amply demonstrate this to be the case, there are likely to be far more suitable places within Bangladesh to pursue this type of policy.

FUTURE WORK PROGRAMME

Assuming that the recommended detailed interventions are to be followed up then a highly specific and suitably phased programme of detailed data collection is required that addresses the issues raised in this preliminary environmental assessment. This requires the hydraulic modelling to be refined for the specific interventions being considered and also interfaced to a Digital Elevation Model (DEM) to automatically produce mapped outputs. In addition it is imperative that the 1991 BBS census data is made available to the study. The detailed studies need to include the following components:

- Detailed fisheries assessment, especially in Zone A and the Intervention 2 area, the Gumti River outfall flood plain 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 the 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 fuel-wood, grazing, fodder and rural energy balance survey.

- Studies of land acquisition requirements, and formulation of an appropriate compensation and resettlement strategy with significant public participation, to produce a resettlement plan under World Bank Operational Directive 4.30.

- A review of the likely direct construction impacts bearing in mind the engineering design, nature of construction contract and the experience with the BWDB implemented Coastal Embankment Rehabilitation Project.

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 World Bank 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

A draft outline for Terms of Reference for such detailed studies is given in Appendix H.3.

H.1 INTRODUCTION

H.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 of these and conclusions drawn from the analysis which allowed recommendations to be made as to which of the interventions should be studied to greater detail in the next phase of the work.

H.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 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 quantify let alone value and in any case they need to be judged against policy priorities, both nationally and regionally, along with an indication as to how these are to be interpreted locally.

H.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 H.1.1. The study area is Planning Unit No 11 in the South East Region and its regional context is shown in Figure H.1.2. The study area was defined by the previous BWDB 1990 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 H.1.3.

Figure H.1.1
Location of the Gumti Phase II Project Area

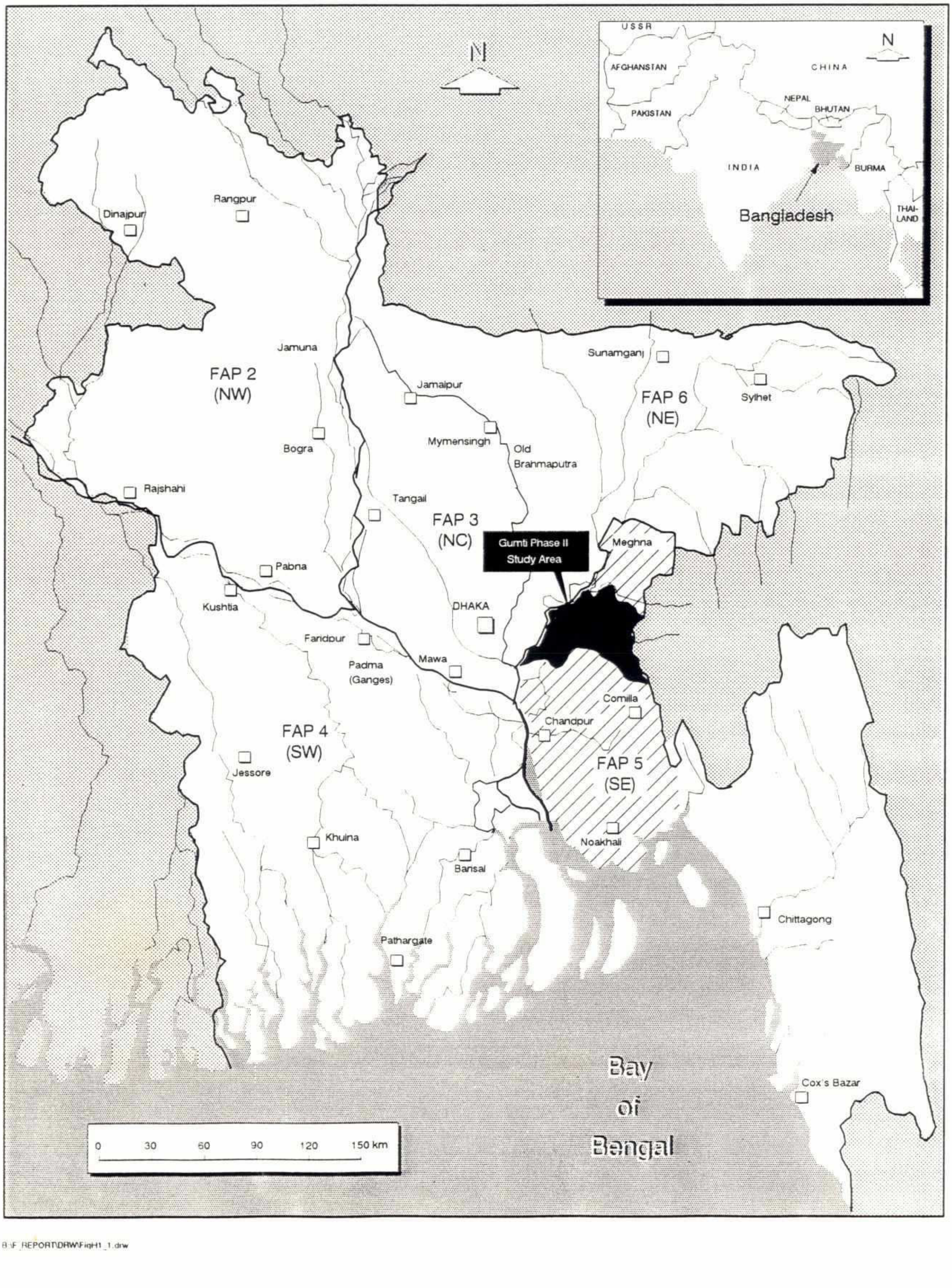

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Figure H.1.2
Regional Planning Context

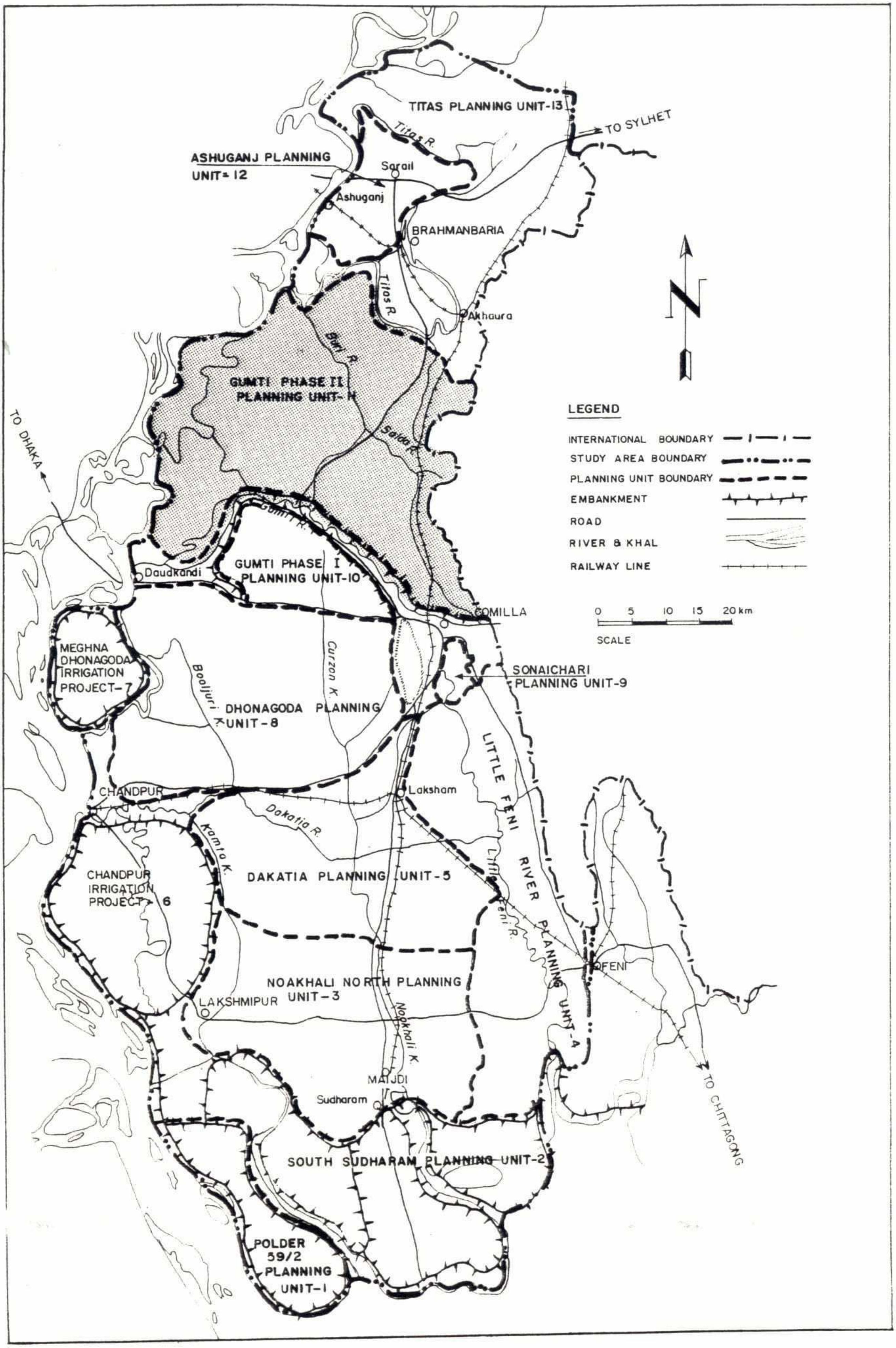
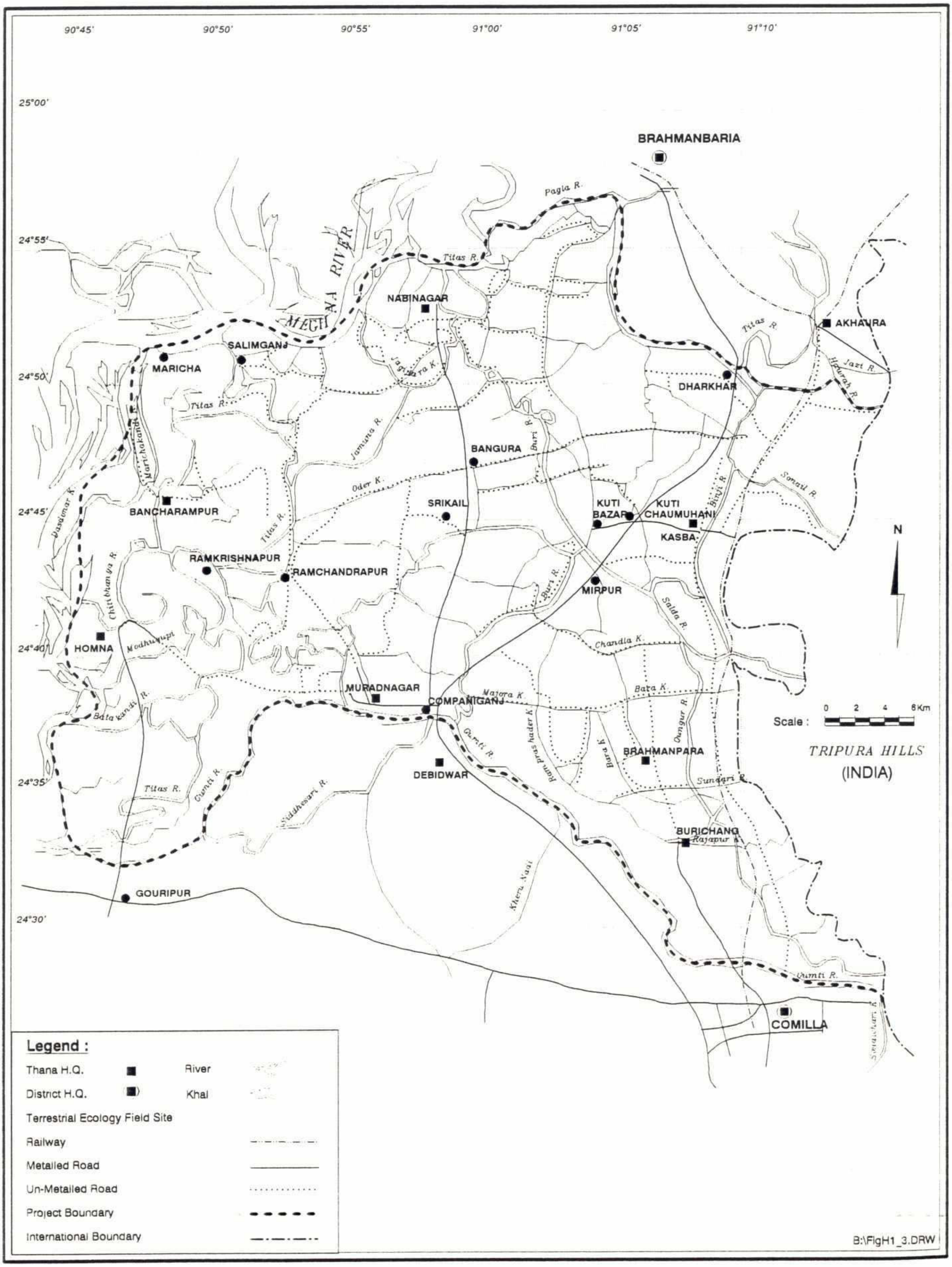


Figure H. 1.3
Project Area Base Map



H.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 basis for most of this type of work. For work in Bangladesh the FAP 16 environmental component has drawn up Environmental Guidelines as a self-standing document in its own right and also as part of the Guidelines for Project Assessment (GPA) for FPCO. The FAP Environmental Guidelines have recently been reviewed by the Bangladesh Department of the Environment and are now to be adopted as the National Guidelines for water sector work throughout the country. In addition the second draft of the National Conservation Strategy (NCS) is now under consideration as part of the National Environmental Management and Planning programme (NEMAP). The 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 possible intervention possibilities with some analysis to allow a recommendation as to the most appropriate one to be taken forward for further detailed study.

H.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
- Agro-economics

The findings of each of these study components are given in the respective sections of the main report and also in the appropriate Annexes. A sample agro-socio-economic survey was carried out in the study area which was principally aimed at obtaining data on agricultural economics. It was of limited use for social impact assessment (SIA) as it was done before the 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.

H.1.6 Public Participation

There was a significant public participation component in the study which carried out a three stage set of visits to four villages from each of the four planning zones. This allowed a needs assessment for water and land planning priorities to be carried out and the results of these are summarised in Table 9.2 of the Main Report. 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 1990 Feasibility 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 impacts 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.

H.2 ENVIRONMENTAL PROFILE OF THE STUDY AREA

H.2.1 Introduction

The environmental profile of the study area, covering both the natural and human environment is given below. The basis for data collection and differentiation of these aspects was the four planning zones shown in Figure H.3.1 as it was envisaged that the likely variation across the study area would require different types of interventions.The planning zones were delineated using a range of criteria and data available to the study at that stage, including FAO ago-ecological zones, MPO flooding zones and topography.

H.2.2 The Natural Environment

H.2.2.1 Mapping and Topography

There is topographic mapping available for the study area at 1:16 000 scale which was derived from infra-red air photography taken in 1987 and supplemented with ground survey levelling.These were prepared for the 1990 Feasibility Study but were not made available in time.These are too detailed and unwieldy to use for feasibility level environmental scoping studies and the topographic data is not available as digital elevation model data which could have been interfaced with the hydraulic model to produce mapped outputs of flood extents, depths and durations.Instead these had to be plotted by hand using a simplified contour map of the study area given in Figure H.2.2.

There is a range of multi-spectral satellite imagery held available for the study which is ideal for preliminary resource assessment use. The most detailed is French SPOT imagery of February 1989 available at 1:50 000 and shown as a reduced mosaic in Figure H.2.1 overlain with the study area base map. There is time series American Landsat imagery available since 1973 but unfortunately all of this is for dry season periods.Imagery was obtain from various sources, including the FAP 19 GIS study of ISPAN, for the following dates:
5th December 73, March 84, 7th January 1990, February 1991, dry season 1992 and January 1993. A comparative digital analysis was carried out by ISPAN between the 1973 and 1993 imagery to give an indication of land erosion and accretion during this time and the output is shown in Figure H.2.7.

There is also a map dated 1914-19 with some slight revision in 1929. This was re-scaled to fit the study area base map to assess changes over time.

H.2.2.2 Surface Water

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. The climatic norms for Comilla are shown in Figure H.2.3 and the most significant aspect is the seasonal variation

Gumti Base Map

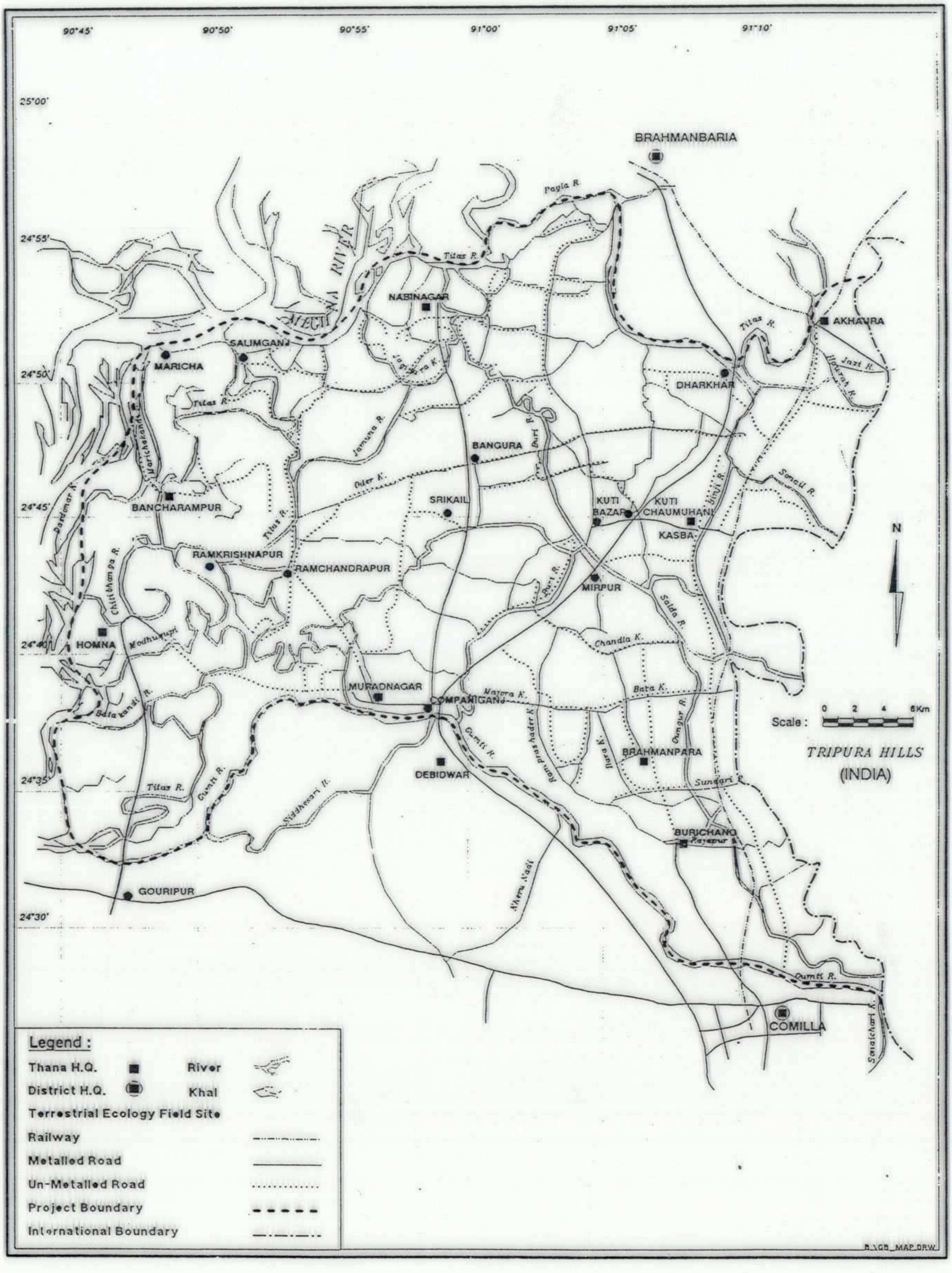


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Figure H.2.1

SPOT Satellite Image of the Project Area, February 1989

Figure H.2.2

Topography Map

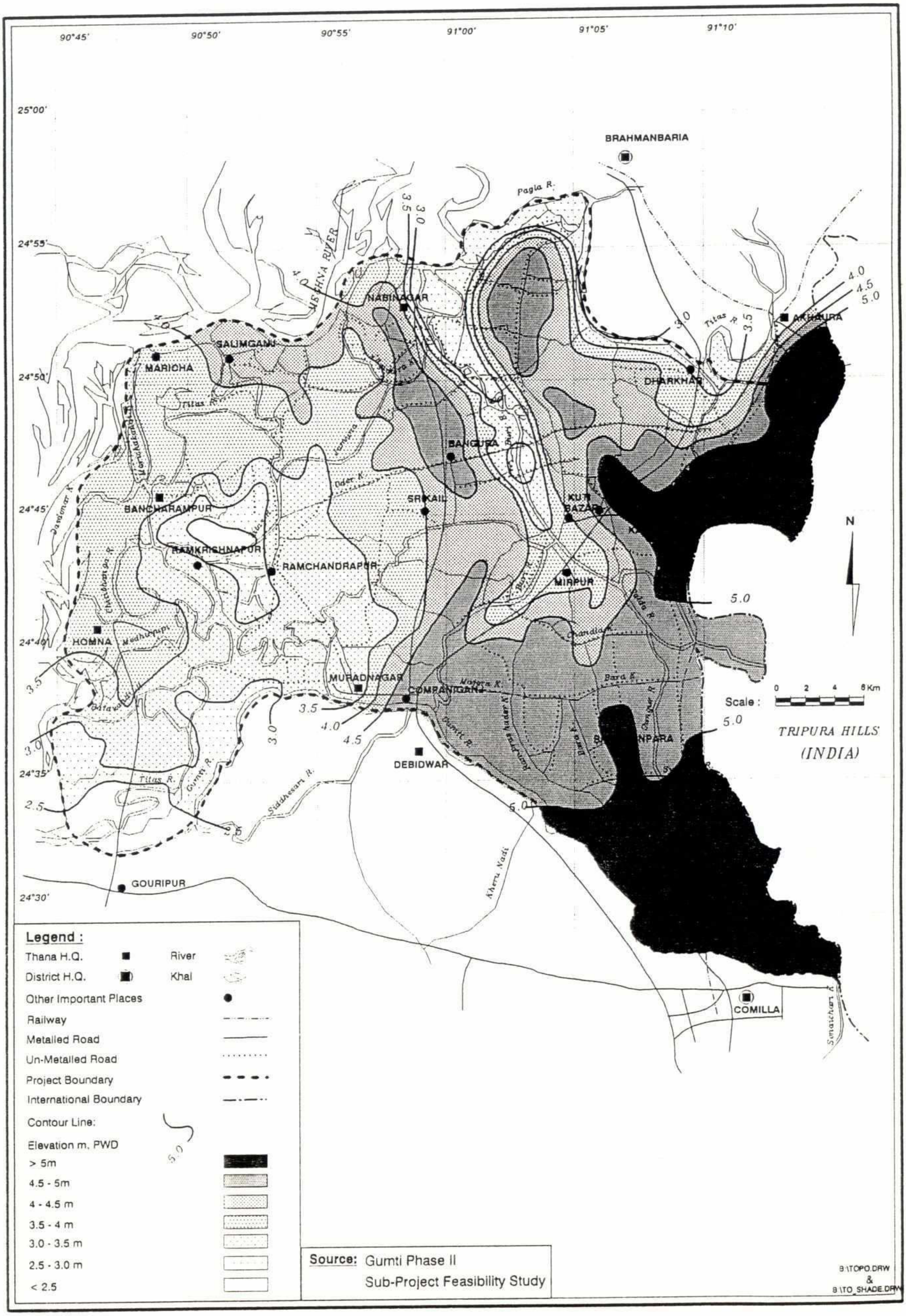
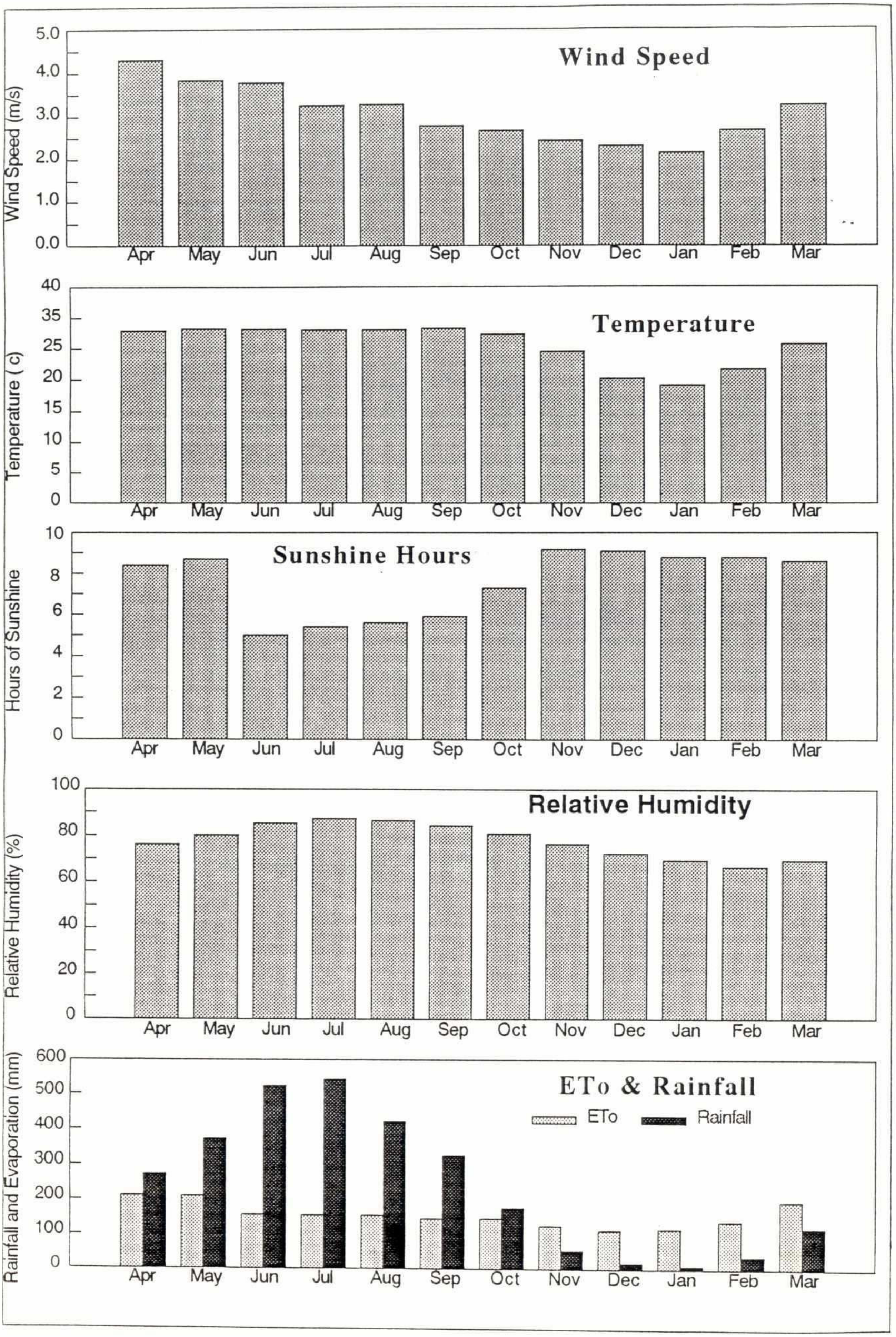


Figure H.2.3

Climatic Norms at Comilla



and high peak levels of rainfall. The MPO flood zones are shown in Figure H.2.4 and give a broad picture of likely peak flood depths but not of flood timing or direction of flow. However with the lack of any wet season satellite imagery this was the best data available prior to the production of the hydrological modelling results.

The flood patterns 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 (0.5m contours, see Figure H.2.2) that could be sensibly handled quickly to give A3 sized map outputs on clear polyester sheets. This was carried out for both a 1 in 2 "normal" year and a 1 in 5 high "normal" year, firstly for the present without intervention situation and latterly for each of the post construction situations for the strategies under consideration. 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 analyzed and subsequently modified with the aim of minimising 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 Figure H.2.5 for a rising flood and Figure H.2.6 for a falling flood.

The mapped outputs from the model were initially surprising as the direction and timing of flooding were different than had first been thought. However the mapped outputs proved to be credible from field observation and reporting. They explained the difficulties that were previously being experienced by attempting to interpret a flooding pattern picture built up from unsystematic and episodic discussion data.

The mapped outputs show that the area firstly floods from the east due to flash flooding from the Indian hills. The consequences of this show on the 1 in 5 year model output as flooding along the Salda river. There is also flooding at the western end of the Gumti right bank flood plain where the embankment stops before it reaches the Meghna River. However this could not be adequately modelled at present and the flooding shown in figure H.2.5 is the result of local run-off rather than the flash flooding. The Gumti flash flooding is thus effectively the downstream impact of its confinement, a process that was started sometime before the year 1660 AD. 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 as it is not concentrated in a confined channel. It 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 Gunghur flow meets the south bound Buri Nadi flow and both join, flowing westwards to the Meghna River. 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 South East 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 indicates that there is surprisingly little difference in the extent of peak flooding for a "normal" and a high "normal" flood, the major difference is its duration. In any 1 in 2 "normal" or higher year nearly all the study area goes under water by at least 0.30m. Flooding extents and timings for the area appear to be determined by the water level

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Figure H.2.4

MPO Flood Zones

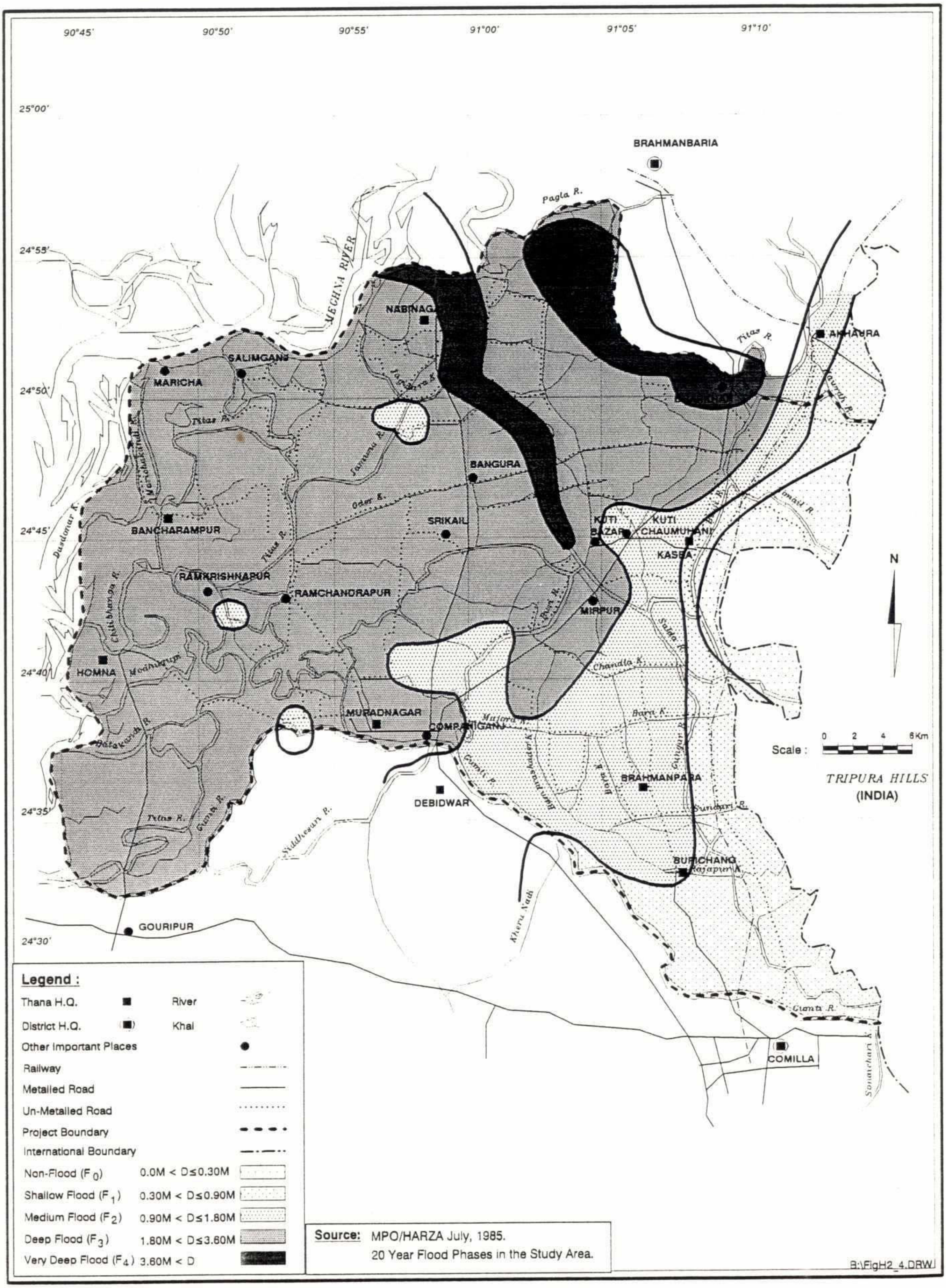


Figure H.2.5
Rising 1 in 2 Year Flood Pattern

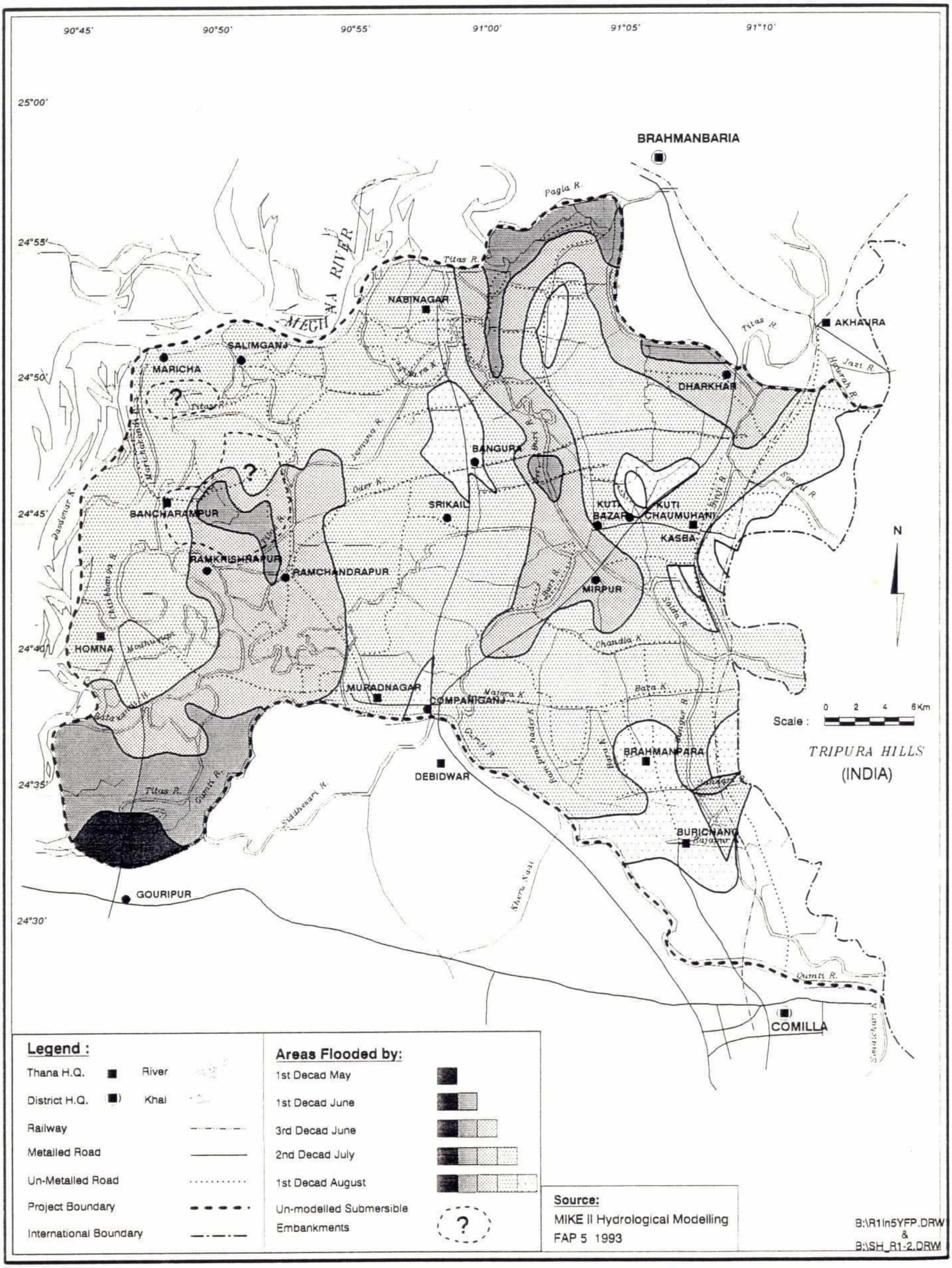
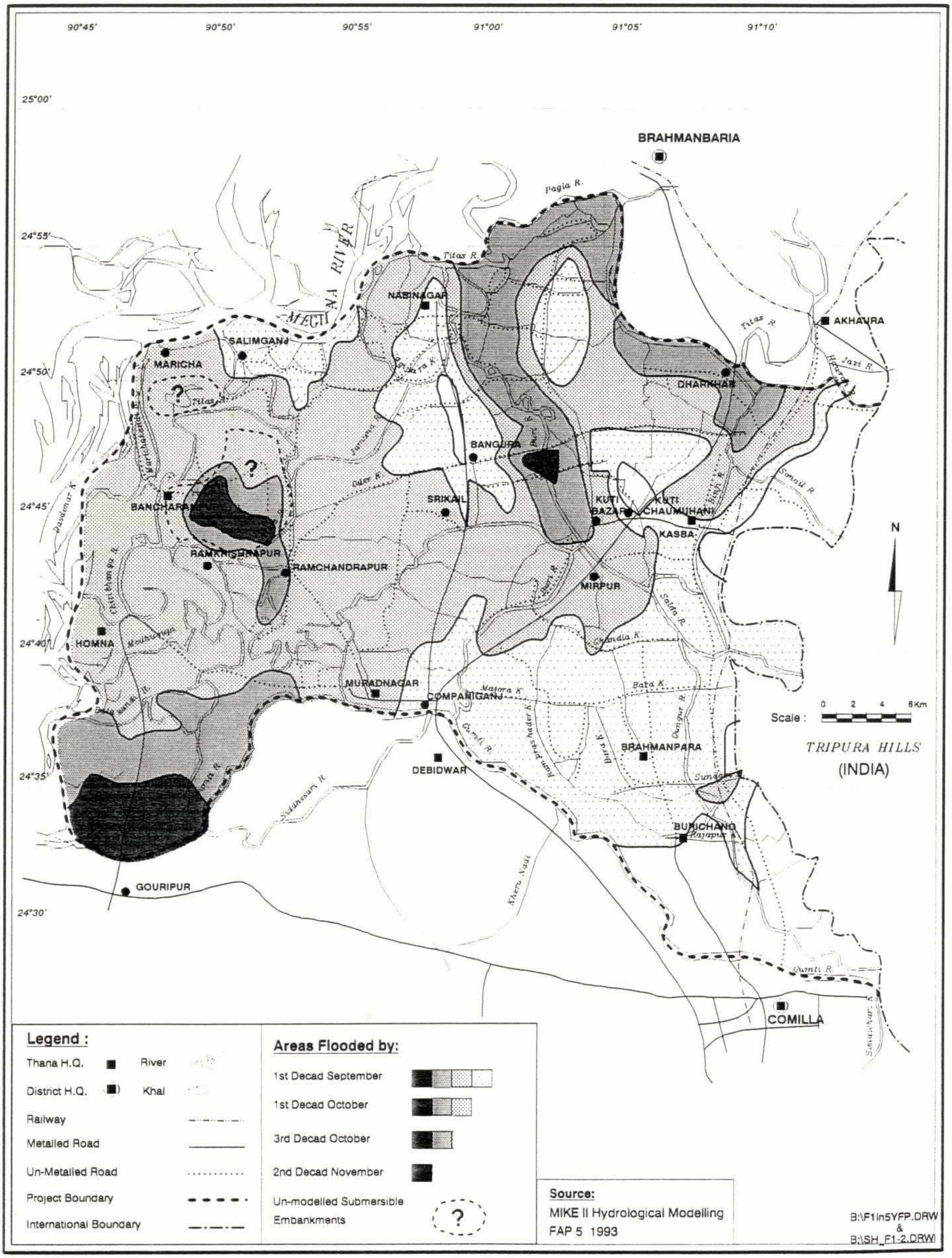


Figure H.2.6
Falling 1 in 2 Year Flood Pattern



Source:
MIKE II Hydrological Modelling
FAP 5 1993

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 one map shown as Figure H.2.5 and the falling flood map in Figure H.2.6. The MPO flood zones are shown in Figure H.2.4 and the climatic norms at Comilla are shown in Figure H.2.3.

H.2.2.3 River Morphology

The digital analysis of Landsat imagery for 1973 and 1993 is given in Figure H.2.7 and shows very little change in main river positions within and adjacent to the study area. This is especially the case in comparison to the lower Meghna and Padma Rivers where there have been very significant changes in this period.
The 1914-1919 map also indicates that there have been very little change in river channel position in the last 75 years and that the main river flood plain is essentially a relic Char land area from the time when the main Brahmaputra river flowed in the course of present Meghna river prior o its sudden change in course during the 1790's.

H.2.2.4 Sedimentation and Erosion

The major sedimentation problem in the study area lies with flow from the Indian hills rather than the main Meghna River channel which is relatively free of sediment, especially when compared with the other main rivers in Bangladesh. The sedimentation in the Gumti River has already resulted in the bed level of this long embanked river rising to the point where it is in some cases higher than the surrounding ground level and has necessitated that the embankments be constantly raised. There are also sedimentation problems in the Gungur and Salda rivers which are attributed with impeding drainage of flash floods from the area.

With regard to erosion from the satellite imagery analysis shown in Figure H.2.7 there would appear to be relatively little problem with the main Meghna River, especially in comparison to the rates encountered with the other main rivers in the country. However there is localised point erosion of a maximum of 20m a year which is an aspect to be considered if major structures such as bridge abutments and embankments are proposed close to the bank edge.

H.2.2.5 Groundwater

The situation with regard to groundwater is given in detail in Annex C with a summary in Section 2.3 of the Main Report. This includes aspects of groundwater quality. There are major constraints to groundwater development, especially for irrigated agriculture, due to relic salinity, gas and depth. In summary much of the western and southern central parts of the study area have limited groundwater potential, especially for irrigation and it would seem worthwhile reserving what resources there are in these areas for potable water use.

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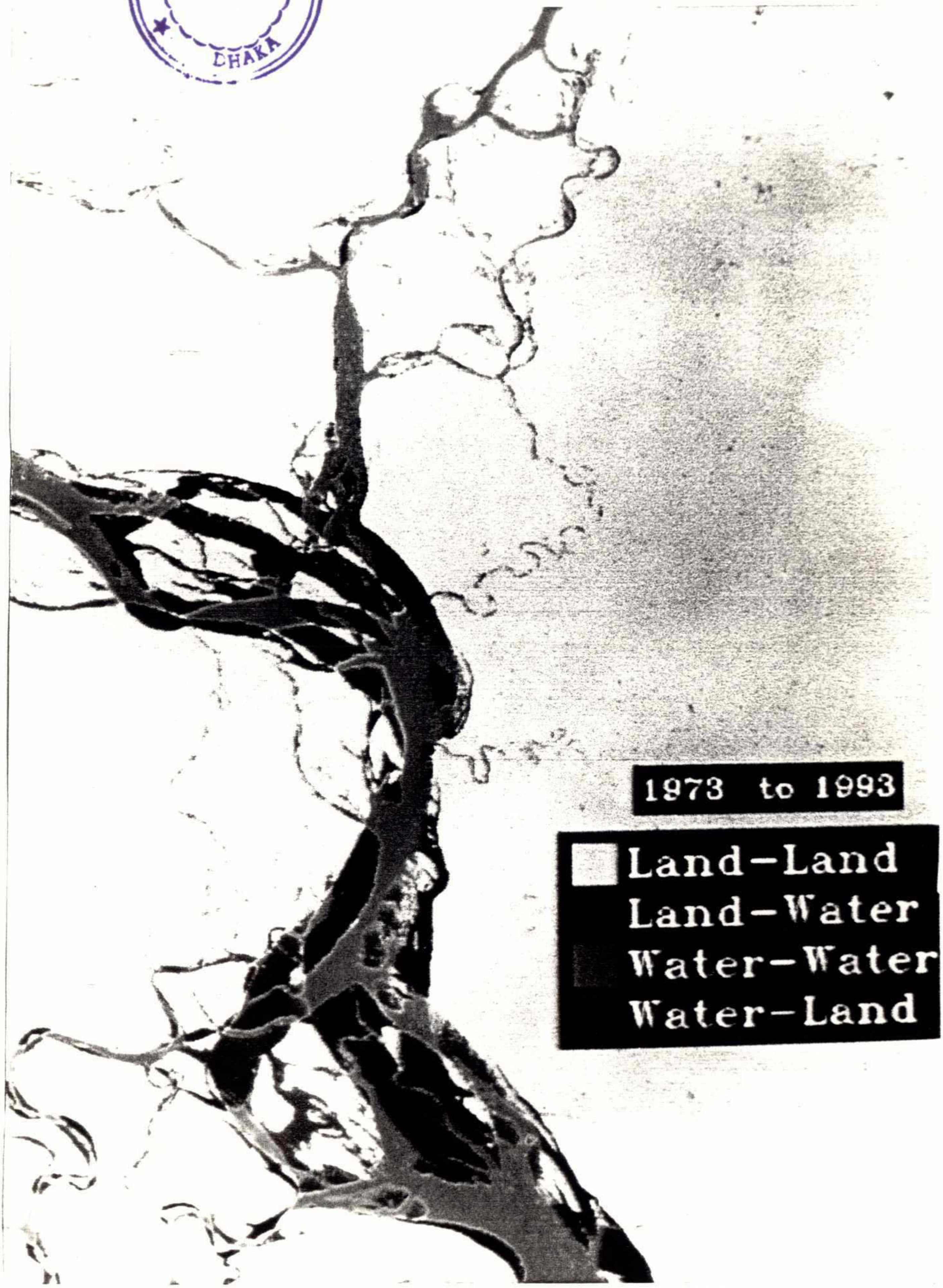
Figure H.2.7
Erosion and Accretion mapping 1973-1993
Source : (ISPAN/FAP 19)



H.2.2.6 Water Quality

An assessment of groundwater quality has been carried out in Annex C and is summarised in Section 2.3 of the Main Report. The situation with regard to surface water has been assessed by carrying out a programme of sampling in both the wet and dry season, the locations being shown in Figure H.2.8 and the results in Tables H.2.1 and H.2.2. These were written up in the previous progress reports including a comparison with the national water quality standards for differing uses which are given at the foot of each table.

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 soil is also low would seem to indicate that the biological process are what allow the area to be 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.

H.2.2.7 Agro-Ecological Zones

The FAO 1988 agro-ecological zone mapping of the study area is given in Figure H.2.9. When superimposed on the March 1989 SPOT satellite imagery this fits remarkably well. These zones are essentially a combination of topography, flood depth and soil type and when combined with a cropping calendar are a useful aid in interpreting land utilisation patterns in a conceptual framework. It was a major criteria for drawing up the planning zones for the study area.

H.2.2.8 Soil Resources

The available soil information for the Gumti Phase 2 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 Gumti Phase II Study between 1988 and 1990 which used the SRDI work, along with additional field data collection. There is also the Land Resources Appraisal of Bangladesh for Agricultural Development carried out by FAO and published in 1988 which produced agro-ecological mapping of the country shown for the project area in Figure H.2.9. 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 summarised in Figure H.2.10 and derived land capability in Figure H.2.11.

TABLE H.2.1

SPREADSHEET FOR WET SEASON (OCT - NOV, 1992)

Sl. No.	Name of the Water Body	Sample Code	Description	Date/ Time	Temperature degree	pH	DO mg/l	CO2 mg/l	CaCO3 mg/l g/l	Nitrate mg/l	Phosphate mg/l	Iodine mg/l	Silica mg/l	Potassium mg/l	Zinc µg/l	Sulphate mg/l	Iron mg/l	NaCl mg/l	Total Coliform n/100 ml.	Faecal Caliform n/100 ml.	Total Bacterial Count/ml	DDT µg/l	DDE µg/l
							CHEMICAL ANALYSIS												MICROBIOLOGICAL ANALYSIS			RESIDUAL PESTICIDES ANALYSIS	
1.	Arsi River	13	Slowly running water; Slightly brown colour; Water hyacinth partly; Sunny morning.	25.10.92 08:30 Hrs.	27.5	7.4	10	14	35	Lost	1.9	<0.01	21.6	2.5	8.3	0.33	0.59	30	3000	3000	>1000	?	?
2.	Dalpar Beel (Flood land)	14	Stagnant water; Greenish brown colour; Submerged vegetation; Sunny morning	25.10.92 10:40 Hrs.	28.5	7.4	12	10	32	Lost	0.93	<0.01	8.4	2.8	23.3	0.49	0.45	25	800	600	>1000	?	?
3.	Madrasa Masji Pond	11	Stagnant water; Pale green colour; Green algae partly; Domestic use; Sunny morning.	26.10.92 07:45 Hrs.	28	7.7	8.5	15	85	Lost	2	0.01	9.6	8	15.1	5.3	0.37	200	4000	3400	>1000	?	?
4.	Ruhitar Beel (Pond)	8	Stagnant water; Pale green colour; Fishing pond; Sunny day.	26.10.92 11:15 Hrs.	29	6.8	9	12	17	Lost	1.9	<0.01	12	1.3	13	4.1	0.07	20	180	70	>1000	?	?
5.	Thana Head Quarter Pond	7	Stagnant water; Greenish brown colour; Green algae partly; Domestic use; Sunny morning.	27.10.92 09:15 Hrs.	29	8	11	12	70	Lost	6.5	0.01	19.6	5.1	15.1	1.5	0.19	100	2000	410	>1000	?	?
6.	Chanduna Beel	4	Stagnant water; Pale blue colour; Sunny day.	27.10.92 10:00 Hrs.	29	7.5	10	8	30	Lost	3.8	0.02	2.4	1.4	6.2	1.3	0.45	35	210	100	>1000	?	?
7.	Titas River	6	Running water; Slightly brown colour; Water hyacinth partly; Sunny day.	27.10.92 11:00 Hrs.	28.5	7.4	11	9	23	Lost	4.8	<0.01	12.4	1.3	16.7	0.66	1	55	2000	1000	>1000	?	?
8.	Saidona Beel	5	Stagnant water; Pale green colour; Slightly turbid; Water hyacinth mostly; Sunny day.	27.10.92 12:15 Hrs.	30	7.5	8.5	10	31	Lost	4.1	0.01	11.2	1.1	12.5	0.33	0.4	42	2000	100	>1000	?	?
9.	Havatia River	9	Slowly running water; Slightly brown colour; Clear water; Sunny day.	28.10.92 10:30 Hrs.	28.5	7.1	8	12	38	Lost	4.2	<0.01	6.8	1.5	11	1.7	0.45	58	3000	1000	>1000	?	?
10.	Korikandi Boe (Flood land)	10	Slowly running water; Greenish brown colour; Clear water; Sunny day.	28.10.92 11:45 Hrs.	29	7.4	9	11	46	Lost	3.8	<0.01	8.4	0.82	13.9	1.2	0.27	36	4000	3000	>1000	?	?
11.	Meghna River	20	Running water; Slightly brown colour; Navigation use; Sunny day	28.10.92 12:50 Hrs.	28.5	7.2	9	12	30	Lost	4.7	<0.01	20.4	1.3	9	1.3	0.68	42	8000	5000	>1000	?	?
12.	Confluence of Titas, Bijni & Hawrah Rivers	15	Slowly running water; Slightly brown colour; Sunny morning.	8.11.92 08:00 Hrs.	26	7.1	13	15	42	10	8.6	<0.01	27.2	2.8	10.5	0.82	2.2	70	840	720	>1000	?	?
13.	Kunigara Beel (Flood land)	3	Stagnant water; Slightly brown colour; HYV crops cultivation; Sunny day:	8.11.92 11:00 Hrs.	28	7.4	10.5	10	26	8.8	10	<0.01	23.6	1.6	18.3	1.2	2.1	38	20	5	>1000	?	?
14.	Meghna River	1	Running water; Greenish brown colour; Navigation use; Sunny day.	8.11.92 12:15 Hrs.	28	7.5	11	8	32	8.8	6.3	0.01	5.6	1.2	22.1	1.7	0.5	40	200	240	>1000	?	?
15.	Titas River	2	Running water; Pale green colour. Water hyacinth partly; Sunny day.	8.11.92 12:30 Hrs.	28	7.5	11	7	32	5.6	9.2	<0.01	9.2	1.4	13.1	1.7	0.45	40	580	480	>1000	?	?
16.	Gumti River	19	Running water; Slightly brown colour; Partly turbid; Sunny morning.	9.11.92 08:10 Hrs.	26	7.7	13	10	65	9	5.4	<0.01	33.2	2.3	17	1.3	0.51	35	1040	900	>1000	?	?
17.	Naigor Beel	18	Stagnant water; Slightly brown colour; Water hyacinth; HYV crops Cultivation; Sunny da	9.11.92 10:00 Hrs.	28	7.1	10.5	12	31	13.8	3.9	<0.01	16.8	2.2	11.6	1.7	0.86	38	1080	1000	>1000	0.006	0.1
18.	Salda River	17	Slowly running water; Deep brown colour; Partly turbid; Sunny day.	9.11.92 11:45 Hrs.	27	7.4	11	11	22	7.5	2.9	<0.01	36	3	13.3	1.3	1.1	36	1420	1200	>1000	?	?
19.	Kallayan Saga (Pond)	16	Stagnant water; Pale green colour Green algae partly; Domestic use; Sunny day.	9.11.92 12:30 Hrs.	29	7.7	13.5	8	16	6.9	4	0.01	8.8	3.6	11.6	1.2	0.76	45	5520	2200	>1000	?	?
20.	Gumti River	12	Slowly running water; Slightly brown colour; Sunny day.	9.11.92 13:30 Hrs.	27	7.6	11.5	10	50	10	1.3	0.01	32.4	2.2	8.2	1.5	0.52	40	2120	1360	>1000	?	?
ENVIRONMENTAL QUALITY STANDARDS (EQS) FOR BANGLADESH, JULY 1991			Recreational Water		20-30	6-9.5	4-5	NYS	NYS	NYS	6	NYS	NYS	NYS	NYS	NYS	NYS	NYS	200	NYS	?	0	?
			Fishing Water		20-30	6.5-8.5	4-6	6	80-120	NYS	10	NYS	NYS	NYS	10000	NYS	NYS	NYS	5000	NYS	?	NYS	?
			Irrigation Water		20-30	6-8.5	5	NYS	NYS	NYS	10	NYS	NYS	NYS	5000	1000	NYS	NYS	1000	10	?	NYS	?
			Drinking Water		20-30	6.5-8.5	6	NYS	200-500	10	6	NYS	NYS	12	5000	400	0.3-1	NYS	2	0	?	0	?

LEGEND:

DO = Dissolved Oxygen; CaCo3 = Calcium Carbonate; CO2 = Carbon-dioxide; NaCl = Sodium Chloride; DDT = Dichloro Diphenyi Trichloroethane; DDE = Dichloro Diphenyl Ethylene Dichloride; NYS = Not Yet Specified.

TABLE II.2.2

SPREADSHEET FOR DRY SEASON (FEB - MARCH, 1993)

											CHEMICAL ANALYSIS									MICROBIOLOGICAL ANALYSIS			RESIDUAL PESTICIDES ANALYSIS	
Sl. No.	Name of the Water Body	Sample code	Description	Date/ Time	Temperture degree C	pH	DO mg/l	CO2 mg/l	EC µS/cm	CaCO3 mg/l	Nitrate mg/l	Phosphate mg/l	Iodine mg/l	Silica mg/l	Potassium mg/l	Zinc µg/l	Sulphate mg/l	Iron mg/l	NaCl mg/l	Total coliform n/100ml	Faecal coliform n/100ml	Total Bacterial Count/ml	DDT µg/l	DDE µg/l
1	Arsi Rever	13	Stagnant water; Pale brown colour; Sunny day.	13-02-93 10:00 Hrs.	23.2	8	10	20	387	188	12.7	?	?	?	?	?	?	?	125	4000	1000	>1000	?	?
2	Dalpar Beel (Flood land)	14	Completely dry	12-02-93 10:10 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
3	Madrasa Masjid Pond	11	Stagnant water; Pale green colour; Domestic use; Sunny day.	8-02-93 15:30 Hrs.	25.6	8	9.5	22	445	119	1.5	2	0.02	13.2	13.5	15	6.2	0.14	230	1850	800	>1000	?	?
4	Ruhitar Beel (Pond)	8	Stagnant water; Slightly brown Colour Fishing pond; Sunny day.	8-02-93 11:50 Hrs.	25	7.1	10	10	46	15	5.5	?	?	?	?	?	?	?	60	850	750	>1000	?	?
5	Thana Head Quarter Pond	7	Stagnant water; Green colour; Domestic use; Sunny morning.	10-02-93 09:35 Hrs.	22.5	8.8	11	6	169	54	9.3	4.1	?	?	?	?	?	?	130	15000	3000	>1000	?	?
6	Chanduna Beel	4	Stagnant water; Pale blue colour; Sunny day.	10-02-93 11:30 Hrs.	24.7	8	14	8	161	102	2.5	1.3	0.01	2	1.6	10	2.2	0.21	65	90	60	>1000	?	?
7	Titas River	6	Running water; Pale green colour; Water hyacinth; Sunny day.	10-02-93 12:00 Hrs.	23.5	7.7	12	16	206	119	12.5	?	?	?	?	19	?	?	70	1700	1450	>1000	?	?
8	Satdona Beel	5	Mostly dry and covered with hyacinth.	10-02-93 13:30 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
9	Havatia River	9	Running water; Greenish brown colour Water hyacinth partly; Sunny morning	8-02-93 10:30 Hrs.	22.2	7.5	11	12	113	70	4.5	?	?	?	?	?	?	?	50	2750	2200	>1000	?	?
10	Korikandi Beel (Flood land)	10	Completely dry.	8-02-93 10:00 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
11	Meghna River	20	Running water; Greenish brown colour Navigation use; Sunny day.	8-02-93 13:05 Hrs.	24.1	7.6	10	15	97	48	1	1.8	0.01	10.4	1.9	14.8	5.6	0.54	70	1450	1050	>1000	?	?
12	Confluence of Titas, Bijni & Hawrah Rivers	15	Stagnant water; Greenish brown colour Sunny morning.	12-02-93 10:50 Hrs.	23.2	7.7	13.5	18	257	120	?	1.4	?	?	?	?	?	0.6	60	1000	30	>1000	?	?
13	Kunigara Beel (Flood land)	3	Completely dry	13-02-93 11:10 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
14	Meghna River	1	Slowly running water; Pale green colo Sunny day.	13-02-93 11:50 Hrs.	23.3	7.7	11.5	8	99	52	?	?	?	?	?	7.5	?	?	58	101	80	>1000	?	?
15	Titas River	2	Slowly running water; Pale green colo Sunny day.	13-02-93 12:25 Hrs.	24	7.7	11	7	98	51	4.7	1.3	0.02	2.5	0.73	19.5	6.8	0.32	60	650	590	>1000	?	?
16	Gumti River	19	Slowly running water; Pale brown colo Sunny day.	15-02-93 12:40 Hrs.	25.5	7.8	13	9	93	45	?	?	?	?	?	?	?	?	50	8000	3000	>1000	?	?
17	Naigor Beel	18	Mostly dry and irrigated	15-02-93 10:45 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
18	Salda River	17	Slowly running water; Brown colour; Very turbid; Sunny day.	12-02-93 12:05 Hrs.	24	7.6	12	16	155	66	?	?	?	34	?	?	?	?	65	25000	10000	>1000	?	?
19	Kallayan Sagar (Pond)	16	Stagnant water; Greenish brown colour Water hyacinth partly; Sunny day.	12-02-93 13:00 Hrs.	25.5	7.8	14	6	62	16	4.7	?	?	?	?	?	?	?	70	7000	5000	>1000	?	?
20	Gumti River	12	Slowly running water; Brown colour; Sunny day.	8-02-93 16:10 Hrs.	23.2	7.7	12	10	91	40	5	2.7	0.01	13.6	2.1	11	3.6	0.17	50	800	600	>1000	?	?
ENVIRONMENTAL QUALITY STANDARDS FOR BANGLADESH, JULY 1991			Recreational Water		20-30	6-9.5	4-5	NYS	500	NYS	NYS	6	NYS	NYS	NYS	NYS	NYS	NYS	NYS	200	NYS	?	0	?
			Fishing Water		20-30	6.5-8.5	4-6	6	800-1000	80-120	NYS	10	NYS	NYS	NYS	10000	NYS	NYS	NYS	5000	NYS	?	NYS	?
			Irrigation Water		20-30	6-8.5	5	NYS	2000	NYS	NYS	?	NYS	NYS	NYS	5000	1000	NYS	NYS	1000	10	?	NYS	?
			Drinking Water		20-30	6.5-8.5	6	NYS	?	200-500	10	6	NYS	NYS	12	5000	400	0.3-1	NYS	2	0	?	0	?

LEGEND:

DO=Dissolved Oxygen; CO2=Carbon-dioxide; EC = Electrical Conductivity; CaCO3 = Calcium Carbonate; NaCl=Sodium Chloride; DDT=Dichloro Diphenyl Trichlor oethane; DDE=Dichloro Diphenyl Ethylene Dichloride; NYS=Not Yet Specified.

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Figure H.2.8

Site Locations for Water Quality Data Collection

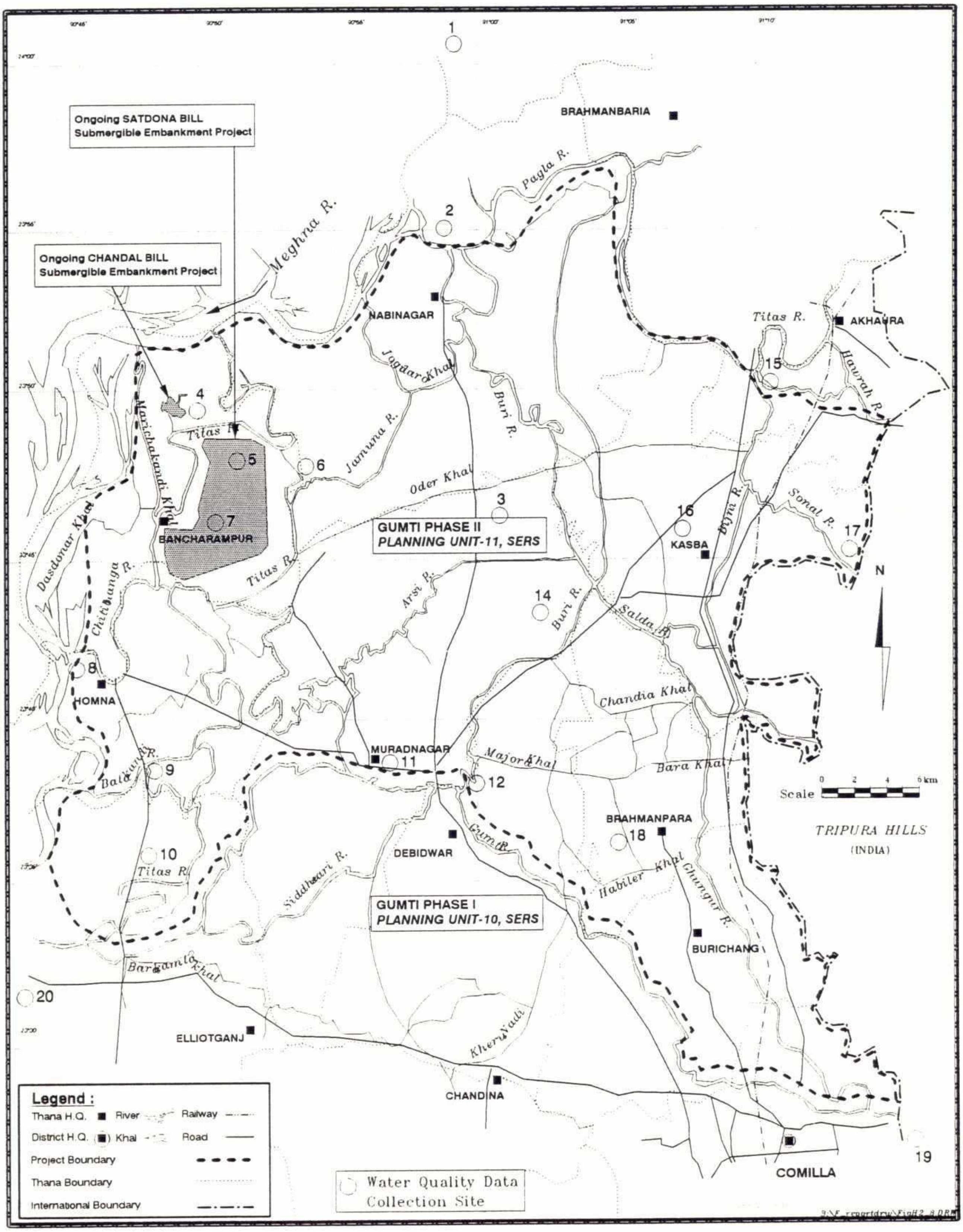
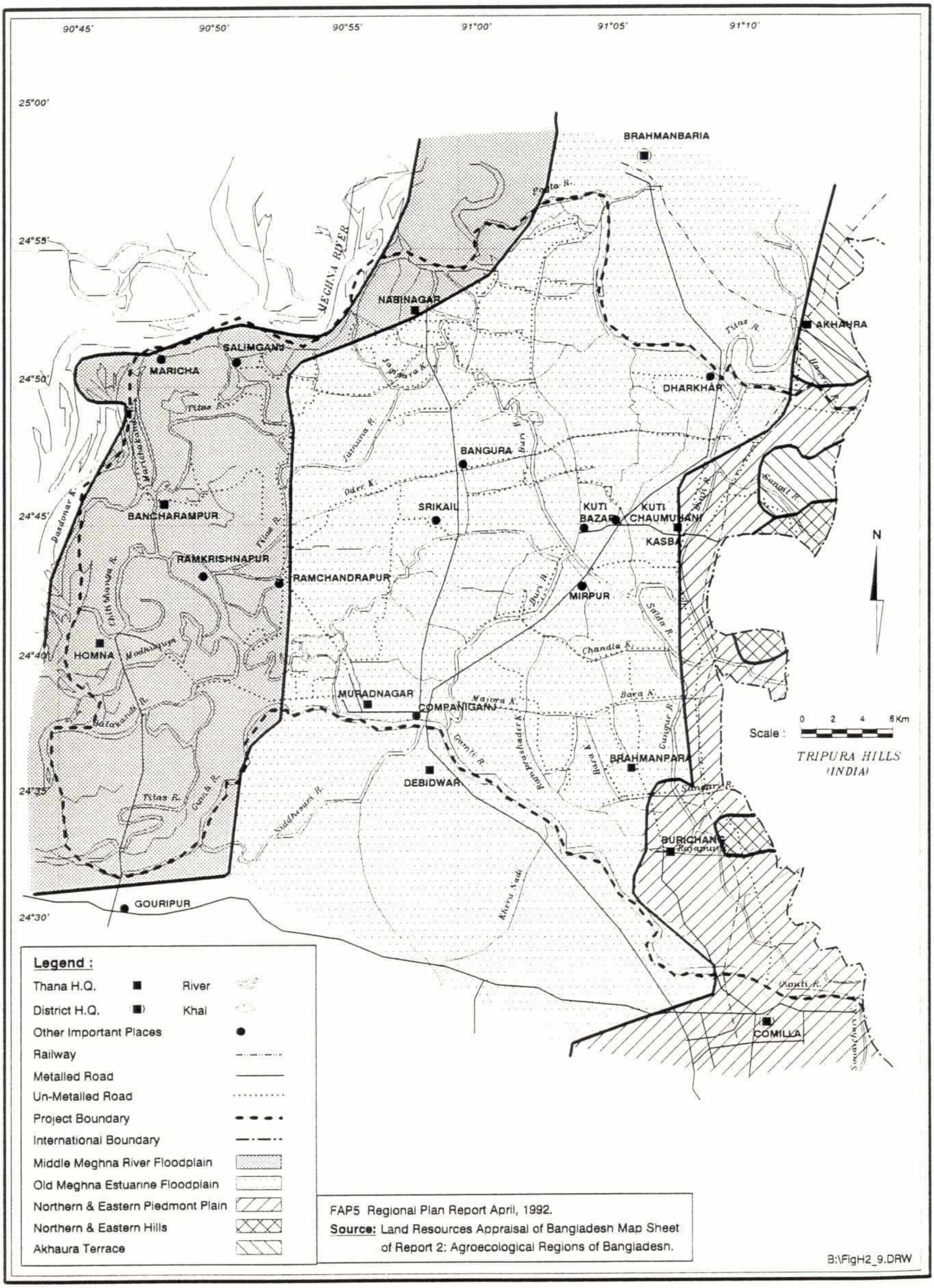


Figure H.2.9

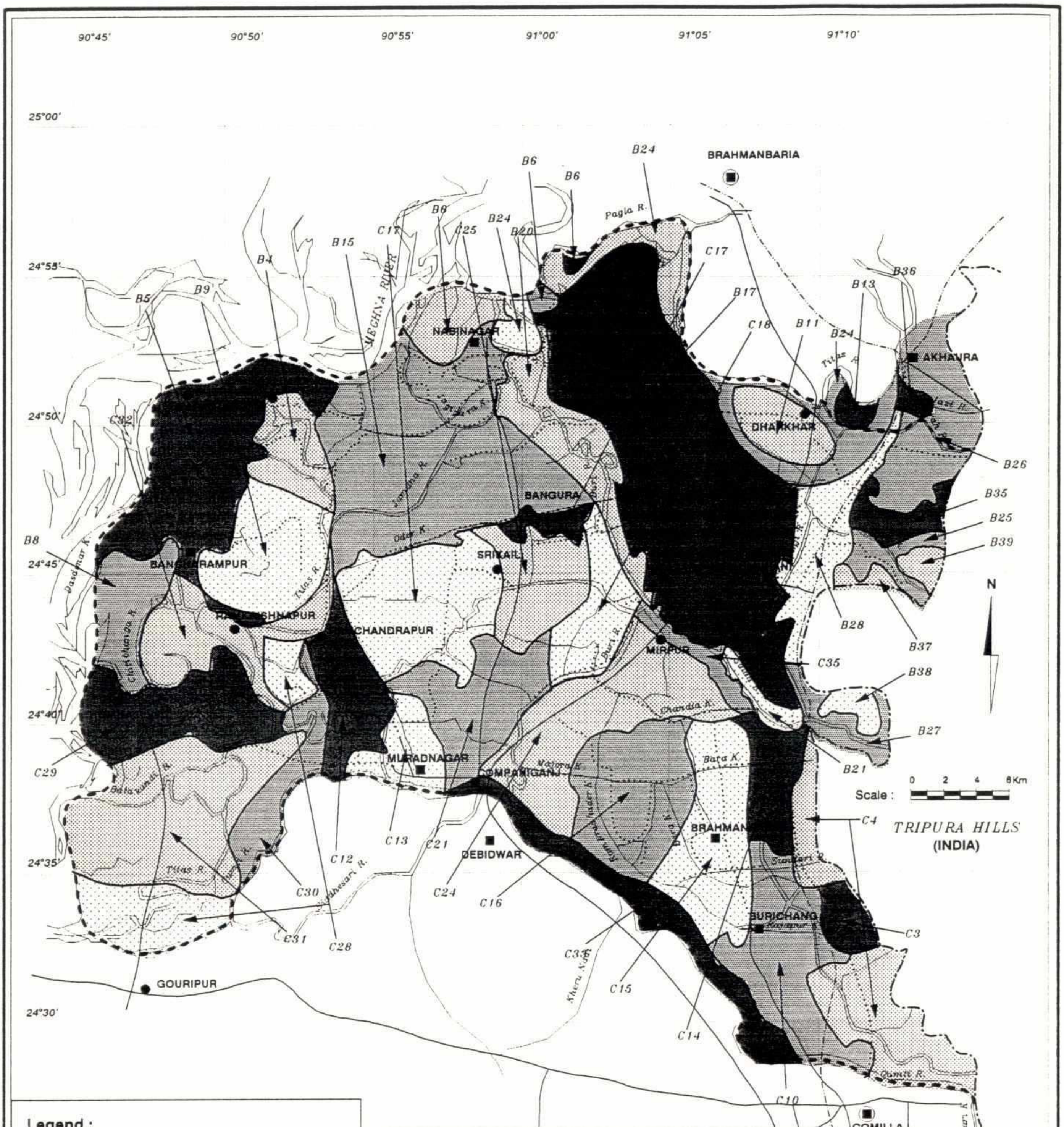
Agroecological Regions in Project Area



(67)

Figure H.2.10

Soil Types



Legend :

Thana H.Q.	■	River	
District H.Q.	(■)	Khal	
Other Important Places	●		
Railway			
Metalled Road			
Un-Metalled Road			
Project Boundary			
International Boundary			

Source: Halcrow Final Report
Gumti Phase II
Annex D: Soils

Soil Association

B2	-Tanger Char – Fuldi	*C3*	-Sankochail – Chakla – Kharrera
B4	-Fuldi – Bancharampur (High)	*C4*	-Bharella – Chakla – Rangari
B5	-Fuldi – Bancharampur (Low)	*C10*	-Chakla – Bharella
B6	-Fuldi Series	*C12*	-Burichang – Godnail – Siddhirganj
B8	-Borda – Bancharampur	*C13*	-Muradnagar – Burichang
B9	-Borda – Fuldi	*C14*	-Burichang
B11	-Jalkundi – Debidwar	*C15*	-Burichang – Jalkundi
B13	-Jalkundi	*C16*	-Barura
B15	-Barura – Dhamti	*C17*	-Barura – Burichang
B17	-Dhamti – Barura – Tippera	*C18*	-Burichang – Barura Jalkundi
B20	-Burichang – Jalkundi	*C21*	-Tippera – Debidwar
B21	-Burichang – Dakatia	*C24*	-Tippera Jalkundi
B24	-Nabinagar – Nasirnagar	*C25*	-Tippera Chandina
B25	-Ramnagar Chakla – Sahajibazar	*C28*	-Borda – Fuldi
B26	-Chakla – Ramnagar	*C29*	-Borda Silmondi
B27	-Pritimpasa Sahajibazar	*C30*	-Manikandi – Fuldi
B28	-Sahajibazar	*C31*	-Tanger Char – Borda
B35	-Nadarabad – Rupa	*C32*	-Tanger Char – Fuldi
B36	-Simrail – Durgapur	*C33*	-Gumti Tippera
B37	-Nalua – Kamuri	*C35*	-Dakatia – Burichang
B38	-Nalua – Salbar – Sahajibazar		
B39	-Rangamati – Juri		

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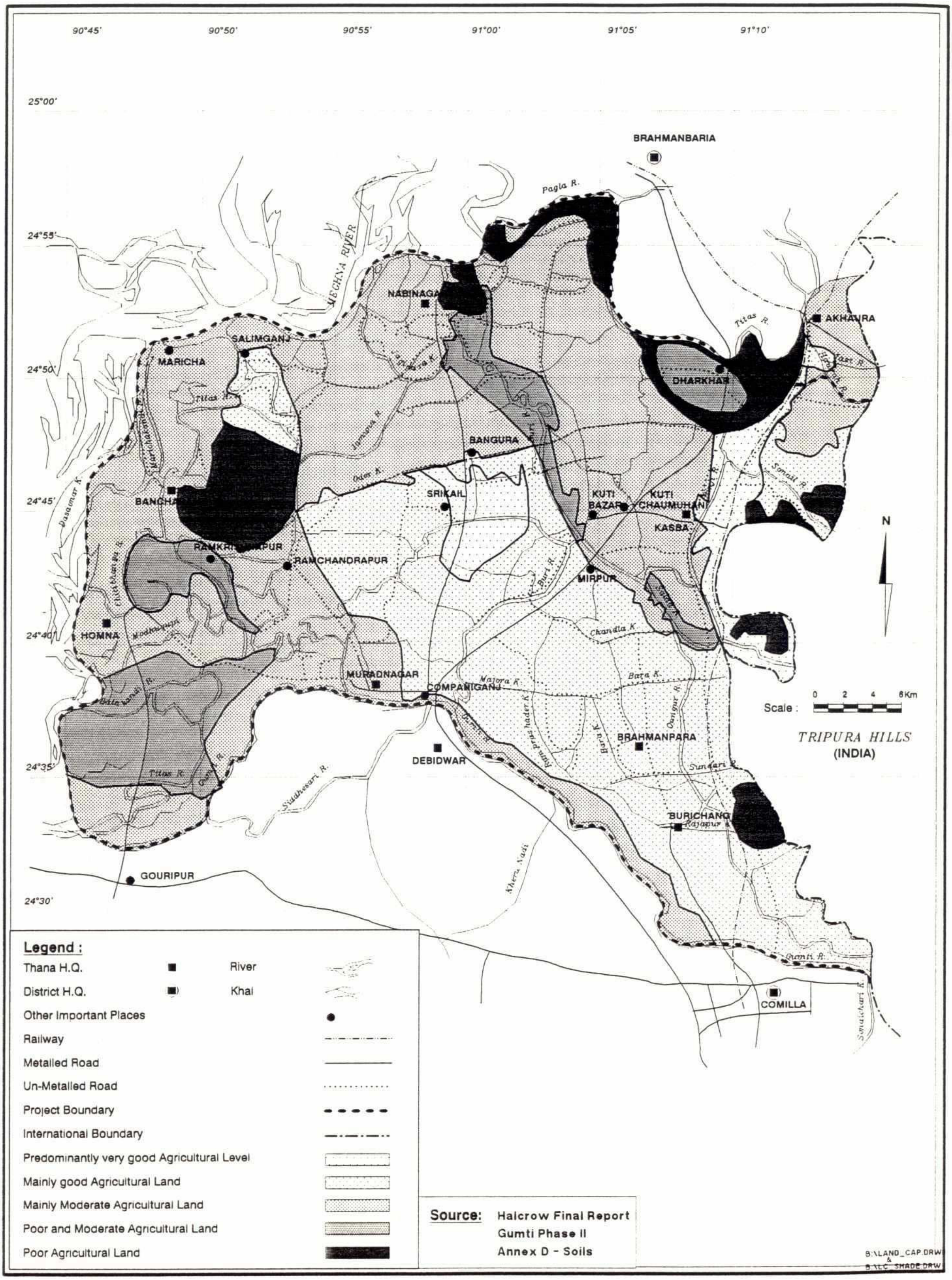
&
B:\ST_SHADE.DRW

Figure H.2.11
Land Capability



The SRDI data collection programme included surface soil chemistry information, mapped and published by Thana. Previous FAP Sub-Regional Feasibility Studies (see FAP 3.1 Final Feasibility Report, Annex 3) have made use of this, often unpublished data, for environmental assessment purposes. 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. The national standards for surface soil chemistry are given in Table H.2.3.

TABLE H.2.3

Rating of Analytical Values of Nutrient Components

Nutrient Components	Low	Medium	High
Ammonium Nitrogen (N) PPM/millimetre Soil	<76	76-150	151-300
Phosphorus (P) PPM/millimetre Soil	<13	13-25	26-75
Sulpher (5) PPM/millimetre Soil	<13	13-25	26-75
Boron (Bo) PPM/millimetre Soil	<0.21	021.0.50	0.51-4.0
Copper (Cu) PPM/millimetre Soil	<1.1	1.1-3.0	3.1-10
Iron (Fe) PPM/millimetre Soil	<21	21-40	41-200
Manganese (Mn) PPM/millimetre Soil	<5.1	5.1-10	11.50
Zine (Zn) PPM/millimetre Soil	<2.1	2.1-4.0	4.1-18
Calcium (Ca) Milliequivalent/100 millimetre Soil	<2.1	2.1-4.0	4.1-18
Magnesium (Mg) Milliequivalent/100 millimetre Soil	<0.81	0.81-2.0	2.1-9
Potassium (K) Milliequivalent/100 millimetre Soil	<0.21	.21-0.40	0.41-1.8
Calcium-Magnesium ratio	<1.3	13.1.7	1.8-3.1
Magnesium - Potassium ratio	<1.7	1.7-2.0	2.1-7.0

Source: SRDI Upazila Land and Soil Utilisation Guide.

Whilst no major soil constraints to agricultural utilisation 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 (both organic and inorganic) would appear to be required on most of the soils 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 and fodder availability for stall fed animals 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 would thus seem to indicate 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 Annex C and summarised in Section 2.3.3 of the Main Report.

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 encompassed a greater diversity of crops than at present.

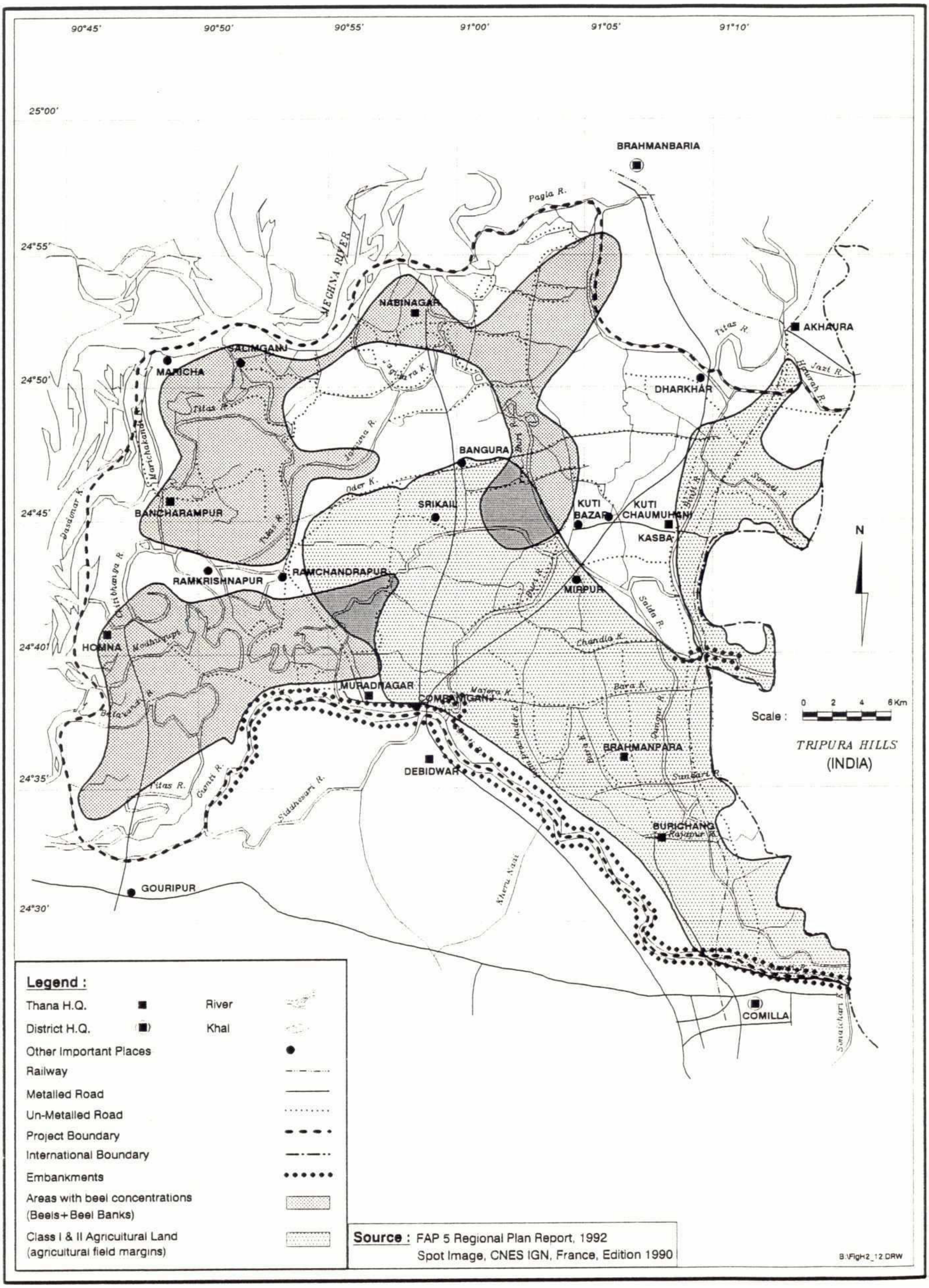
The main constraint to the expansion of irrigated agriculture appears to be the availability of water rather than soil conditions and there has recently been a significant up-take of groundwater irrigation, particularly in the south-east of the study area. However the chemical composition of irrigation water is important, as it many 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 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 and will require appropriate management.

H.2.2.9 Ecology

An ecological assessment of the study area is given in Annex D and summarised in Section 6.2 of the Main Report. The main ecological habitat zones for flora and fauna are shown in Figure H.2.12. There are significant aquatic habitats in perennial watercourses and particularly the western part of the study area. However the greatest diversity in fauna was found in the north eastern part of the study where there are both aquatic and terrestrial environments. Flora and fauna inventories were carried out for the study area and have been tabulated as Appendices to the Ecology Annex. In summary, the area has very high levels of flora and fauna and high bio-diversity, especially when compared to many other parts of Bangladesh. This would appear to be linked to the season flooding pattern of the area which creates a wide range of habitats. There is also considerable economic use made of these common good resources, especially flora which constitutes a naturally renewable resource for domestic fuel, building materials and medicinal uses.

Figure H.2.12

Ecology Habitat Zones (Flora and Fauna)



H.2.2.10 Flora

The main vegetation types are shown in Figure H.2.13 and details of the distribution of plant groups by sampling site are given in Annex D. In all, 85 terrestrial plan species were identified from 8 sampling sites spread across the study area. The greatest number and diversity of plant groups were found in the central part of the study area where habitats tend to be more variable and the intensity of agricultural use is lower than the less flooded lands of the south eastern part of the study area. The greatest use of these was for fuel (63 species) but there was considerable medicinal use of plant species, with over 55% of identified species being used in this way. Some 38% of species were used as timber and 35% as a source of food. In terms of aquatic flora, 51% of the nationally recorded species of planktonic algal genera were found in the study area. The aquatic flora forms the basis of the nutrient system for the rich fisheries of the area.

H.2.2.11 Fauna

Some 87 species of fauna (not including fish which are dealt with in section H.2.3.6 below) were recorded in the study area from 8 sampling sites with the north eastern part recording the highest levels but all other sites having at least 55 species. The number of mammals was low, reflecting the high human population densities in the area, but bird life was abundant and diverse although mainly confined to resident rather than migratory species and reported to be declining due to habitat loss and human predation. The Laye Indian Civet and Fishing Cat, both endangered species, were recorded in one site and Gangetic Dolphins, listed as internationally threatened were commonly found in the study area. The main agricultural pests reported were rats and these appear to be increasing as agriculture intensifies, land is drained and predator habitats diminish.

H.2.2.12 Seismic Activity

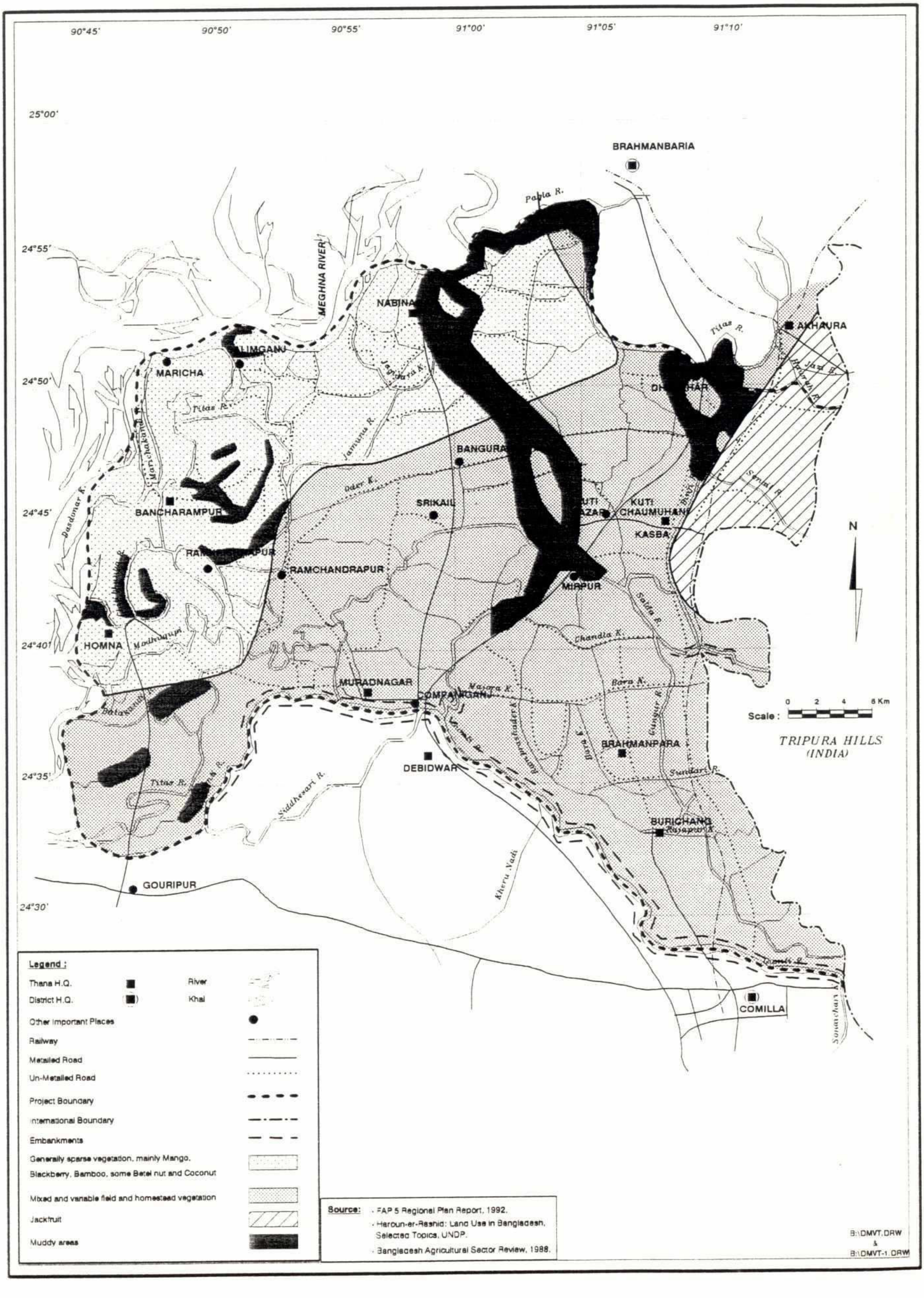
The study area lies in a medium level earthquake risk area, but there was a serious event in 1897 with its epicentre to the north. There was severe damage to embankments as liquefaction occurred and most masonry buildings were damaged, many of them badly. There were resulting changes in ground level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

H.2.2.13 Other Natural Hazards

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 the earliest of these 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

Figure H.2.13

Distribution of Main Vegetation Types



of Gumti 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.

The area has one of the higher tornado risks in the country and the last major one was in 1969 and caused 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 Kutcha houses in Daudkandi Thana being destroyed. Subsequent cyclones include 1965, 1970, 1985 and April 1991.

H.2.3 The Human Environment

H.2.3.1 Introduction

The levels of interaction between man and the natural environment are very high throughout Bangladesh as population densities are very high and the study area has some of the highest of these. There is a high level of use of natural resources and this can put pressure on the supply of these, especially those that are slow to naturally renew themselves. Any environmental assessment needs to take the levels of livelihood dependency on the natural environment into account and then judge what are the likely trends in these in a with and without intervention situation.

H.2.3.2 Population, Settlement and Land Tenure

The present Administration Boundaries for the study area are shown in Figure H.2.14 and these constitute the data collection units for most socio-economic parameters. They have been fixed for a considerable period of time and are based upon the Police Station Maps and BBS Small Area Atlas which are in turn based upon the 1919 survey maps reproduced in the Government Gazetteer. However the most recently available census data for the area dates from 1981 and is now badly out of date. The 1991 data is expected imminently but until this is made available to the study there must be considerable reservation attached to interpretation of the present situation in the area. The human population densities for 1981 are shown as a distribution map in Figure H.2.15 and range between 500/km2 up to 1750/km2. The map gives an indication of the likely spatial variation in the pattern but overall densities are likely to have increased in the last 10 years and there may have been significant movements of people from the rural areas into the larger towns, as has been found to be the case at Noakhali were 1991 data is available.

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

89

Figure H.2.14

Administrative Boundaries (District, Thana and Union)

Source: Gumti Phase II Feasibility Study 1st progress report

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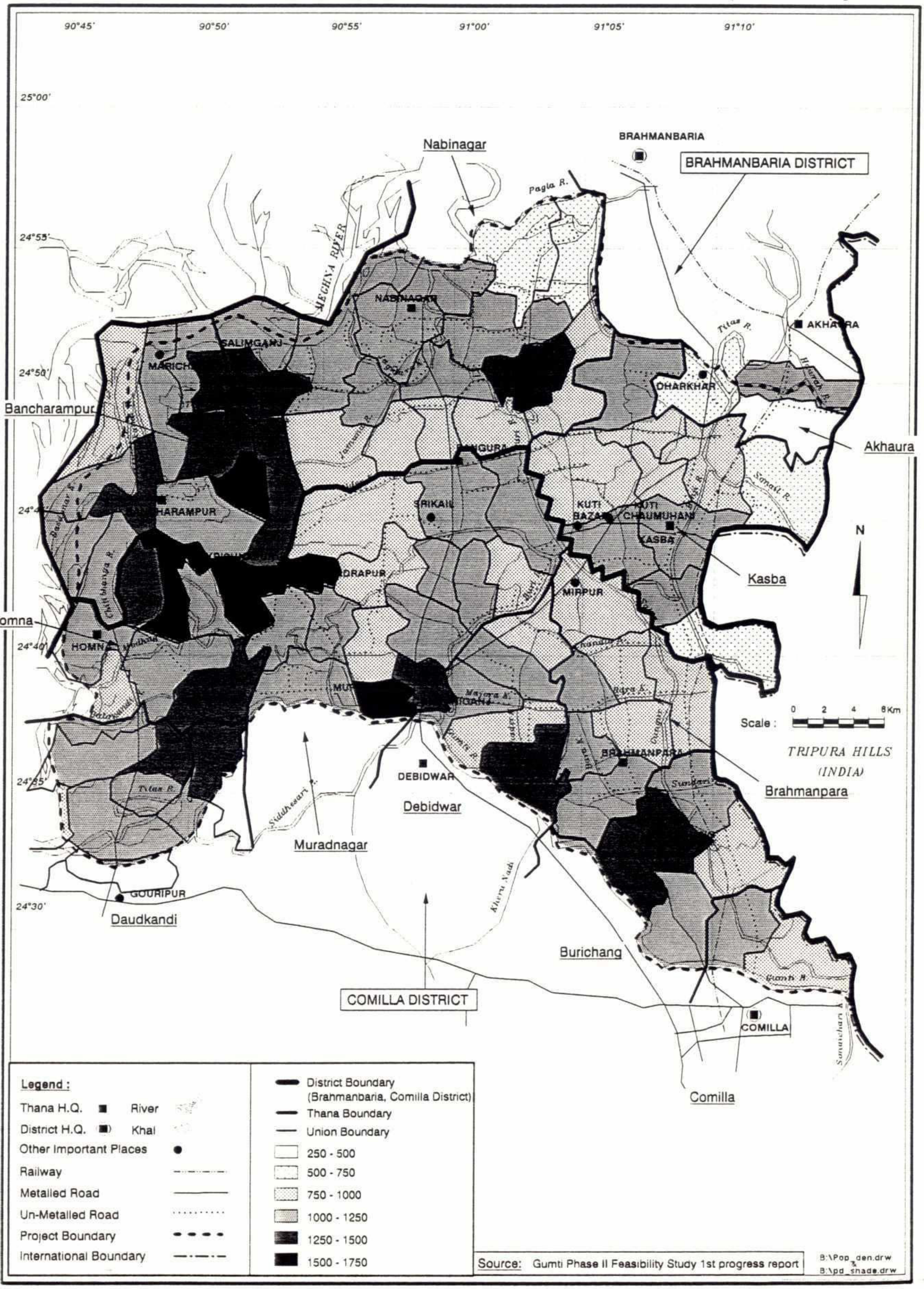
Figure H.2.15
Human Population Density 1981
Mean People/km² by Union



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/km2) and 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.

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 reclaimed for re-use. This is particularly the case in many parts of Bangladesh where sources of durable building materials are hard to find and also means that the number of sites constructed from such materials are in any case likely to be small, irrespective of the size and sophistication of past human settlement.

Despite this, there is evidence from inscribed pillars that there was known well organised human settlement within the area that now comprises Comilla District as early as the years 340BC to 380AD. 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 20km 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.

H.2.3.3 Household Economic Livelihood

As stated above, the latest full socio-economic data available for the area is the BBS census for 1981. A map showing the distribution pattern of the proportion of population landless (defined as below 0.02ha, normally enough for a homestead and no more) in 1981 is given in Figure H.2.16. Apart from the urban dominated areas there are higher levels of landlessness in the western and north central parts of the study area with maximum levels of 60%. However these are likely to have increased since 1981. The levels in the south eastern part of the study area (Planning Zone A) where the agricultural system is the most intensive are surprisingly the lowest at 19%. However more up to date data is required to investigate this further.

A distribution map of the proportion of the population with agriculture as their primary economic activity 1981 in given in Figure H.2.17. This illustrates the importance of agriculture in the eastern part of the study area, with the exception of the peri-urban area around Comilla. In the western part of the study area it is known that fishing is important as a primary and secondary occupation and this is summarised in Table H.2.4.

Figure H.2.16

Proportion of Population Landless 1981 (< 0.05 Acre)

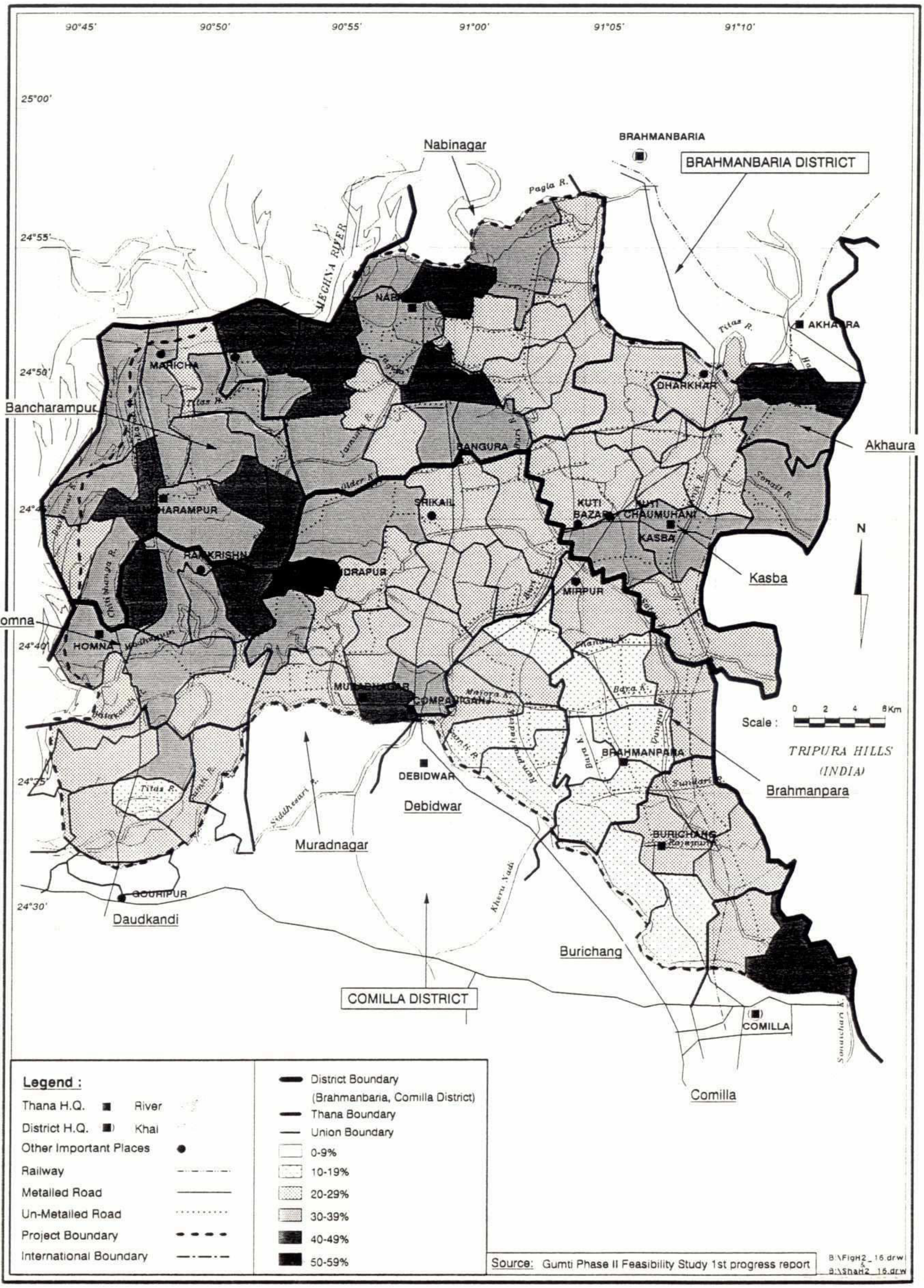


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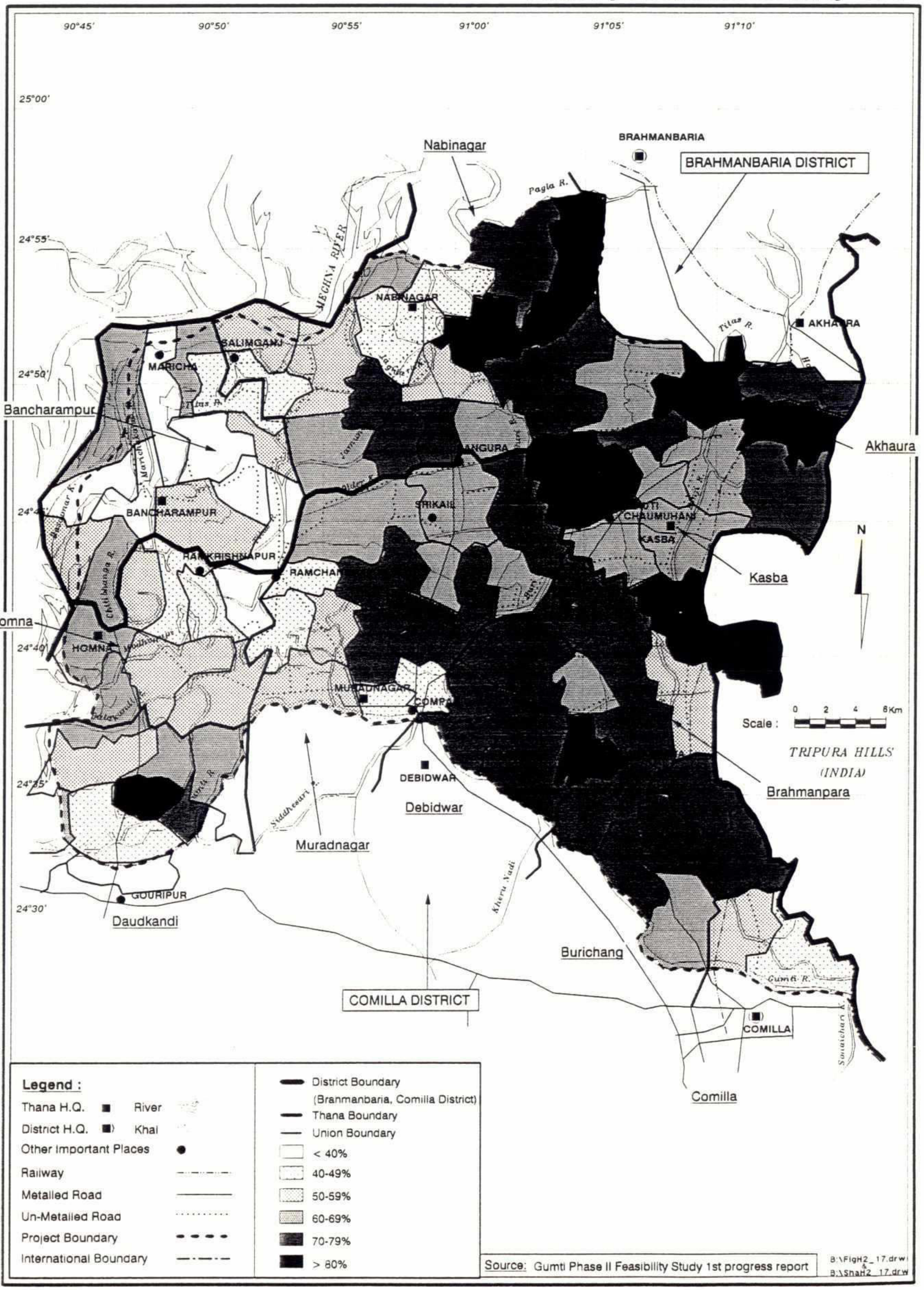
Figure H.2.17
Proportion of Population with Agriculture as Their Primary Economic Activity 1981



Source: Gumti Phase II Feasibility Study 1st progress report

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TABLEH.2.4

Number of Fishing Households in the Gumti Phase II Study Area

	Number of Fishing Households								
	Number of Households	Full - Time	%	Part - Time	%	Occasional	%	Total	%
Zone A	61,140	1,207	2	1,888	3	11,034	18	14,129	23
Zone B	53,193	2,173	4	3,374	6	19,807	37	25,354	47.7
Zone C	82,281	7,650	9	11,270	13	21,092	26	40,012	48.6
Zone D	96,653	5,428	6	18,363	18	63,876	66	87,667	90
Total	293,267	16,458	5.6	34,895	11.9	115,809	39.5	167,162	57

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

As an overall indicator of levels of development the spatial variation in 1981 literacy rates is given in Figure H.2.18. This again shows the more developed status of the eastern part of the study area with rates of 35% compared to 20% in the west, although again more up to date data is required to study this further.

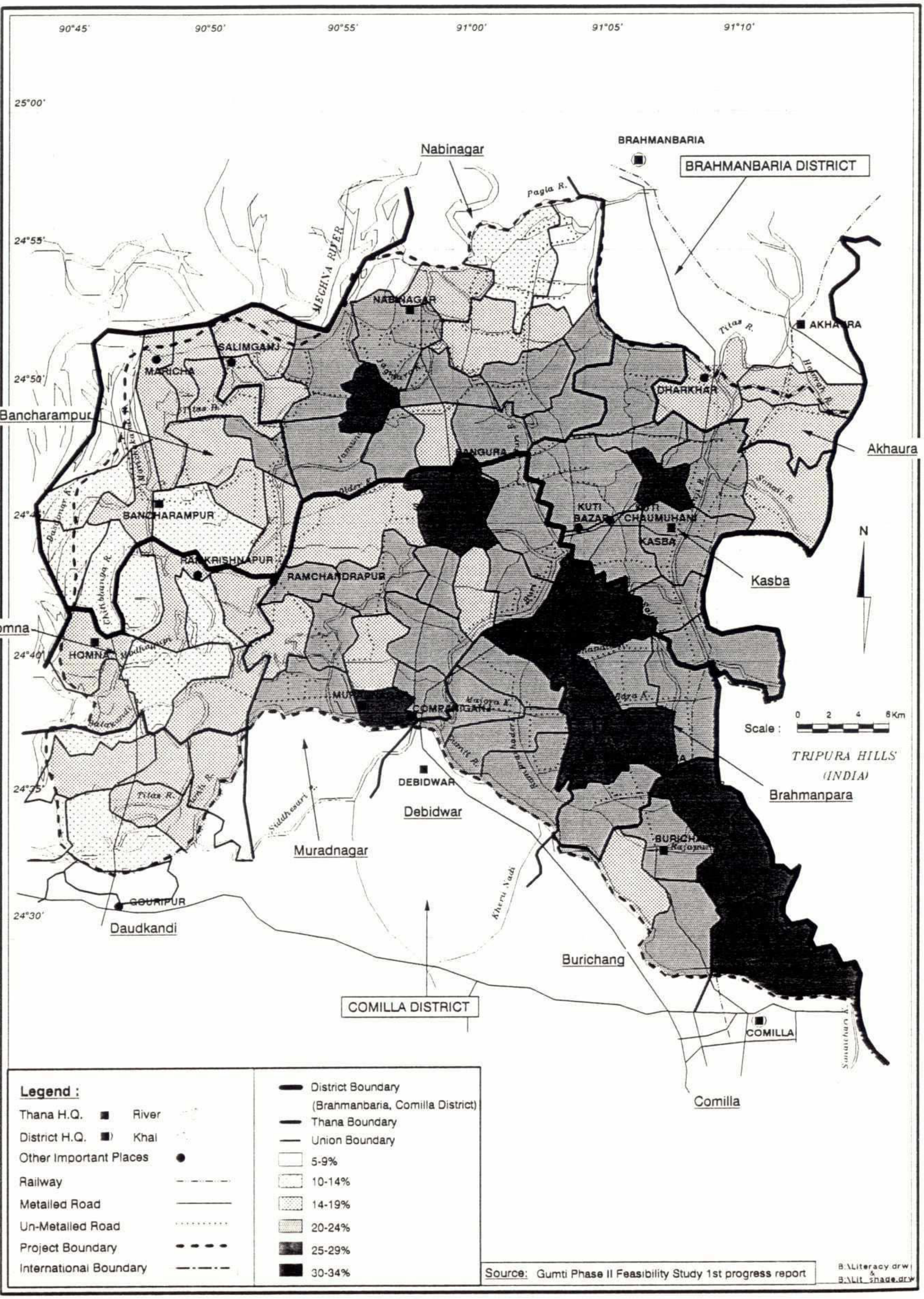
H.2.3.4 Common Resource Rights

There is widespread use of "common good" resources, particularly fish but also fuel wood and flora. However as agriculture intensifies common access to these and others, particularly grazing land, becomes more difficult. The promotion of irrigated agriculture will accelerate this process still further and it has implications for draught animal, fuelwood and animal protein availability.

H.2.3.5 Agricultural Land Use

It is impossible and not useful to attempt to map land-use in a formalised way for much of Bangladesh due to its complexity in both seasonal and spatial terms. Even attempts to do this using detailed SPOT multi-spectral satellite imagery down to 1:25 000 have failed to produce useable information and if anything have confused the situation still further. Instead a conceptual model is required which combines the agro-ecological zones (Figure H.2.4) with the simplified seasonal cropping calendar shown in Figure H.2.19.

Figure H.2.18
Literacy Rate 1981



Source: Gumti Phase II Feasibility Study 1st progress report

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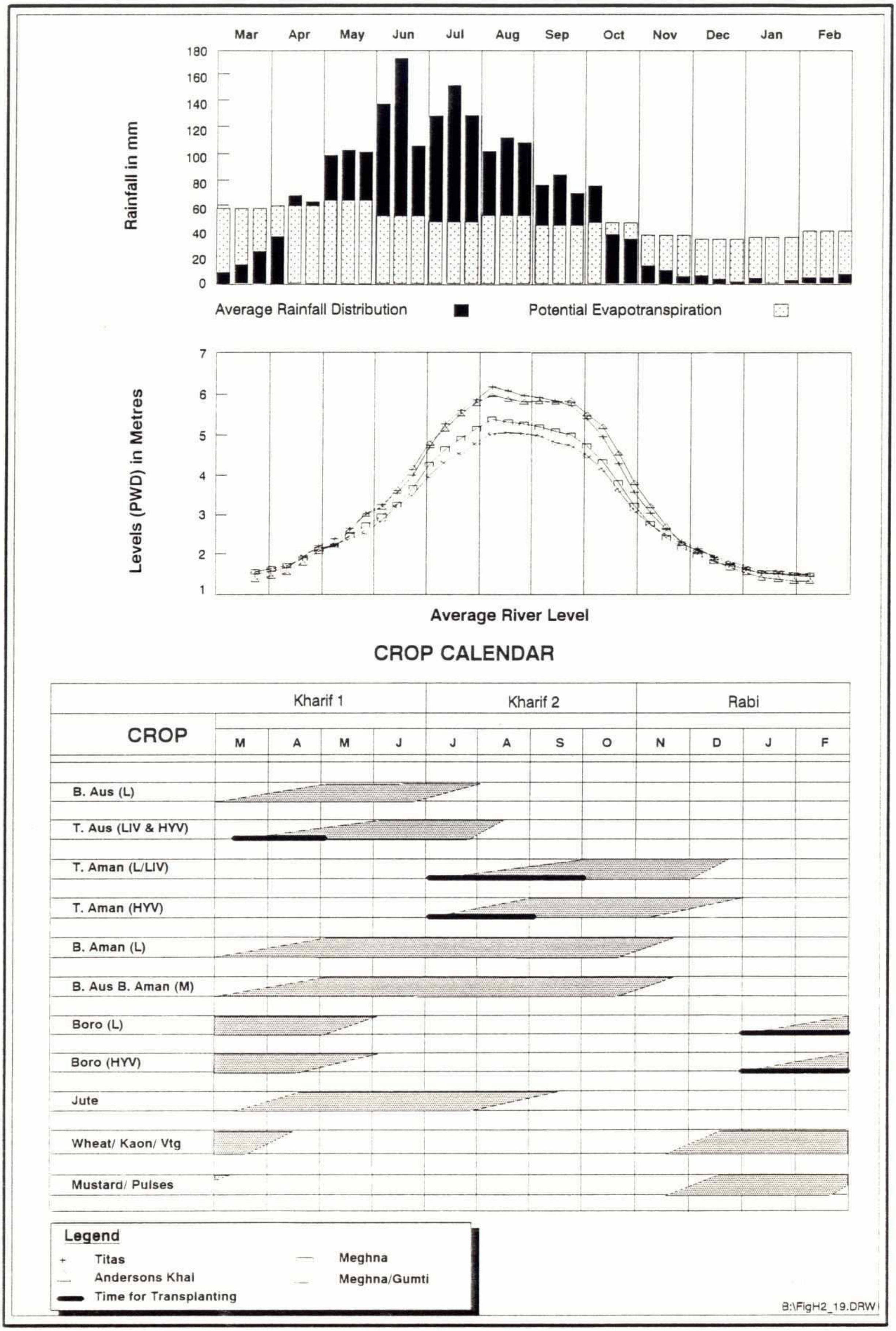
Figure H.2.19
Simplified Cropping Calendar



H.2.3 6 Fisheries

The level of fishing activity in the study area is very high indeed, being one of the most productive areas in the country with an estimated annual catch of 26 800tonnes. The fish systems are shown in Figure H.2.20 and illustrate the wide spatial variation in these. The degree of household dependence on fishing is shown by Planning Zone in Table H.2.4. This shows that 66% of households are directly dependent upon fishing to some degree in the west where as this falls to 18% in the eastern part of the study area. More details concerning the fisheries system are given in Annex F.

H.2.3.7 Forestry and Fuelwood

The use of vegetation for fuelwood has already been mentioned as part of the ecological studies and vegetation distribution is mapped in Figure H.2.13. There would appear to be very little large scale commercial use of forestry resources in the area and there are no designated forestry areas or reserves. Due to the fact that much of the study area is inundated by water for up to three months a year this is not surprising. There is however great use made of homestead vegetation both as fuel and construction material and this is readily available to most households even in flood times.

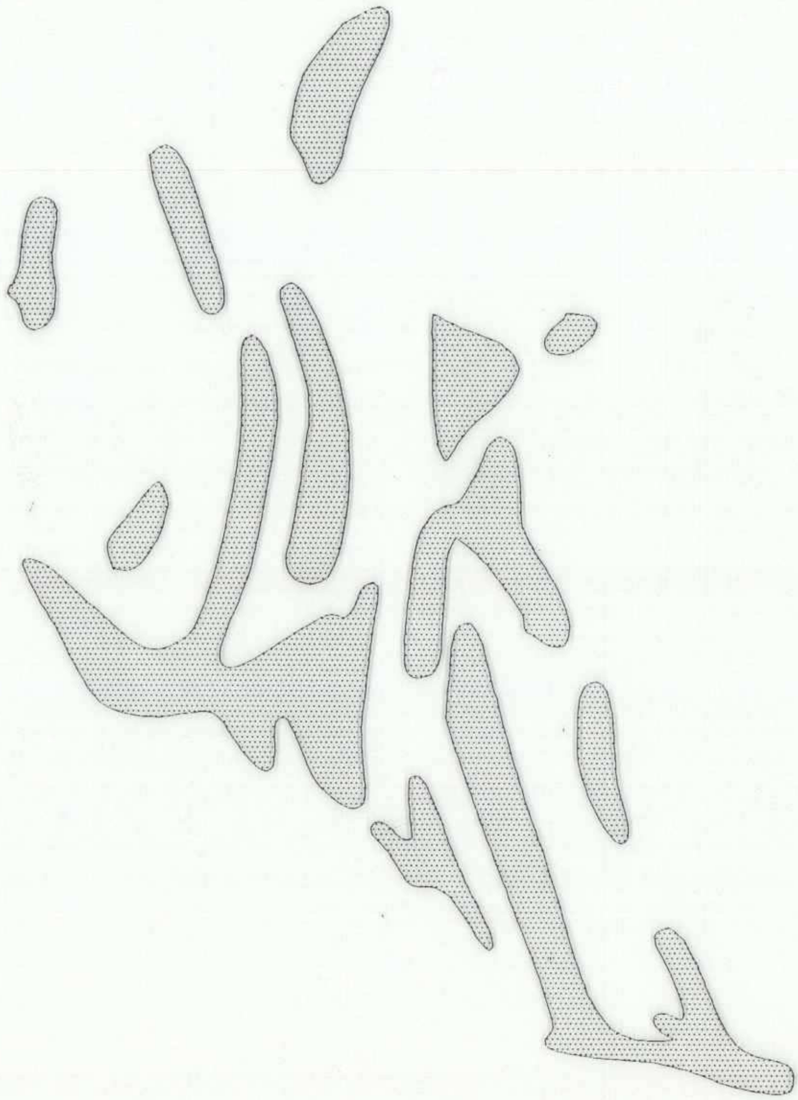
H.2.3.8 Livestock

Of most concern is the requirement for draught animals for agriculture. This is related to their cost and the availability of grazing land and fodder for stall fed animals. There would appear to be a lack of animals for such purposes and the situation is likely to get more difficult as agriculture intensifies resulting in there being less common grazing land being available, demand for animal power increasing and a possible reduction in fodder availability if short stem rice varieties displace long stem ones. There is however an increasing trend to use power tillers and whilst these may raise issues concerning agricultural sustainability (animal power is inherently sustainable, whereas fossil fuelled machines require the use of external and non replaceable fuel source) they would seem to be a pragmatic solution to a serious constraint to agricultural production.

H.2.3.9 Off-Farm Activities

There would appear to be significant non-farm economic activities in the urban areas and also in the rural areas where there are concentrations of specialised economic activities. A notable example of this is weaving in the western part of the study area. The urban informal sectors are apparent in the very south eastern part of the study area and also in the small to medium sized towns in the area.

Figure H.2.20b
Pond Concentrations



Legend :

Pond Concentrations

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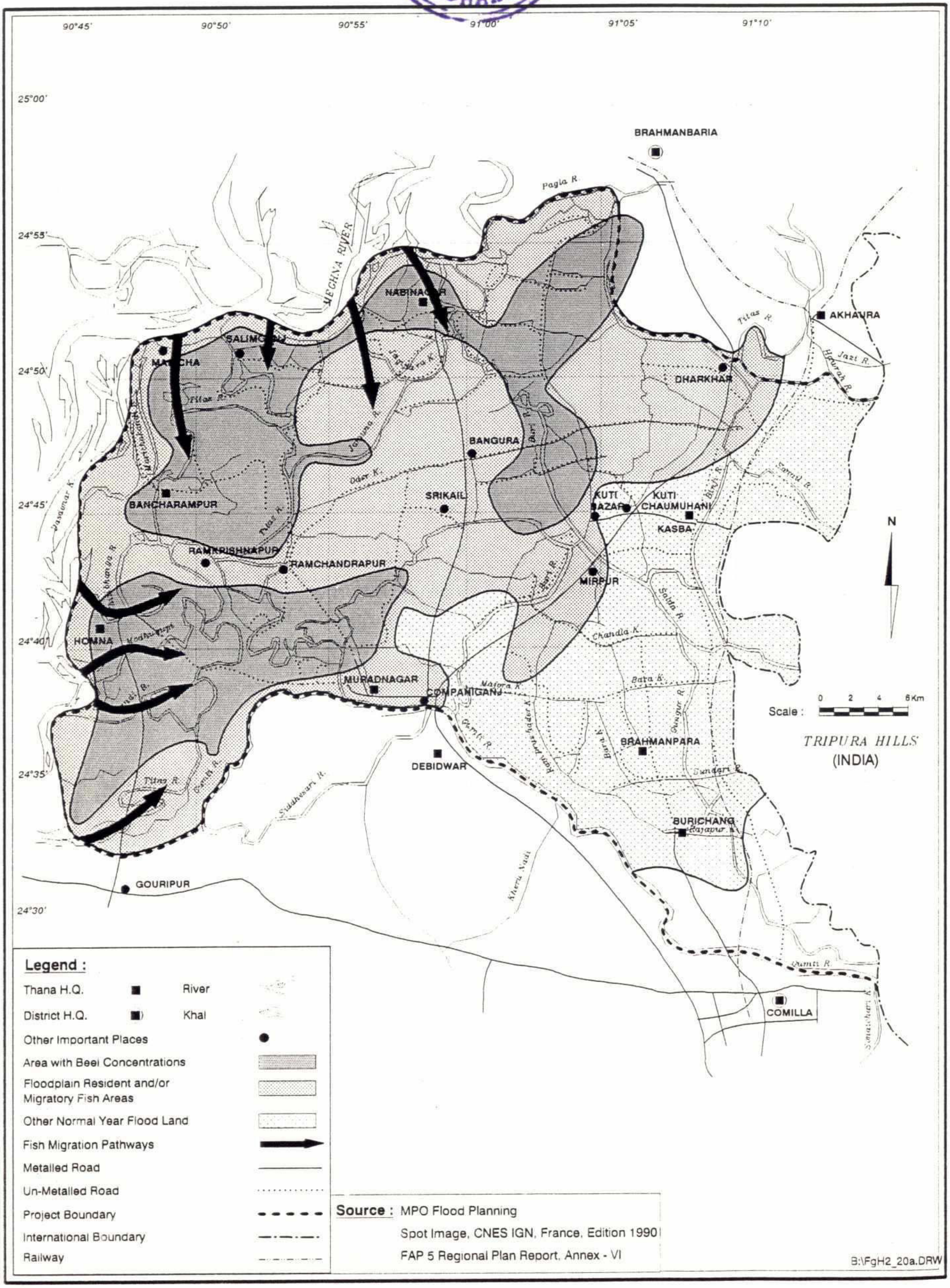
Figure H.2.20a

Fish Systems



H.2.3.10 Industry

The main industrial activities for the area lie just outside it in Comilla and have little influence on the area as waste disposal for this appears to be confined to the town or within the embanked Gumti River. There are agro-processing operations, such as rice mills, within the study area but these do not appear to be as widespread as in other parts of Bangladesh, possibly because the communications system appears to be better.

H.2.3.11 Drinking Water

The 1981 BBS data indicating the proportion and spatial distribution of households having access to potable water is shown in Figure H.2.21. This has been confirmed through the public 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 (the 1991 data is not available for Gumti which is a major shortcoming in all the socio-economic analysis for the study) in the Noakhali north area indicate that although the 1981 provision levels were low, there were very significant improvements in the following ten years. 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 Annex C there are serious problems 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 2.3.3 of the Main Report and Annex C.

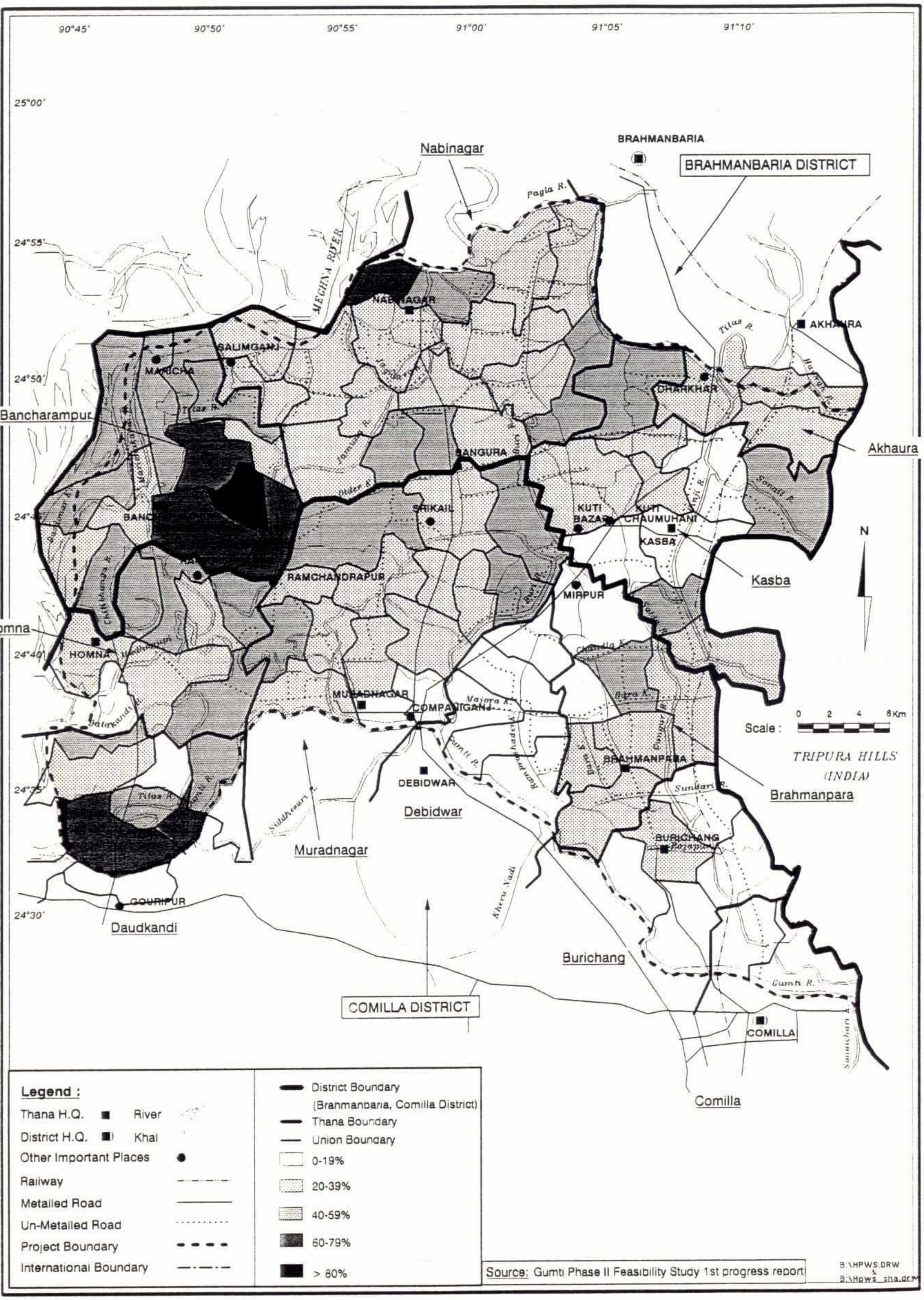
H.2.3.12 Human Health and Nutrition

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 this Annex. The findings of the study were that there are serious problems with waterborne disease in the area with diarrhoeal diseases being a problem in the eastern part of the study area and malaria in the western half. The incidence figures for these by zone are shown in Figures H.2.22 and H.2.23 respectively.

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 what Dhal was consumed in the area was brought for cash and very little of it is actually grown in the study area.

Figure H.2.21

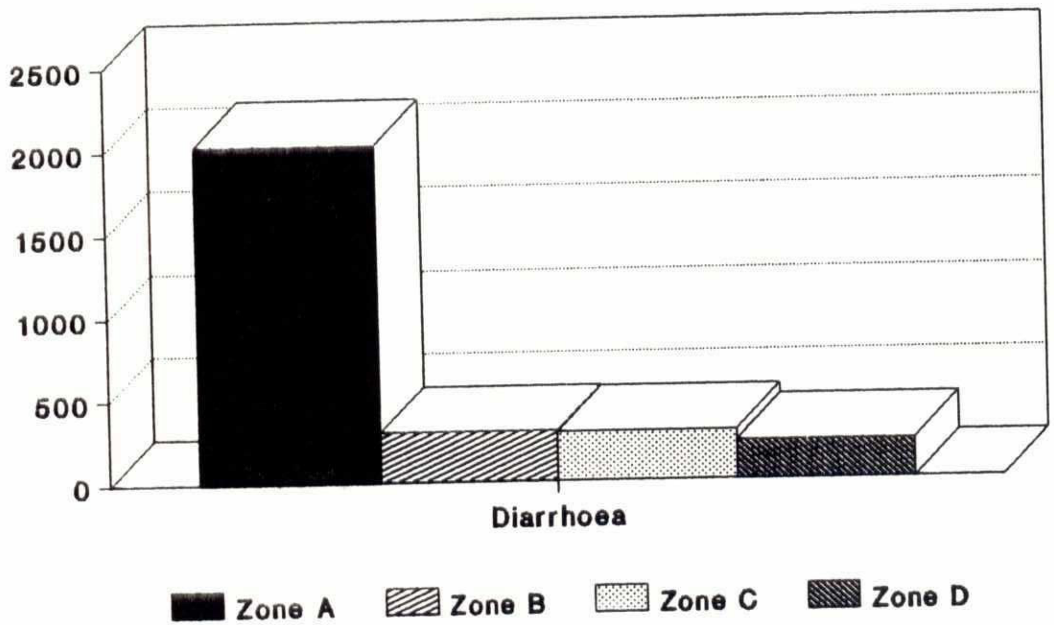
Households with no Potable Water Supply 1981



Source: Gumti Phase II Feasibility Study 1st progress report

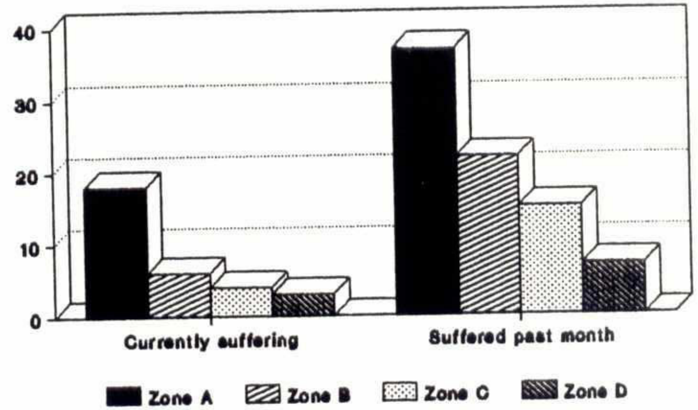
Prevalence of Diarrhoea

Number of cases for 1991
(Estimates based on zone population)



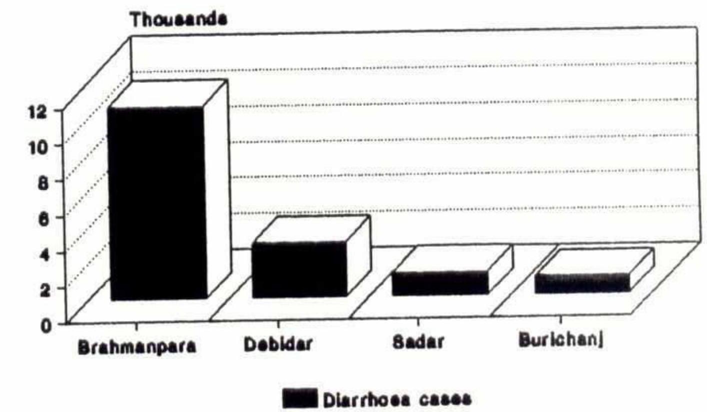
IEDCR source

Prevalence of Diarrhoea
Currently and during past month



Field survey

Diarrhoea during 1990
Thana wise reported cases from zone A



Civil Surgeon, Comilla

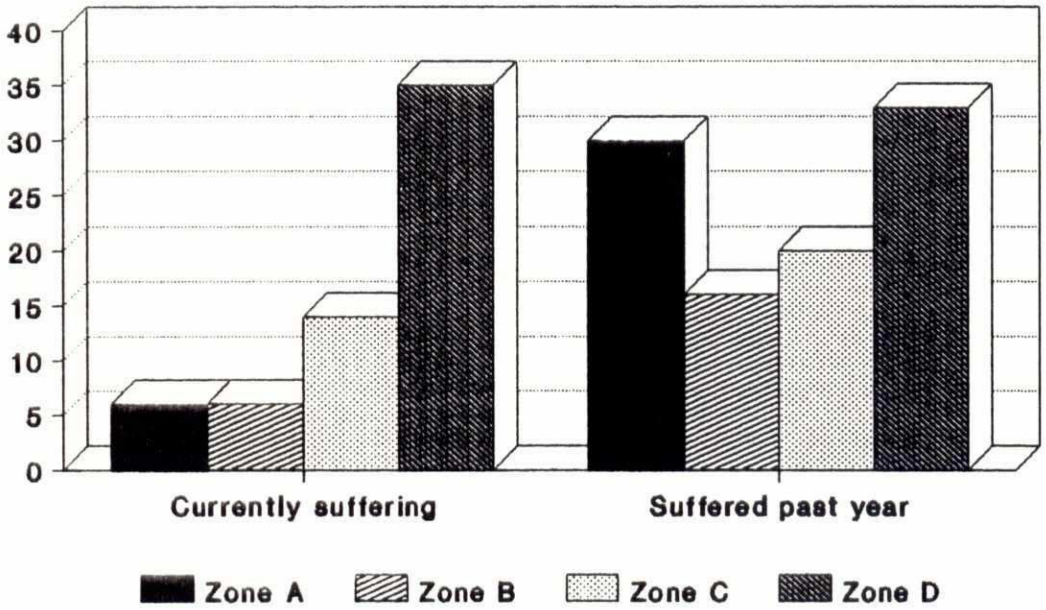
Figure H.2.22

50

Prevalence of Malaria

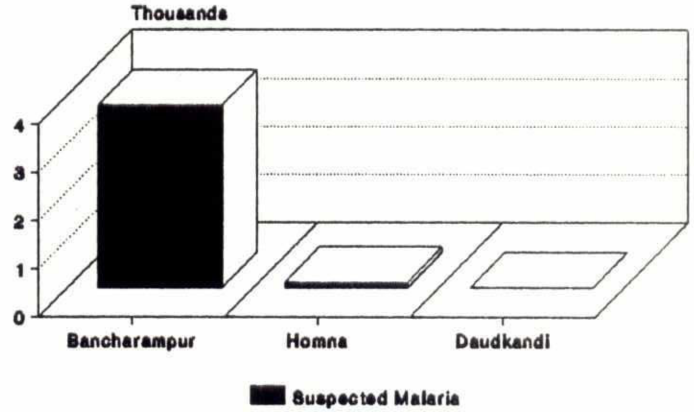
Figure H.2.23

Prevalence of Malaria
Currently and during past Year



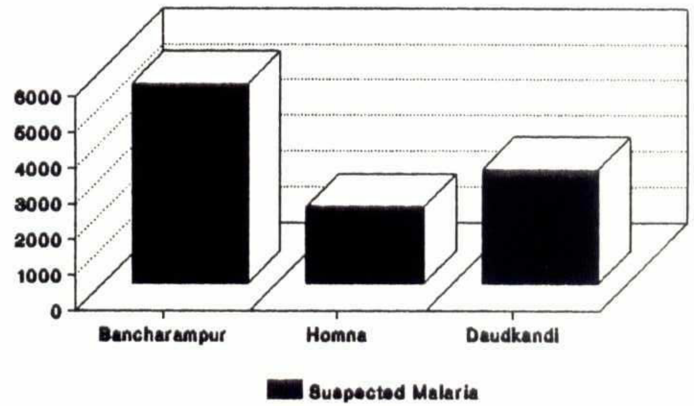
Field survey

Suspected Malaria During 1990
Thana wise reported cases from zone D



Civil Surgeon, Comilla

Suspected Malaria During 1991
Thana wise reported cases from zone D



IEDCR Source

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.

H.2.3.13 Access and Transport Infrastructure

The situation with regard to transport infrastructure has been given in Section 7.2 of the Main Report and is highly variable, both spatially and seasonally. In general road communications in the area are surprisingly good, especially when compared to other parts of Bangladesh. There is also an extensive on-going programme of improving these. The road network is on embankments and this has implications for the passage of flood water through the area. The waterborne navigation system is extensive but there was sufficient time only to use the data on large traffic (shown summarised in Table H.2.5), where as the impact issues are likely to require most consideration of localised, small scale movement.

H.2.3.14 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.

TABLE H.2.5

1990 Report Water Traffic Survey Results

Period		March to April			September to October			
Station		Mahismari Batakandi	Radhanagar Homna	Kanikara Buri Nadi	Kanikara Buri Nadi	Mahishmari Batakandi	Salimganj Titas	Homna
1	Nr of Vessels per day each day	14	25	52	34	12	53	26
2	Nr of service launches per day each way	3	13	0	0	3	35	12
3	Nr of Goyna * per day each way	0	8	0	0	0	0	12
4	Nr. of Passengers each way per day	236	1742	663	815	120	779	1516
5	Nr. of Passengers on peak days per day each way	373	1849	800	880	212	965	1755
6	Goods in Tonnes per day each way	38.6	98.7	81.2	55.3	5.6	32.8	105.9
7	Max Draft	2.44 m	1.52 m	2.44 m	3.05 m	2.13 m	1.20 m	1.52 m
8	Largest size (beam) of Vessel	5.18 m (beam)	6.09 (beam)	4.27 m (beam)	4.57 m (beam)	4.87 m (beam)	4.87 m (beam)	6.09 m (beam)
9	Nr of largest size plying per day each way **	3	13	-	-	3	-	12

* A Goyna is a kind of contry vessel that carries passengers over long distances.It is generally powered by a small diesel engine with a locally-made propeller fitted to the shaft.

** The BIWT Masterplan specifies representative vessels as follows:

Passenger launch carrying 250 pessengers or less - L < = 29.44 m,B < = 6.5 m,D < = 1.22 m

Cargo launch carrying 150 tons and less - L < = 27.00 m,B < = 6.7 m,D < = 2.25 m

- 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.

H.2.3.15 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.

H.2.4 External Factors and the Regional Context

The national and regional context of the study are shown in Figures H.1.1 and H.1.2 respectively. The major issues that are likely to influence water and land development possibilities in the study area centre around possible upstream constraints and downstream constraints to development that already exist and if any proposed upstream or downstream development is likely to pre-empt or invalidate intervention possibilities in the study area. In addition consideration needs to be made of any interventions proposed for the study area will directly or indirectly effect existing and proposed development possibilities in both upstream and downstream areas. There is at present considerable uncertainty as to the nature of these issues and all that can be done at this stage to highlight possible factors that need to be taken into account when drawing up development possibilities for the study area.

H.2.4.1 Upstream Constraints

The most likely upstream constraints to development will be any created by interventions as part of the FAP 6 North East Regional Study work and also any development on rivers in India, specifically any dams or abstraction for irrigation. At present very little is known as to the likely nature of these and it will be difficult to give indications as to specific problems and issues that are likely to arise which could influence the appropriateness of proposed interventions in the Gumti Phase II area. If anything any dams on the Indian rivers would be likely to attenuate peak flows and depending upon the way that the dams are operated this could be beneficial. However abstraction of water for irrigation from any perennial rivers during the dry season could result in lack of water for existing downstream users.

H.2.4.2 Adjacent Floodplains and Chars

There has been great concern voiced as to the likely effects of water management interventions on those areas immediately adjacent to them. Specifically the proposals for embanking parts of the Jamuna River have been shown by the flood modelling outputs of FAP 25 to increase the flooding in unprotected areas where the present flooding situation is already worse. However the similar data for the stretch of the Meghna River adjacent to the Gumti Phase II study area indicates that if the Meghna River were to be embanked then water levels in the unprotected area during a peak flood like 1988 would actually be lower than in an unprotected situation.This was demonstrated in the FAP 25 report of February 1993.The reason for this is that the proportion of local inflow into the Meghna is far greater than the other large rivers in Bangladesh and thus construction embankments in the Gumti area will actually cause increased duration of local flooding as has been shown in the study hydraulic modelling outputs. This in itself would seem to question the validity of rain river embankment construction in the area, irrespective of other dis-benefits and the costs incurred. In addition the nature of the unprotectable land in the Meghna is very different indeed than the Jamuna (there are on-going studies at FAP 16 looking at this) being far more permanent and subject to the sudden changes in erosion and accretion. They are essentially relic Char lands from the time when the Brahmaputra flowed through the area prior to its change of course in the latter part of the 18th Century. For these reasons it would appear that the likely impacts on the adjacent land will not be very great as the area floods annually and in fact this constitutes a major constraint water management possibilities in the study area.

H.2.4.3 Downstream Constraints

The major downstream constraint to water management in the study are is the water level in the main Meghna river during the monsoon season. This determines the flow of water through the study area for much of the time and only when this is released does the area drain, and then relatively rapidly. The only way of overcoming this constraint is to rely upon embankments and pumped drainage with sufficient capacity to cope with local rainfall and also the fact that at times natural drainage will be restricted by the provision of embankments. The costs and benefits of doing this have been assessed as part of Strategy D and E and on a small scale level for Intervention 4 in Strategy C. It does however pose a major hydraulic engineering dilemma for the area.

H.3 DEVELOPMENT PROPOSALS AND IMPACT ASSESSMENT METHODOLOGY

H.3.1 Development Options and Strategies

H.3.1.1 Selection of Broad Development 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) (related to the Terms of Reference Item 4) with A being a without intervention option and B being basic flood response, were drawn up for comparative consideration. Strategy (c) was a mixed strategy which took into consideration the study areas great diversity, looking at different interventions in the various planning zones (shown in Figure H.3.1) based upon proposed interventions suggested in the public participation exercise. Strategies (d) and (e) were those suggested in the 1990 Feasibility Study and illustrated in Figures H.3.2 and H.3.3.

This first stage impact analysis thus considered a comparative assessment of these five possibilities on a 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 minimised for a particular broad strategy.

A brief description of each strategy is given below and a ranking matrix (Figure H.3.4) has been constructed giving a comparison of the likely outcome of each strategy for the major identified environmental issues. 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 public participation exercise. For those issues which are considered to have serious negative impacts an indication is given as to the possibilities for mitigation of these (i.e. if it is technically feasible) and also some idea of the likely costs of this.

H.3.1.2 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.

Figure H.3.1
Planning Zones (A, B, C & D)

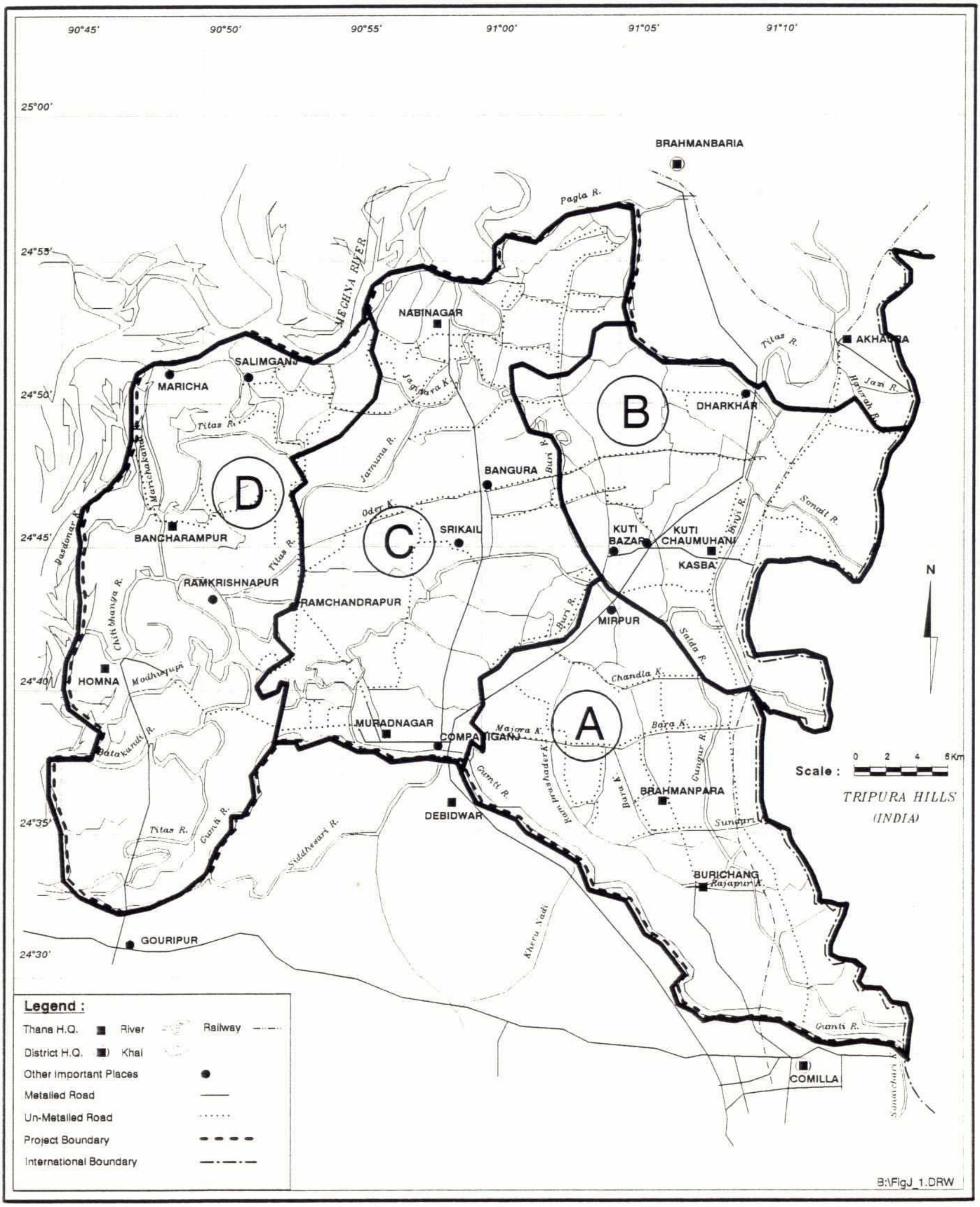


Figure H.3.2
Map of Strategy (d)

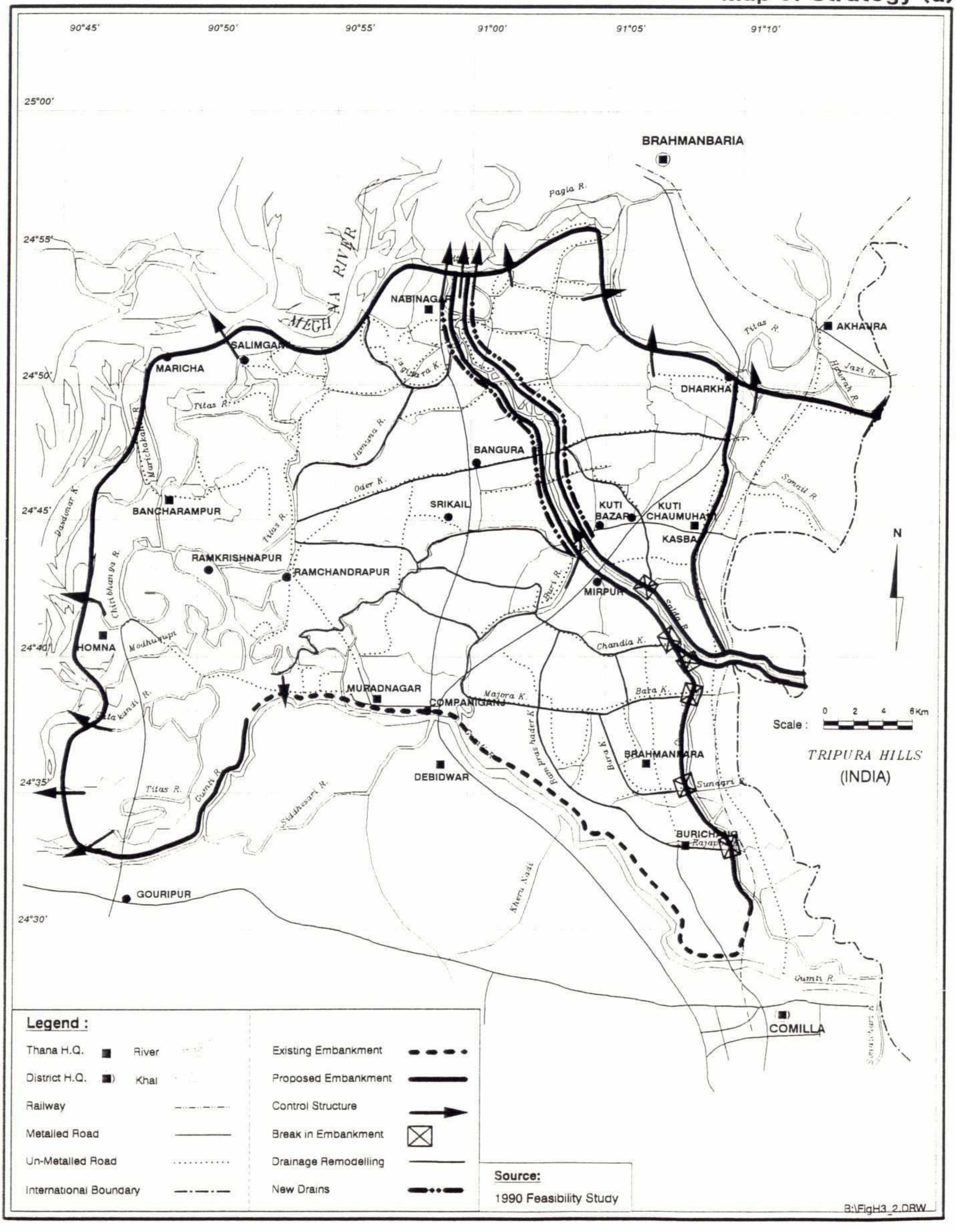
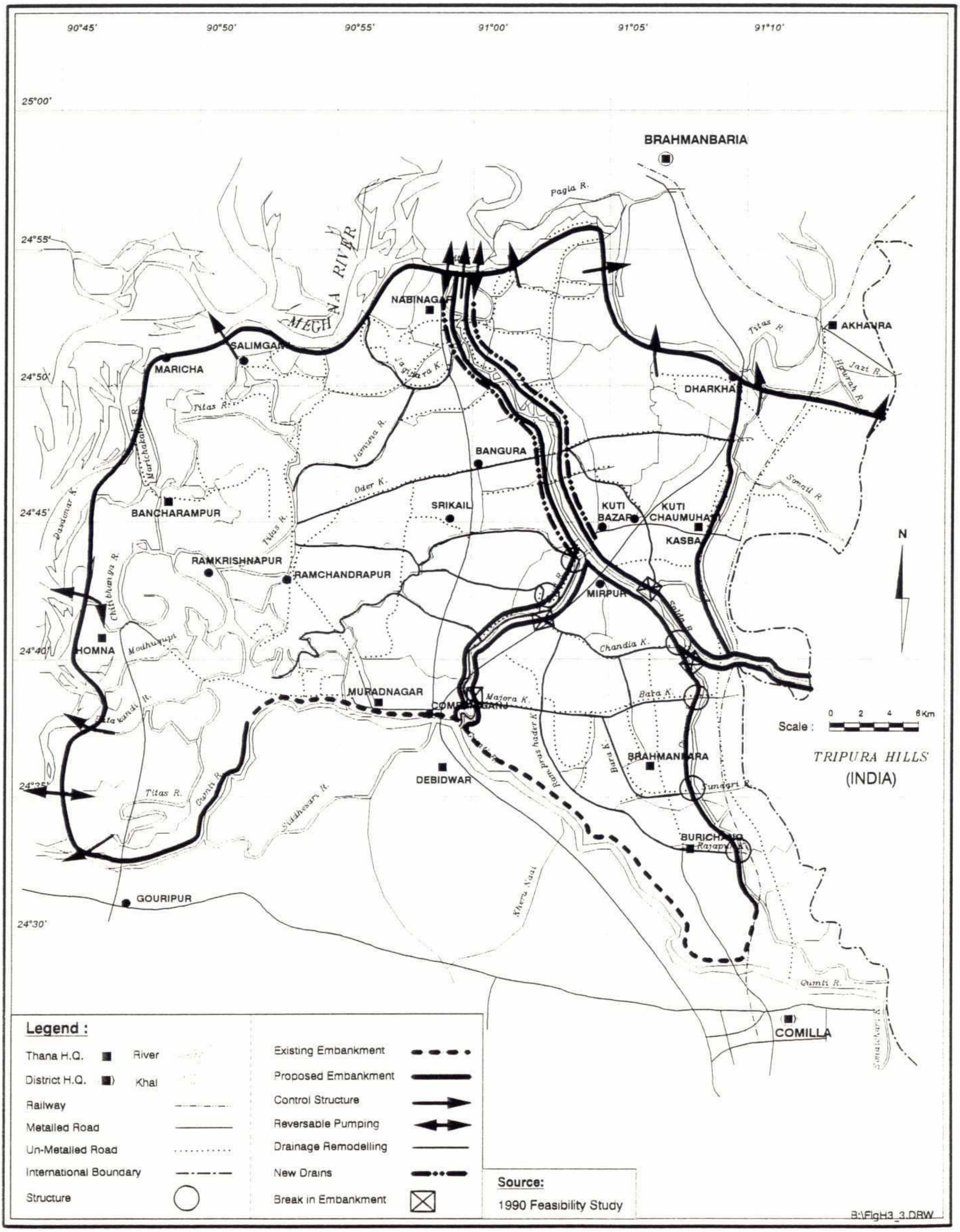


Figure H.3.3
Map of Strategy (e)



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 trends. 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 FAP's 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.

Strategy (c) - A Mixed Programme of Controlled Flooding and Small Scale Polderisation 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 in those areas where groundwater use is constrained by water quality.

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Strategy (d) - Full Polderisation, Drainage and Groundwater Irrigation

This strategy, shown in Figure H.3.2 and suggested in the 1990 Feasibility Study for the area, prevents 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 Polderisation, Drainage and Surface Water Irrigation

This strategy, which was also suggested in the 1990 feasibility study for the area, is shown in Figure H.3.3. 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 attuned to local peoples 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.

H.3.2 Comparative Assessment of Broad Strategies

H.3.2.1 Preliminary Impact Assessment Matrix

The comparative impact assessment matrix for these strategies is given in Figure H.3.4. 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, where as 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

Gumti Phase II Feasibility Study
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		
Ecology										
Flora			0	-1	-1	-1	-2	-2		
Fauna			0	-1	-1	-1	-2	-2		
Fish	*		0	-1	-1	-2	-6	-6	N	
Seismic Activity (*1)										

Figure H.3.4

THE STUDY AREA HUMAN ENVIRONMENT	P	LP	NOW	(a)	(b)	(c)	(d)	(e)	MP	MC
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										
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		
Road			0	0	+1	+2	+2	+2		
Archaeology and Cultural Sites			0	0	0	0	-1	-1		

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Figure H.3.4

EXTERNAL FACTORS	P	LP	NOW	(a)	(b)	(c)	(d)	(e)	MP	MC
-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		
-UPSTREAM IMPACTS										
Peak Back-Up Flooding	*		0	?	?	?	?	?		

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 = Option A (Without Project)
B = Option B (Flood Proofing)
C = Option C (Controlled Flooding)
D = Option D (Polder + GW Irrigation)
E = Option 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.

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 the 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 areas in 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 by it. There is a requirement for development 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 embankments would seem to be an example of what can happen if this is not carried out. It would appear that these have caused immediate and severe fish losses as they were designed without the benefit of an understanding of the flooding patterns in the area. They would seem to be 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 on the hydrology of the area and have rational crest heights and structure opening locations and sizes. Khal deepening would seem to offer potential benefits to both agriculture, through dry season water provision (although having little effect on drainage) and possibly 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 programmes 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 and above 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 tackle 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 careful in identifying the intervention types and areas.

Strategy (d) - Polderisation, 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 flood plain is not greatly diminished, the fisheries system is likely to suffer overall losses of some 34% (see Table H.4.2) 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 which raises 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 polderisation 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 polderisation 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) - Polderisation, 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 worsens. However these have been sized for providing irrigation benefits in the dry season and are inadequate for drainage water volumes. All these dis-benefits would seem to negate against its consideration irrespective of the economic analysis which gives it a poor rate of return.

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 Strategy (d) or (e)

3.2.2 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 be 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 and regional, along with how these are to be interpreted at sub-regional level. There needs to be a clear statement of policy aims and objectives and also a multi-disciplinary decision making framework set up to appraise this. A reasonably firm outline is required as to the nature of, along with a commitment to setting up, the necessary integrated multi-disciplinary institutional structure 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) if became apparent that smaller units than this would need to be considered if an appropriate strategy that minimised 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 in the selection process for detailed study.

H.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 public participation programme. These interventions are shown in Figures H.3.5 and H.3.6 combined together, the latter being those that were included in the with project hydraulic modelling. It should be noted that some of these interventions cross planning zone boundaries and 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 deepening of the Buri/Salda River system justified in its own right but considered a conditional requirement of intervention 1B.

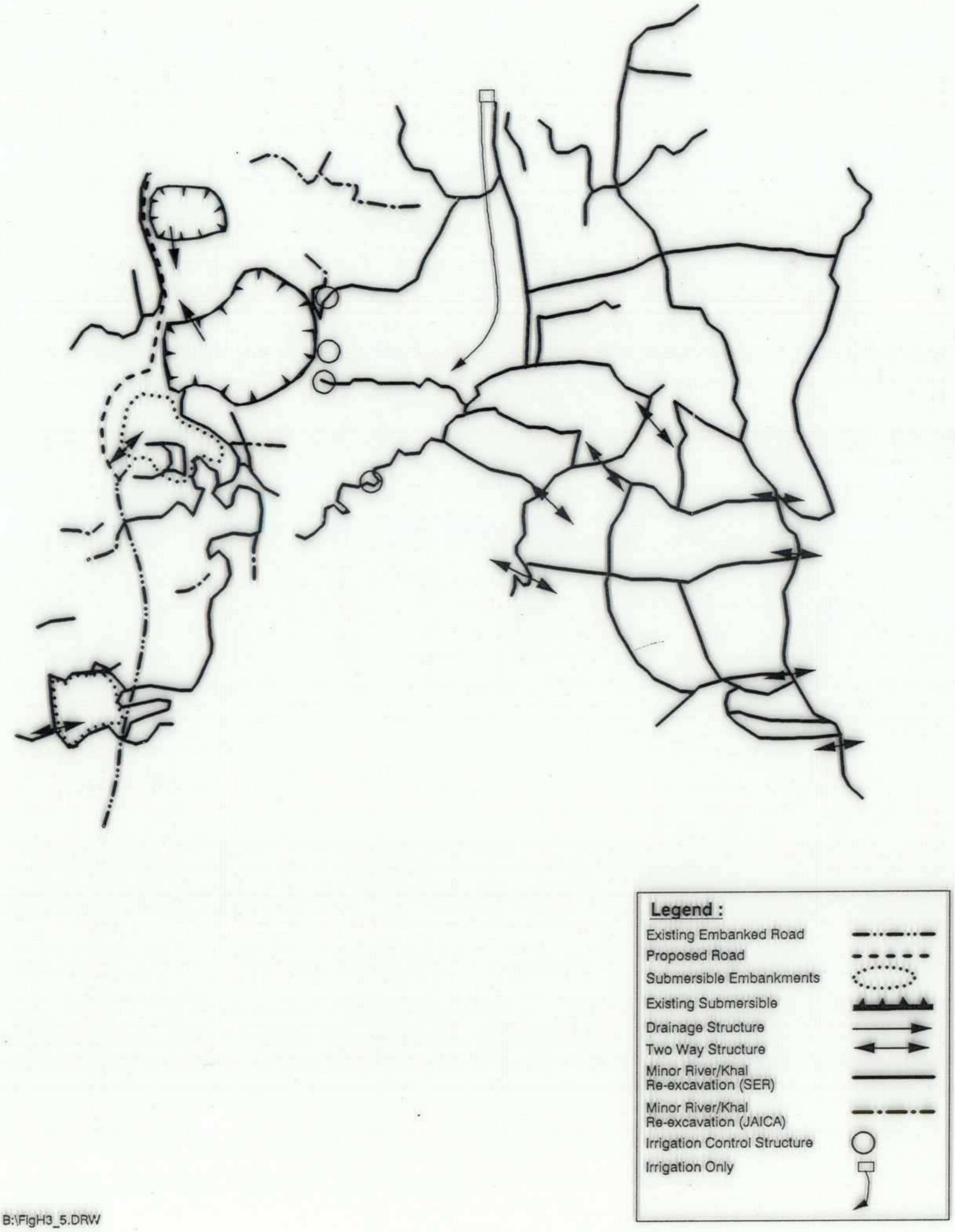
1B Controlled flooding of the western part of Zone A. This allows limited managed in-flow into the area via 4 gated structures in the north west which uses an existing road embankment as one side of the protected area and four in the east placed within a new embankment on the east bank of the Salda river.

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 the settlement of 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 season 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.

Figure H.3.5
Un-Modelled Intervensions



B:\FigH3_5.DRW

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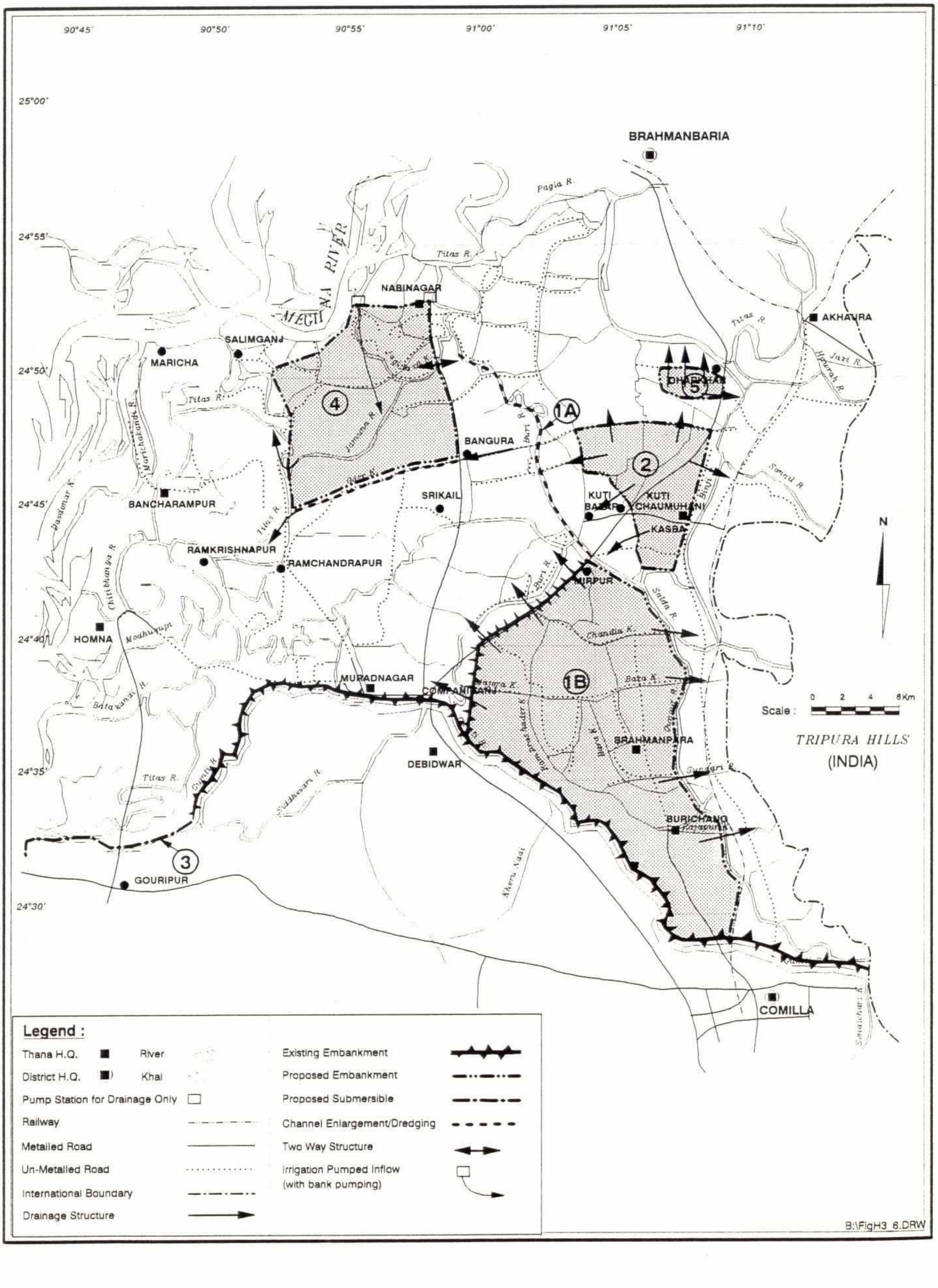
Figure H.3.6
Modelled Detailed Intervensions



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 northwest part of the study area.

7 A major Khal deepening programme throughout the study area. In Zone D 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.

H.3.4 Hydraulic Modelling of Detailed Interventions

The proposed detailed interventions that have been incorporated into the hydraulic model are shown in Figure H.3.6. The effects on the rising and falling flood pattern for a 1 in 2 "normal" year, if all seven interventions were constructed, are shown in Figure H.3.7 and H.3.8 respectively. The differentials in flood extents for the with and without detailed interventions by each 10 day period are shown in Figures H.3.9 to H.3.17. The broad conclusion of this analysis is that intervention 3 is effective in preventing the early flooding due to downstream impacts of previous upstream Gumti River embanking. Intervention 1B is partially effective in delaying flash flooding into the protected part of Zone A and throughout a normal year reduces the mean extent of flooding in the protected area by some 30%. The induced flooding effects of this on surrounding land are nearly all mitigated for by intervention 1A. Intervention 2, the medium sized polder, results in an internal mean annual flood plain area reduction of 40% and the intervention 4 pumped polder is very effective indeed with the floodplain remaining flooded to a depth of less than 0.30m all the year. According to the model, intervention 5 has no effect on the extent of 0.30m 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 outside the intervention areas as a result of the implementation of the considered developments. Overall the changes in flood plain extent as a result of the interventions are surprisingly small. For a 1 in 5 "high normal" flood there is even less difference, in other words the intervention is less effective in drawing down the limit of the extent of 0.30m depth flooding.

H.3.5 Detailed Impact Assessment Matrix

The environmental rating matrix for each of the seven interventions is shown in Figure H.3.18. 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 H.4.

Figure H.3.7
Rising 1 in 2 Year Flood Pattern with Interventions

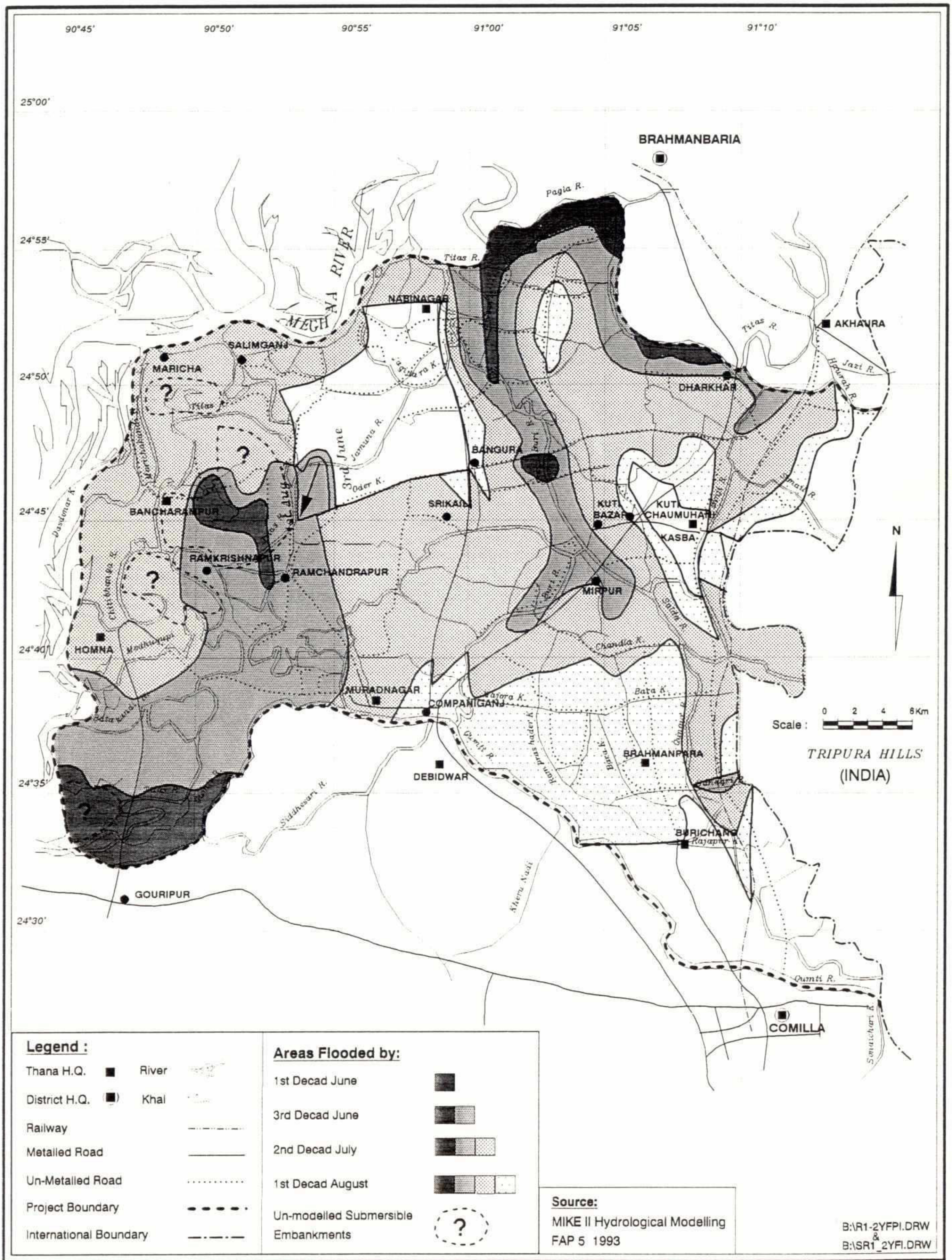


Figure H.3.8
Falling 1 in 2 Year Flood Pattern with Interventions

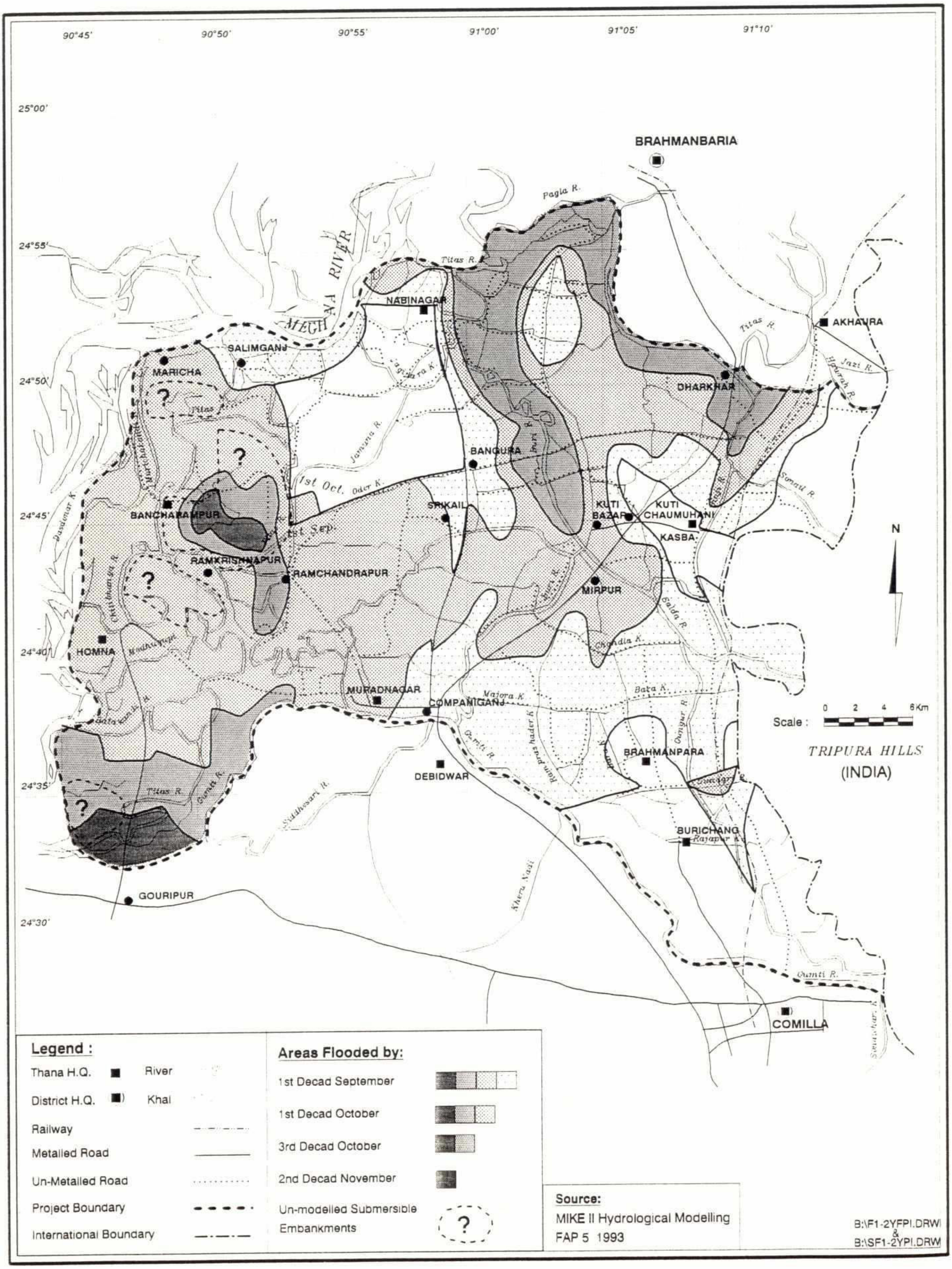
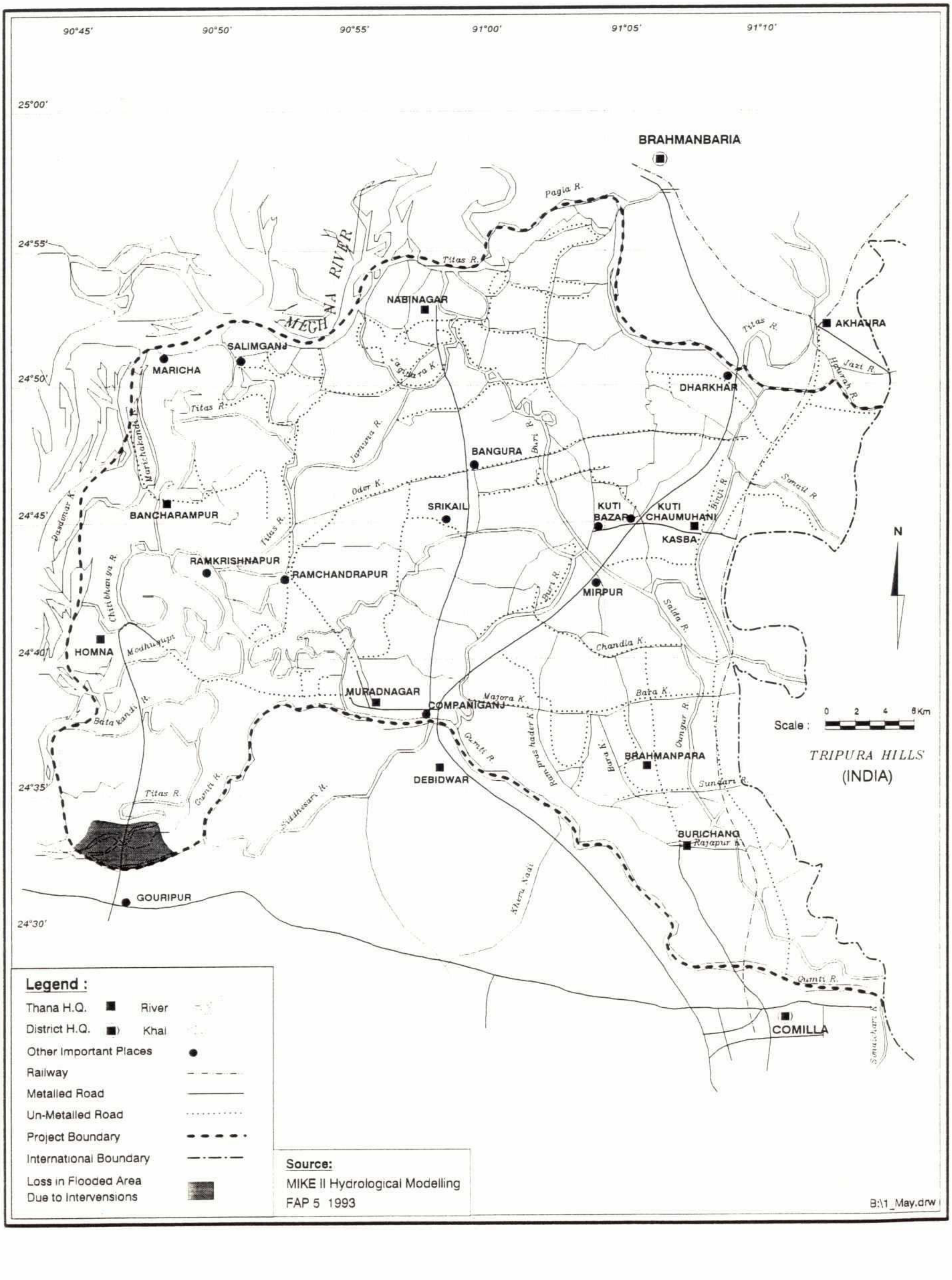


Figure H.3.9

Differential Flood Modelling by Decad
1st Decad in May



Source:
MIKE II Hydrological Modelling
FAP 5 1993

Figure H.3.10
Differential Flood Modelling by Decad
1st Decad in June

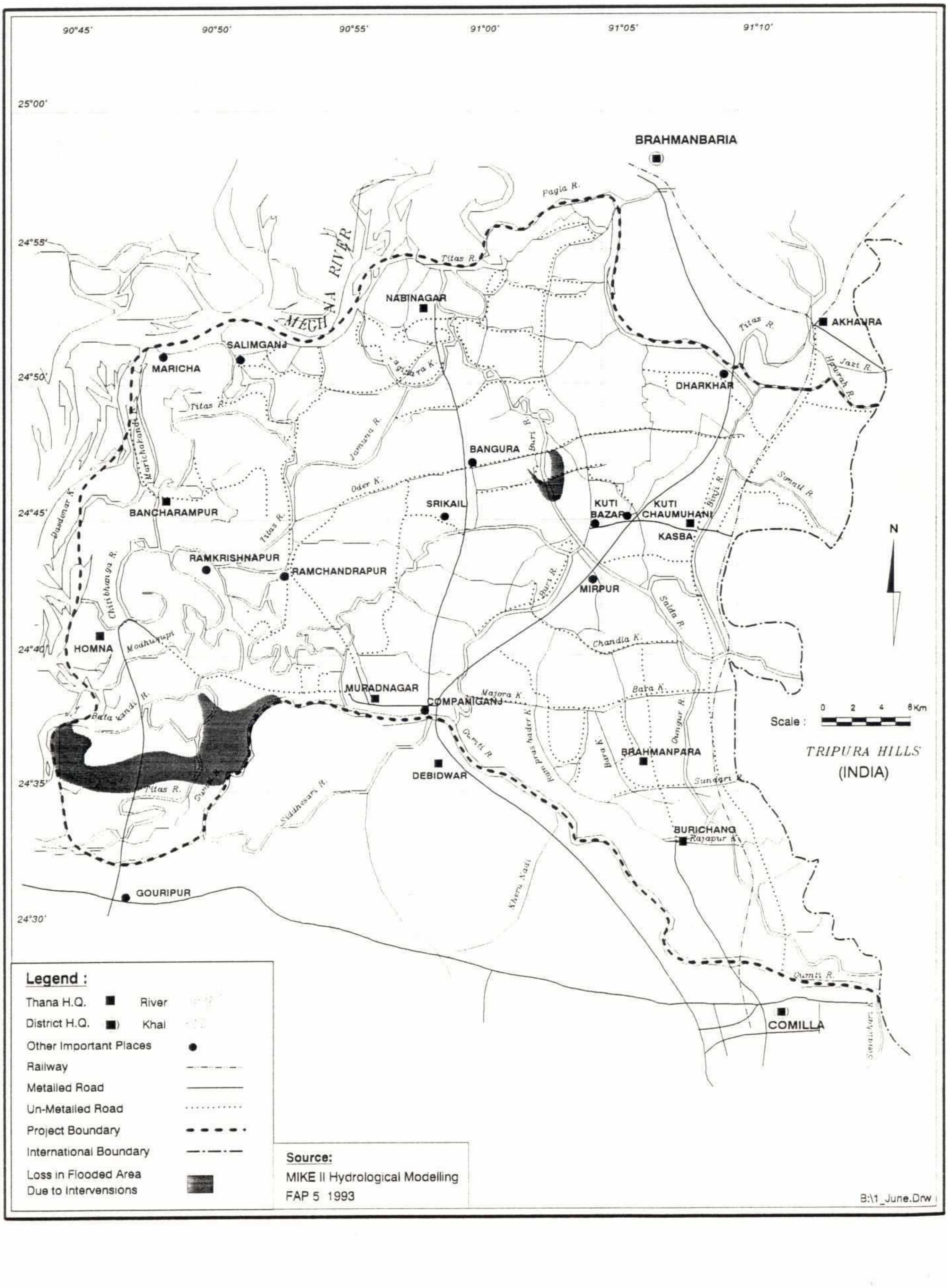


Figure H.3.11
Differential Flood Modelling by Decad
3rd Decad in June

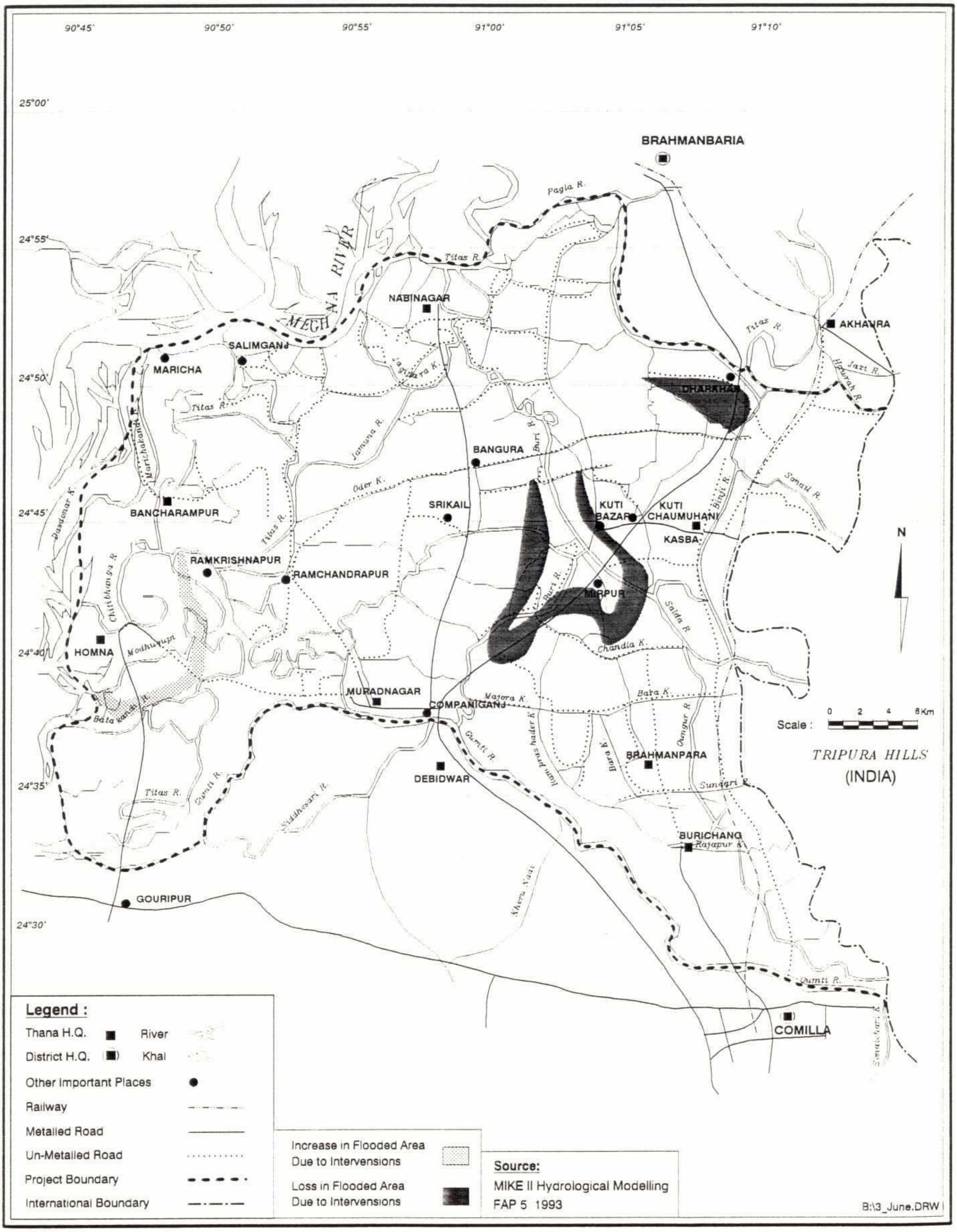


Figure H.3.12
Differential Flood Modelling by Decad
2nd Decad in July

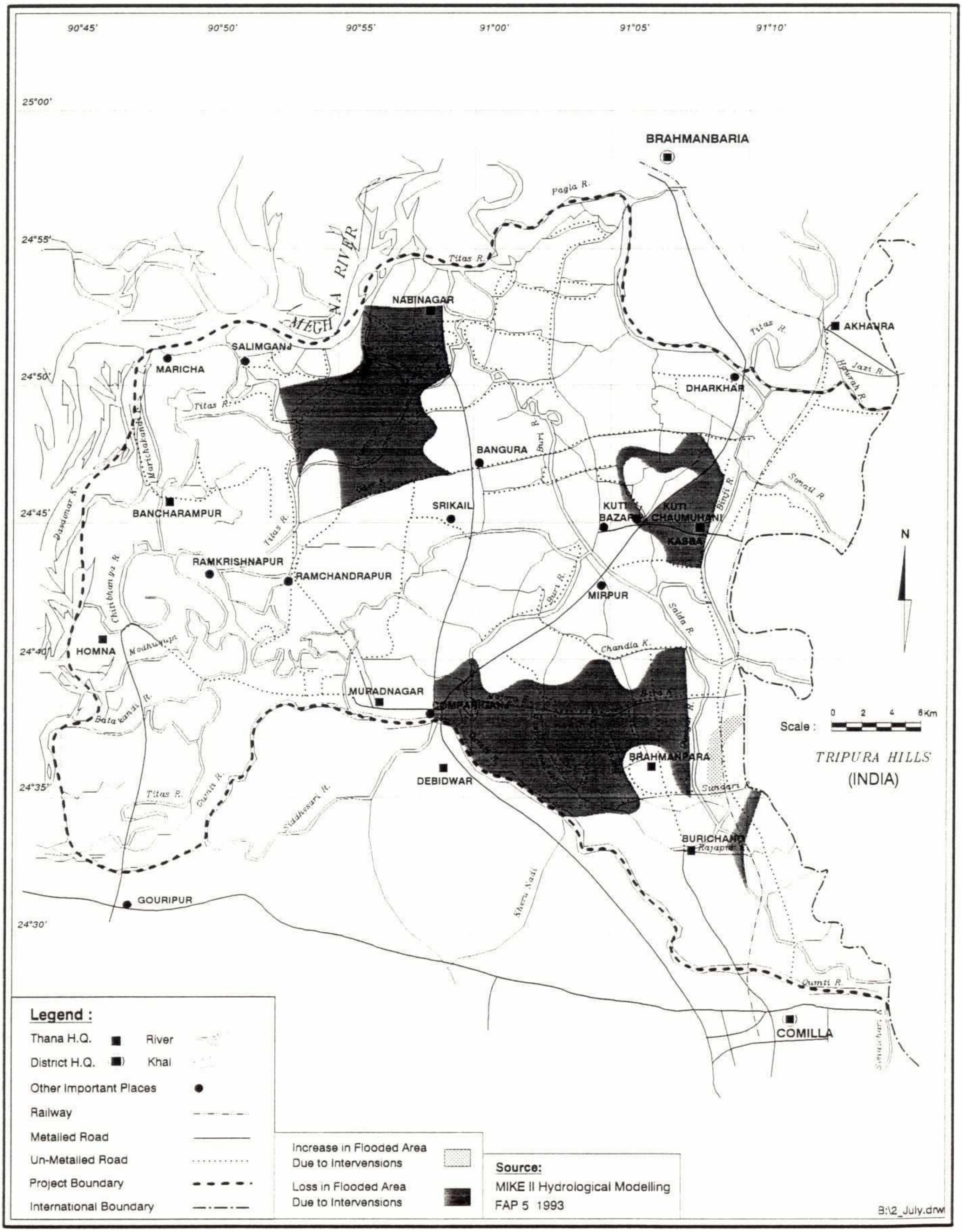


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Figure H.3.13
Differential Flood Modelling by Decad
1st Decad in August

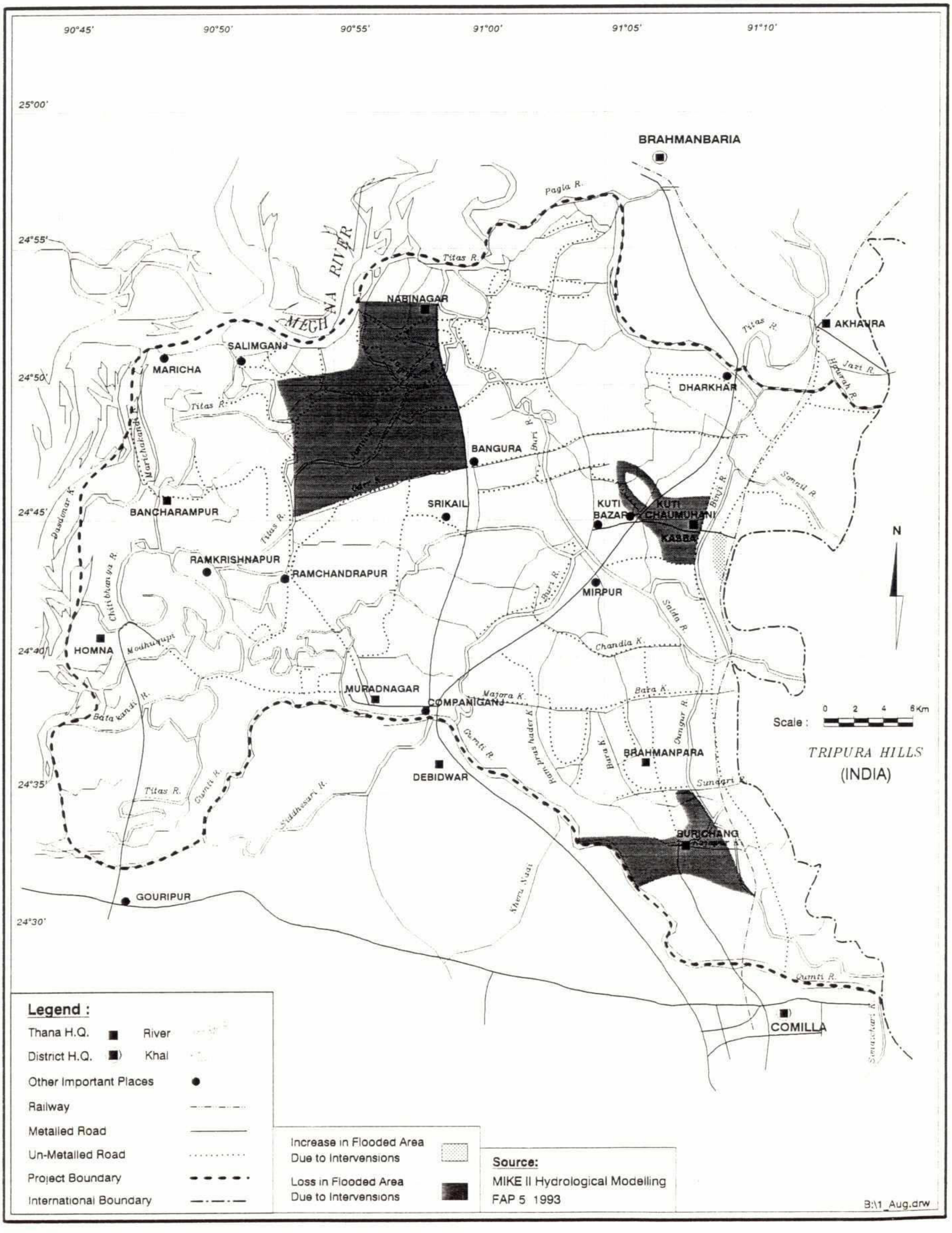

Figure H.3.14

Differential Flood Modelling by Decad
1st Decad in September

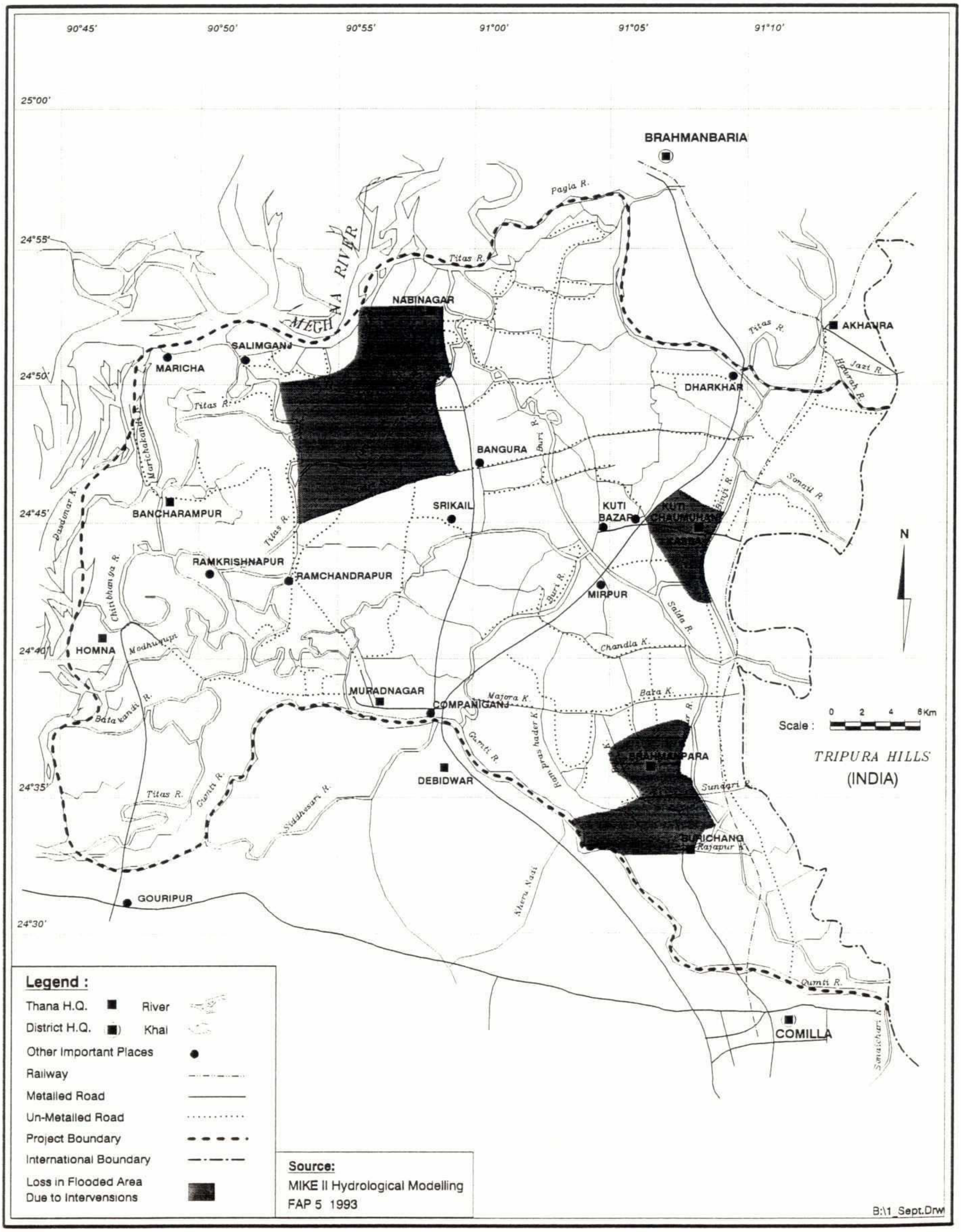

Figure H.3.15
Differential Flood Modelling by Decad
1st Decad in October

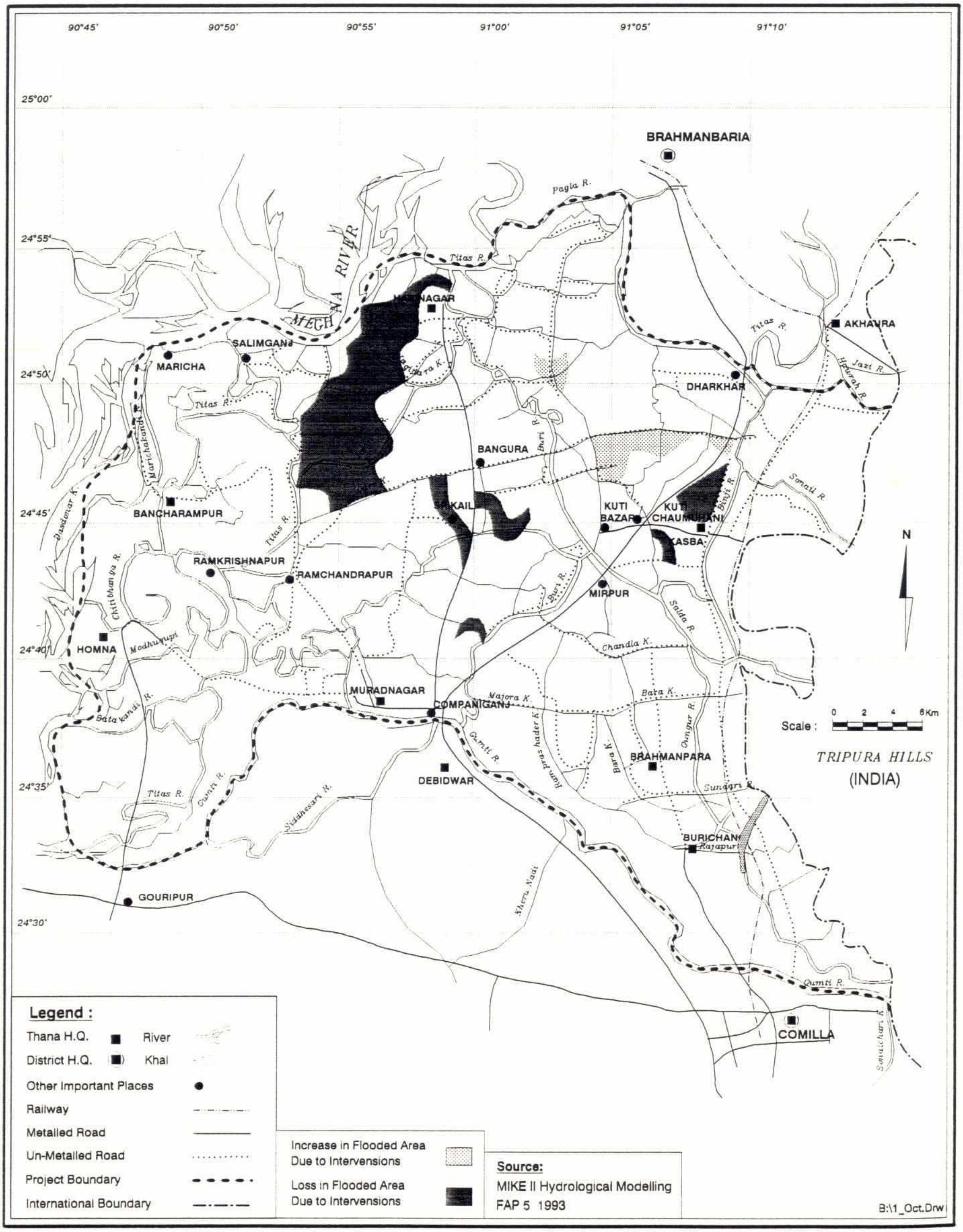

Figure H.3.16

Differential Flood Modelling by Decad
3rd Decad in October

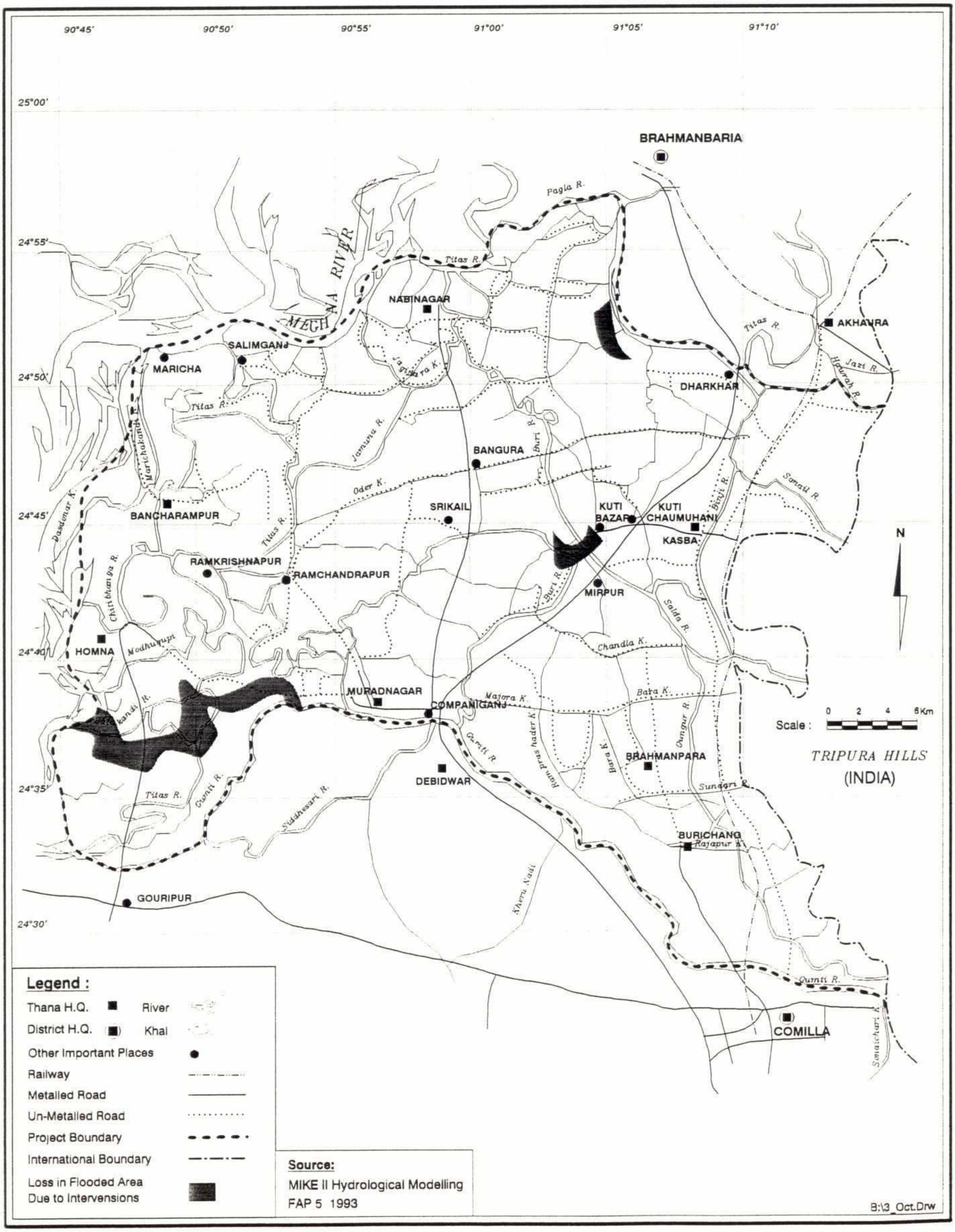

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Figure H.3.17
Differential Flood Modelling by Decad
2nd Decad in November

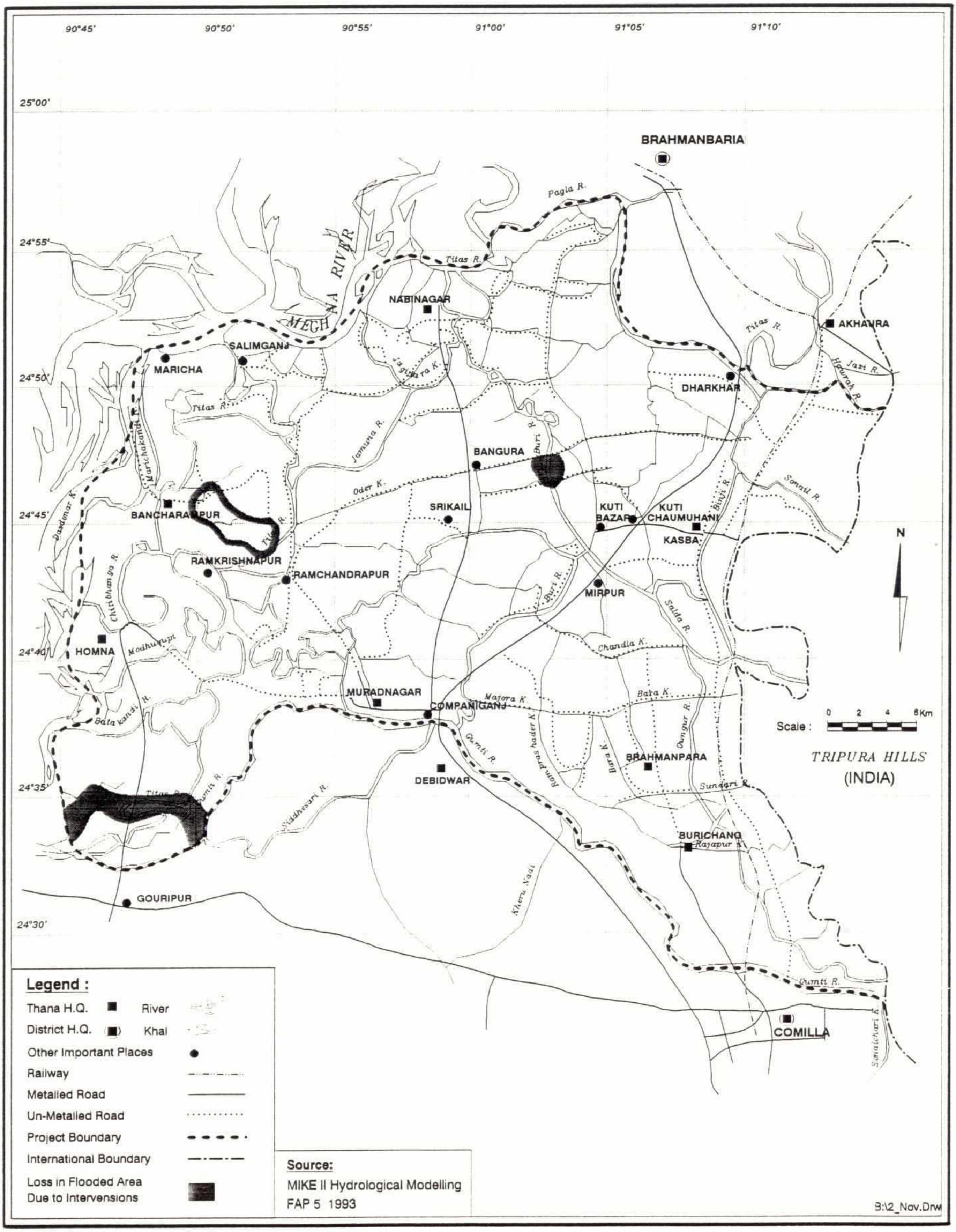

Figure H.3.18

Environmental Rating Matrix of Proposed Detailed Interventions

ISSUES	P	1	2	3	4	5	6	7	MP	MC
THE NATURAL ENVIRONMENT										
Hydrology										
Surface										
Flooding Damage to Land	*	+5	+3	+4	+4	+2	+1	0		
Drainage Problems	*	+3	-1	0	+5	-1	-1	+2		
Surface-Water Availability		-3	-2	-1	+4	-1	0	+3		
Groundwater Irrigation		+4	+4	0	+2	+2	0	0		
Domestic Water Supply	*	-1	-1	0	+1	-1	0	+2		
Erosion										
Meghna		0	0	0	0	0	0	0		
Cross Drainage		0	0	0	0	0	0	0		
Sedimentation										
Meghna		0	0	0	0	0	0	0		
Side Drainage	*	+2	+1	+3	+2	+1	0	+4		
Within Project Area		+2	+1	+3	+2	+1	0	+4		
Clogging/Smothering		+3	+2	+2	+2	+2	+1	+3		
Soil Fertility		-1	-1	0	-2	-1	-1	-1		
Navigation	*	-2	-2	-2	-3	-2	-2	+3		
Water Quality										
Domestic Water Quality		-1	-1	0	-1	-1	-1	0		
Agriculture Water Quality		-1	-1	0	+1	-1	-1	+1		
Land Resources										
Soil										
Quality/Chemistry		-1	-1	0	-2	-1	-1	0		
Waterlogging		0	+1	+1	+2	+1	+2	+1		
Erosion		0	0	0	0	0	0	0		
Ecology										
Flora		-1	-1	0	-2	-1	-1	-2		
Fauna		-1	-1	-1	-2	-1	-1	-2		
Fish	*	-2	-4	0	-5	-4	-4	+3	N	
Seismic Activity (*1)										

THE HUMAN ENVIRONMENT	P	1	2	3	4	5	6	7	MP	MC
Economic Livelihoods										
Risk		+3	+2	+3	+3	+1	-2	+3		
Settlement		+2	+2	+3	+2	+1	+1	0		
Land Tenure										
Scarcity		-1	-2	-2	-3	-2	-2	-2		
Land Values		+2	+2	+3	+3	+1	+1	+2		
Common Resource Rights										
Fish	*	-2	-4	0	-5	-4	-4	+2	VD	
Fuelwood		-2	-2	0	-3	-2	-1	-1		
Grazing		-2	-2	0	-3	-2	-1	-1		
Fodder		-2	-2	0	-3	-2	-1	-1		
Agricultural Output		+2	+4	+1	+5	+2	+2	+4		
Fishing ("Professional")	*	-2	-3	0	-5	-3	-4	+3	PO	CO
Forestry and Fuelwood		-2	-2	0	-3	-2	-1	-1		
Livestock		-2	-2	0	-3	-2	-1	-1		
Wage Paid Employment	*	+3	+3	0	+4	+3	+1	+5		
Industry		+2	+2	0	+3	+2	0	+2		
Drinking Water Availability	*	-1	-1	0	+2	-1	0	+2		
Human Health										
Waterborne Diseases										
Diarrhoea	*	-3	-2	-1	-2	-2	-1	-1		
Cholera	*	-3	-2	-1	-2	-2	-1	-1		
Insect Borne Diseases										
Malaria	*	0	0	0	-1	0	-1	-1		
Kala-azar		0	-1	0	0	-1	0	0		
Drinking Water Quality	*	0	0	0	-1	0	-1	0		
Sanitation		-1	-1	0	-1	-1	-1	-1		
Nutrition	*	-2	-4	0	-5	-4	-4	+2	VD	
Mental Health		+1	+1	+2	+1	+1	0	0		
Access and Transport Infrastructure										
Waterborne										
Meghna		0	0	-1	-1	0	-1	0		
Side Rivers	*	+1	-1	0	-1	-1	-1	+2		
Within Project Area		-3	-3	-3	-3	-3	-3	+3	PO	
Railway		+1	0	0	0	0	0	+1		
Road		+2	+2	+1	+2	+1	+1	0		
Archaeology and Cultural Sites		0	-1	0	0	0	0	0		

EXTERNAL FACTORS WITHIN STUDY AREA	P	1	2	3	4	5	6	7	MP	MC
Upstream Back-up Flooding	*	-3	-3	0	-1	-3	-2	+3	MI	
Downstream Knock-on Flooding		-1	-1	-1	+1	-1	0	-2		
EXTERNAL FACTORS OUTSIDE STUDY AREA										
-UPSTREAM CONSTRAINTS										
Increased FAP 6 Flooding	?	0	0	0	?	0	?	?		
Indian Dams on Upper Meghna	?	0	0	0	?	0	?	?		
Gumti River Hydro Dam		+1	0	+3	0	0	0	0		
Upstream Sediment In-flow	*	+3	+2	+3	+1	+1	0	+3		
-UPSTREAM IMPACTS										
Peak Back-Up Flooding		-1	-1	?	-1	-1	0	+2		
-DOWNSTREAM CONSTRAINTS										
Meghna River Water Levels	*	+1	+1	-2	+5	+1	+1	0		
-DOWNSTREAM IMPACTS										
Knock-on Flooding	*	-1	-1	-2	-1	-1	0	0		

LEGEND

RATING OF IMPACT

-5 Severe Irreversible Negative Impact
-4 Significant Negative Impact
-3 Moderate Negative Impact
-2 Slight Negative Impact
-1 Very Slight Negative Impact
0 Present Baseline Situation and No Change
+1 Very Slight Positive Impact
+2 Slight Positive Impact
+3 Moderate Positive Impact
+4 Significant Positive Impact
+5 Very Significant Positive Impact
MI = Mitigation is Addressed Intrinsically
VD = Mitigation Very Difficult
PO = Mitigation Possible
CO = Mitigation Costly
PC = Mitigation Prohibitively Costly
N = Mitigation Not Possible

ABBREVIATIONS/HEADINGS

P = Expert Priority Issues
1 = Intervention 1
2 = Intervention 2
3 = Intervention 3
4 = Intervention 4
5 = Intervention 5
6 = Intervention 6
7 = Intervention 7
MC = Mitigation Possible?
MC = Mitigation Costly?
(+1) = A Constraint not an Impact
* = Major Issues
F = In Times of Flood
LF = In Low Flows
PF = In Peak Floods
? = Insufficient Data to Assess

Note: The predicted impacts are assumed to be those some six years after completion of construction of the proposed interventions.

H.4 PRINCIPAL NEGATIVE IMPACTS FOR DETAILED PROPOSED INTERVENTIONS UNDER STRATEGY (c)

H.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 was 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.

The work has concentrated on the likely negative impacts that are likely to occur within the intervention areas. However there is the possibility of impacts being felt outside the intervention areas but still within the study area. Great efforts have been made to minimise these but they difficult to predict at present and would require more detailed hydraulic modelling work. There are also possible impacts outside the study area and again whilst great efforts have been made to minimise these there is insufficient data to assess these at present. Of more serious consideration is the likely effects of other development, particularly upstream interventions under FAP 6 that may pose constraints upon development possibilities for the Gumti Phase II area. Again these have been commented upon in Section H.4.3 below but considerably more data and hydraulic modelling would be required once there was a clear consensus as to what is being recommended in the FAP 6 area.

H.4.2 Internal Negative Impacts

H.4.2.1 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 H.3.4 above. The conclusion from this is that the reduction in area of flood plain due to the interventions is not very great, but it is likely that the most serious effect of the interventions, especially on the fisheries system, are likely as a result of the barrier effects of closed embankments upon fish migration.

H.4.2.2 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 H.4.1 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 H.4.2 which gives estimates of overall percentage fisheries catch losses. These

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TABLE H.4.1

Estimated Fisheries Impacts Due to Strategy C in Gumti Phase II By Interventions 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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TABLE H.4.2

Change in Fish Production Estimates in Gumti Phase II
Due to Strategies C, D & E Without Mitigation and Management

	Fishery System	Existing Situation WO (MT)	% Total Catch	WO Year 6 (MT)	% Total Catch	Strategy 'E' Year 6 (MT)	% Total Catch	Difference in Year 6 'E' and WO %
Zone A	Int Rivers/Khals	378	1.41	345	1.26	171	0.94	-50.53
	Beels	0	0.00	0	0.00	0	0.00	0.00
	Floodplain	2,750	10.27	2,512	9.19	525	2.89	-79.11
	Ponds*	3,133	11.70	4,080	14.92	4,080	22.44	0.00
Zone B	Int Rivers/Khals	314	1.17	287	1.05	108	0.59	-62.39
	Beels	85	0.32	78	0.28	35	0.19	-55.42
	Floodplain	3,021	11.28	2,759	10.09	1,210	6.65	-56.15
	Ponds*	1,299	4.85	1,692	6.19	1,692	9.30	0.00
Zone C	Int Rivers/Khals	477	1.78	436	1.59	279	1.54	-35.85
	Beels	758	2.83	692	2.53	394	2.16	-43.14
	Floodplain	5,458	20.38	4,985	18.23	2,615	14.38	-47.54
	Ponds*	2,300	8.59	2,995	10.96	2,995	16.47	0.00
Zone D	Int Rivers/Khals	477	1.78	436	1.59	373	2.05	-14.46
	Beels	296	1.11	270	0.99	134	0.74	-50.44
	Floodplain	5,372	20.06	4,906	17.95	2,711	14.91	-44.75
	Ponds*	664	2.48	865	3.16	865	4.76	0.00
Total	Int Rivers/Khals	1,646	6.15	1,503	5.50	931	5.12	-38.09
	Beels	1,139	4.25	1,040	3.81	562	3.09	-45.95
	Floodplain	16,601	61.99	15,162	55.46	7,060	38.82	-53.44
	Ponds*	7,396	27.62	9,632	35.23	9,632	52.97	0.00
Grand Total		26,782		27,337		18,185		-33.48

* Includes cultured ponds only

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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 H.4.1. 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 losses in fish production, including those from ponds over the first six years after construction is completed, are estimated to be 3122t for Strategy (c), 9224t for Strategy (d) and 9153t for Strategy (e) (from Table H.4.2). 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 every evidence that these figures, which are based upon pre- FAP 17 checking of FRSS data, are not 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 with and without intervention differentials are the important figures in doing such a comparative assessment and they 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 self consumption. Even so, in the total study area 40% of all households 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 consumption. 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.

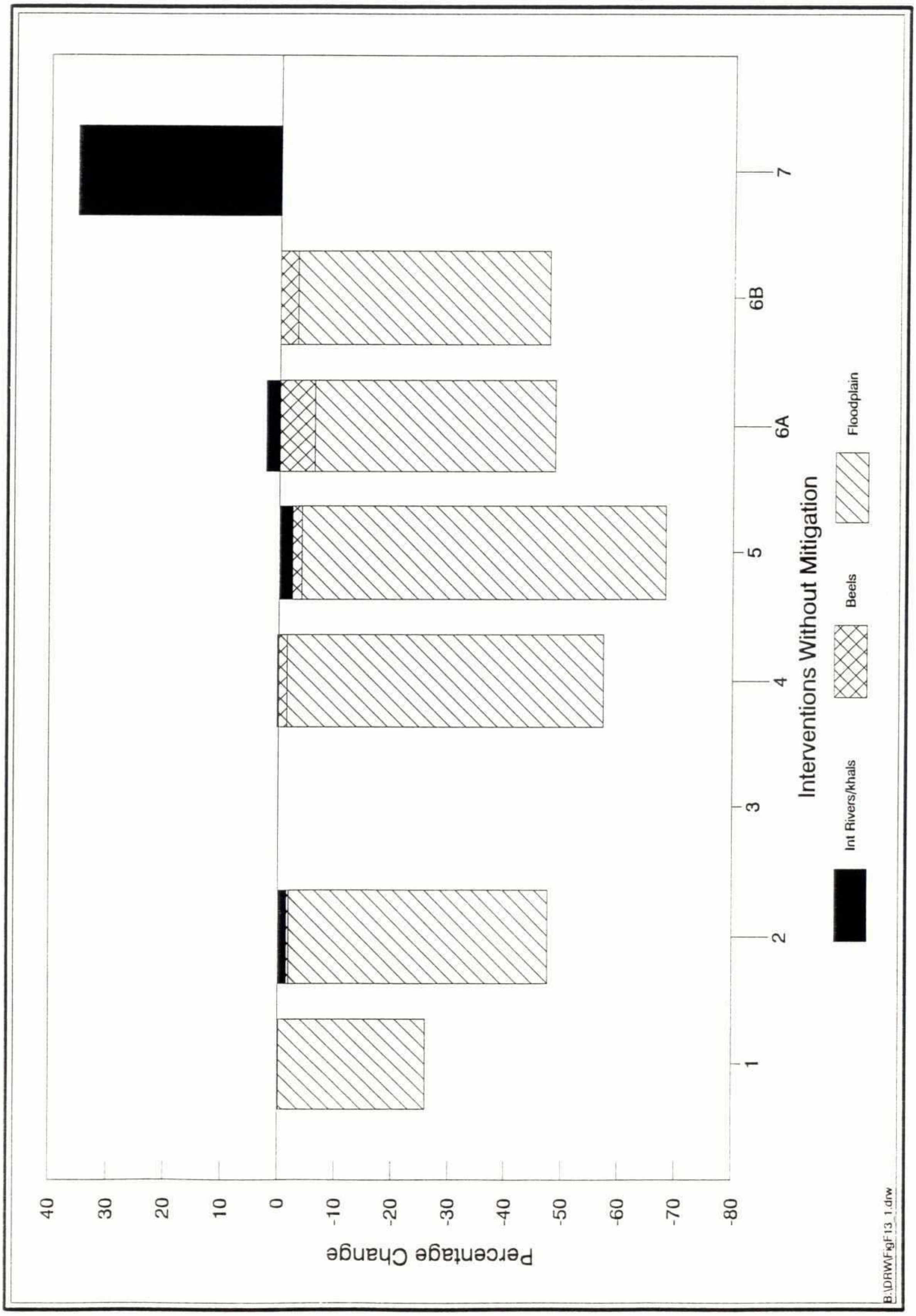
In terms of the detailed interventions, there are severe losses to the common good fisheries resources in interventions 2, 4, 5 and 6. These are likely to have serious local effects on occasional fishermen and will produce the significant reductions in the availability of animal protein, particularly to poorer households. The losses to professional fishermen are likely to be most significant in interventions 4 and 5.

H.4.2.3 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 central issue 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.

Figure H.4.1

Estimated Fisheries Impacts of Strategy C in Gumti Phase II



H.4.2.4 Decline in Flora and Fauna

The assessment of the effects of the detailed interventions on the ecological system are given in detail in the Ecological Annex D. The natural fisheries system is likely to suffer the most serious problems, especially in the 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, but many can be avoided by careful planning and allow regeneration to occur more quickly in those cases, such as Khal deepening, where there may be some longer term benefits.

H.4.2.5 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 health data collection programme and subsequent monitoring to gain sufficient knowledge to tackle this issue.

H.4.2.6 Soil Fertility Issues

The issues concerning soil fertility are outlined in Annex E and apply to any area which is proposed to be drained or come under irrigated cropping. Analysis of these issues requires access to the existing SRDI surface soil chemistry data with a follow-up monitoring programme. The following comments are general issues that are likely to arise as a result of draining areas that were seasonally flooded and also irrigating areas that dried out in the dry season.

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 upconing in relation to geological conditions. This work would seem to indicate that groundwater quality needs to monitored to check whether its increased use for irrigation in these or in adjoining areas will cause problems with soil chemistry and also result in saline water being drawn into aquifers that are presently non-saline. Monitoring data would need to be collected and interpreted in the light of considerations for likely salinity development in surface soils as a result of groundwater irrigation development, particularly in the south eastern part of the study area. However this also needs to bear in mind the likely dilution and dispersion effects of the high levels of rainfall in the area which would seem likely to minimise this potential problem.

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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 and resulting risk to water quality are explained in Section H.4.2.8 below. 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 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 Appendix H.V.

Irrespective of any planned water development intervention there is considerable scope for improving existing rain-fed agriculture, particularly by utilizing appropriate and environmentally sound soil and land management practises. 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 the up-take of irrigation. Comments on the FAP 3.1 Feasibility Study Report by expert reviewers indicated that within the national perspective the Comilla area is one of the most important that should be subject to such monitoring, due to the fact that has been in the forefront of irrigation development in the country. Such a monitoring programme could be best carried out as part of any 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.

H.4.2.7 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 analysis.

H.4.2.8 Fuelwood, Grazing and Fodder

The complex linkages and interaction within the rural energy system based around crop residual availability and its 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 this. A crucial factor is the change in availability and quality of straw for stall fed cattle and the competition for its use as domestic fuel and building material. Fuel wood now appears to be reserved for commercial users such as brick making and pottery as it is so scarce and expensive. Animal dung is 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 whilst having sustainability issues of their own would seem to relive pressure on a stressed system.

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H.4.2.9 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 peoples participation exercise indicate that in 14 of the 16 studied villages there are still serious problems. In terms of local peoples 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.

H.4.3 External Impacts and Constraints

Possible impacts of the interventions on areas outside them include those within the study area but outside the intervention areas and also those outside the study area. These are shown in the detailed impact assessment matrix as far as is possible. However there is insufficient data to address many of these issues and overall there are too many unknown factors, especially the likely nature of FAP 6 upstream proposals. There are thought to be few impacts within the study area but outside the intervention areas as the interventions have been deliberately designed to minimise these and the hydraulic modelling work has allowed this to be tested and optimised. However any more detailed work on this would require additional hydraulic modelling work to be carried out. Due to the relatively small scale of most of the detailed interventions there is thought to be very little induced impact on areas outside the study area. Of greater concern is the likely constrains that could be placed on the viability of the proposed interventions by upstream development as part of the FAP 6 study. The likely specific issues are discussed below.

H.4.3.1 The Gumti River

The continuation of the Gumti right embankment is likely to have little additional negative impact in terms of increased flood risk as this problem has already asserted itself due to the past history of embankment construction. If anything the situation should be improved within the study area as has been demonstrated by the hydraulic model outputs. There may however be justification for similarly extending the left embankment of the river to the same point. However all this assumes that there will be an open-ended maintenance programme for the embankments, both in terms of preventing breaches and also raising them to counteract river bed accretion due to sedimentation, to ensure that catastrophic failures will be prevented. The implications of such a failure are very serious indeed and are likely to create greater flood losses than if there were no embankment. The history of prevention of such failures on the Gumti is not good and it is imperative that this is resolved in a sustainable and effective manner.

H.4.3.2 Upstream Impacts and Constraints

Some of the interventions are likely to cause some limited upstream back-up flooding within the study area. This particularly applies to embankments in interventions 1, 2 and 5. However by appropriately phasing these and including the Khal deepening programme component of intervention 1 they can be alleviated as shown by the hydraulic modelling outputs. There are likely to be only very slight and localised induced upstream impacts outside the study are created by any of the detailed interventions due to their relatively small scale nature. Of far greater importance are the likely constraints that could be imposed on the study area by proposed upstream development, particularly submersible embankments being considered by FAP 6. These could well pass on earlier flooding to the study area, however until more definite data is available as to the likely nature of these proposals and the implications of these can be hydraulically modelled there is little that can be said about this issue at the moment. This also applies to the possible development of any dams on the Upper Meghna in India. The development of similar dams on the upper Gumti is likely to be beneficial to the area as early flash flooding and peak flow will be attenuated. The issue of inflowing sediment is addressed, although perhaps only temporarily, by many of the interventions by way of Khal deepening works and confinement of sediment to the main river channels.

H.4.3.3 Downstream Impacts and Constraints

Again there are likely to be few and even then only very minor induced flooding impacts downstream. The downstream constraint of Meghna main channel water levels will remain the most crucial aspect of the hydrology of the area and there is little that any interventions can do to change this. This factor, when combined with the high levels of rainfall in the study area, is the reason why large scale engineering interventions are either uneconomic or ineffective in reducing flood extents in the study area and in many cases will actually make the situation worse.

H.4.4 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 minimising these. This has been achieved by following existing embankment and road alignments, but even so intervention 1B will need a land acquisition component. 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 if this is the case. An inventory of assets along the proposed alignment will be needed followed by an assessment of likely livelihood loss to individual households. This will have 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 multi-purpose use of embankments leading to the development of linear settlements as has been proposed for the Coastal Embankment Rehabilitation Project (CERP). 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 and using labour intensive construction techniques this could greatly increase the demand for wage paid labour at a time of the year and in locations where it is in short supply, particularly for specifically vulnerable social groups.

H.4.5 Hazard Risk and Sustainability

The whole question of physical stainability 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 far more so than if the embankment had not existed. This is made particularly serious n the case of the Gumti by the high levels of sedimentation which have resulted in the embankments heights having to be continuously raised to counteract river bed rise. This must question how wise it is to embark upon embanking the Salda and Buri rivers, as once this process is started there is little choice but to continue with an open-ended programme of dredging, embankment raising and maintenance. This will entail continuous investment and 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 such events indicate 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 Appendix G. Others, particularly those concerning livelihood loss to full-time and part-time fishermen and boat owners, operators 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 in the case of a loan how this is to be repaid and for both situations what better alternative use this money could have been 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.

H.5 IMPACT MITIGATION AND ENVIRONMENTAL MANAGEMENT PLANNING

H.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 viable, a major factor being that the agricultural benefits offered are either limited and/or cannot overcome the likely losses to fisheries production to produce the economic return demanded by donors. 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 expected to have serious fisheries losses which require it to be very 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 to be carried out only on these four interventions.

H.5.2 Impact Mitigation

The aim of impact mitigation is to design the interventions to be as environmentally friendly as possible by minimising environmental dis-benefits and maximising benefits. In addition there should be targeted programmes to tackle specific negative impacts in defined places or amongst particular social groups. Another aspect is to design the operation of the intervention to allow identified environmental issues to be addressed. In the case of fisheries losses in Intervention 1B (controlled flooding to Zone A) some mitigation is possible, depending upon the water management priorities for controlled flooding as opposed to recruitment of migratory fish species.

Mitigation considerations should also feature heavily in tackling construction issues, especially for Intervention 7 (Khal deepening) and the extension of the Gumti right embankment (Intervention 3). 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. There would appear to be few benefits from Khal deepening as dry season gravity feeding of these would not be possible. It is thus a straight policy decision as to the justification of promoting agricultural benefits which results in fisheries losses.

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H.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 and this would not normally be considered justifiable until a firm commitment has been given to taking the recommended interventions to further study. This would need to be done if the study is to be followed up. The outline notes for a future work programme indicate what sort of data collection requirements are needed to allow such an EMP to be drawn up.

H.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 required. 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.

H.5.5 Residual Impacts for Recommended Interventions

Table H.5.1 gives a summary of the major negative environmental issues for the recommended interventions, along with 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.

TABLE H.5.1

Residual Impacts for Recommended Aggregated Intervensions 7, 3, 1A, 1B and 2

Principal Negative Impacts By Priority	Quantitification	Valuation	Mitigation Possibilities of Costs	Residual Impacts
Fisheries				
- Lost Cash Resource	- 1472 tonnes	Tk. 36 m	- 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 data needed	Not yet possible	Management needed	Very little if careful
Decline in Flora and Fauna	Detailed baseline and monitoring data needed	Not normally posisble	Limited possibilities	Yes, depends on priorities
Fuelwood/Grazing/Fodder (Fertilizers, water quality)	Data needed	Possible but difficult	Possible	None

H.6 CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK PROGRAMME

H.6.1 Conclusions

The environmental component to the study has concentrated on providing a continuous environmental perspective to the evolution of an appropriate and environmentally sensitive water and land development strategy plan for the area. This included consideration and re-evaluation of two alternative strategies proposed by the 1990 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 polderisation. There is potential for encouraging surface water irrigation by Khal deepening 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 finally solve the long term problem of downstream aggravated flooding that partially embanking the river has caused for many years. The intervention of controlled flooding in Zone A addresses the problem of early flash flooding from the Indian hills but needs to be combined with downstream Khal deepening if induced downstream and upstream flooding is to be avoided.

H.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 bank embankment.
- Intervention 1A and 1B - Deepening and remodelling of the Salda River and controlled flooding in part of Zone A.

However the economic analysis indicates that the latter pair of interventions (1A and 1B) are not economic unless their cost is shared by Intervention 2 (the larger of the exclusion polders in Zone B), as the latter has significant agricultural benefits. However this intervention has significant fisheries losses in this area, with socio-economic and nutritional loss implications, especially to occasional fishermen (37% of the population) and also to the 4% of households dependent upon full-time fishing and some of the 6% who are part-time ones. It thus becomes a political decision as to if it is considered that the fisheries losses in the Intervention 2 area can be justified by the agricultural benefits in that area 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 it 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 seems to be very unwise within the Gumti area which is so rich in fisheries resources. If it is wished to promote a policy of increasing agricultural production through increased irrigation and flood control provision then the Gumti Phase II area is not a suitable place to do this. Irrespective of the question of environmental suitability, the economic losses to the fisheries resources amply demonstrate this to be the case, there are likely to be far more suitable places within Bangladesh to pursue this type of policy.

H.6.3 Future Work Programme

H.6.3.1 Data collection programme

Assuming that the recommended detailed interventions are to be followed up then a highly specific and suitably phased programme of detailed data collection is required that addresses the issues raised in this preliminary environmental assessment. This requires the hydraulic modelling to be refined for the specific interventions being considered and also interfaced to a Digital Elevation Model (DEM) to automatically produce mapped outputs. In addition it is imperative that the 1991 BBS census data is made available to the study. The detailed studies need to include the following components:

- Detailed fisheries assessment, especially in Zone A and the Intervention 2 area, the Gumti River outfall flood plain 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 the 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 fuel-wood, grazing, fodder and rural energy balance survey.
- Studies of land acquisition requirements, and formulation of an appropriate compensation and resettlement strategy with significant public participation, to produce a resettlement plan under World Bank Operational Directive 4.30.
- A review of the likely direct construction impacts bearing in mind the engineering design, nature of construction contract and the experience with the BWDB implemented Coastal Embankment Rehabilitation Project.

H.6.3.2 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 World Bank 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

A draft outline for Terms of Reference for such detailed studies is given in Appendix H.3.

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PHOTOGRAPHIC PLATES

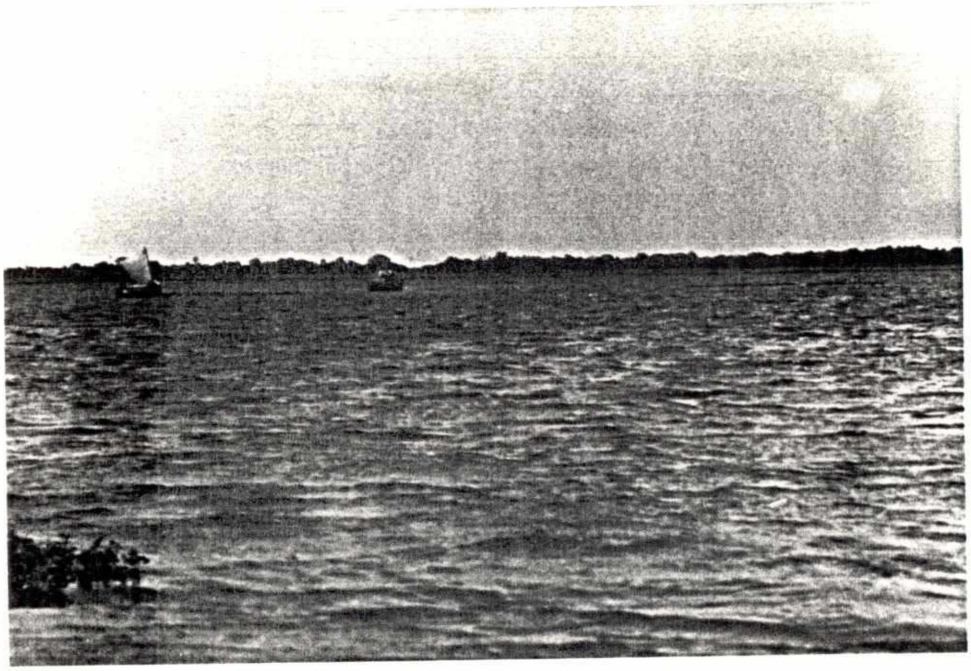

Plate 1
Main River

Plate 2
Small Internal River

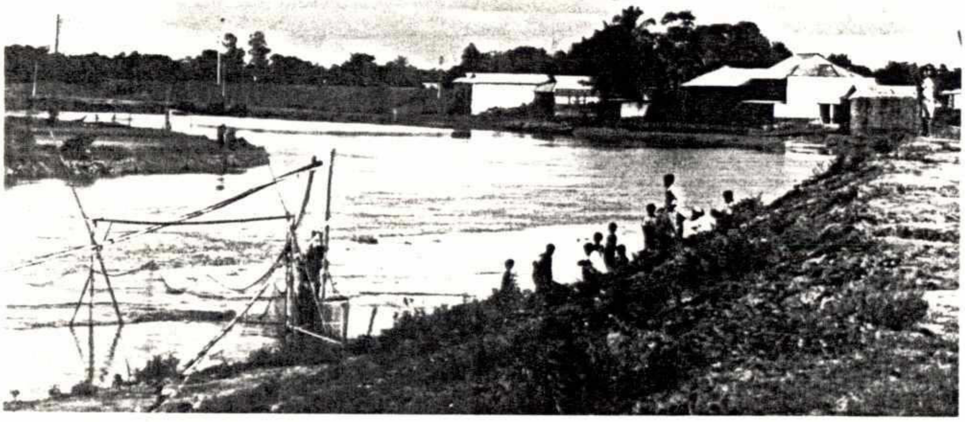

Plate 3
River Gumti near Comilla
- Flood Season

Plate 4
River Gumti near Comilla
- Low Flow Condition

Plate 5

River Titas Flood Plain near Nabinagar
- Flood Season

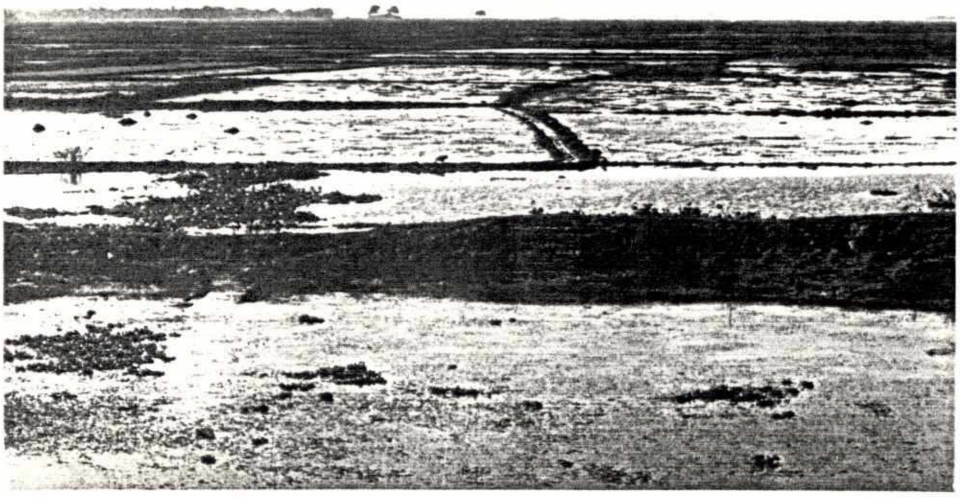

Plate 6

River Titas Flood Plain near Nabinagar
- Falling Flood

Plate 7

Meghna Flood Plain near Chandal Beel
- Flood Season

Plate 8

Meghna Flood Plain near Chandal Beel
- Dry Season

Plate 9
Shaishaduli Beel

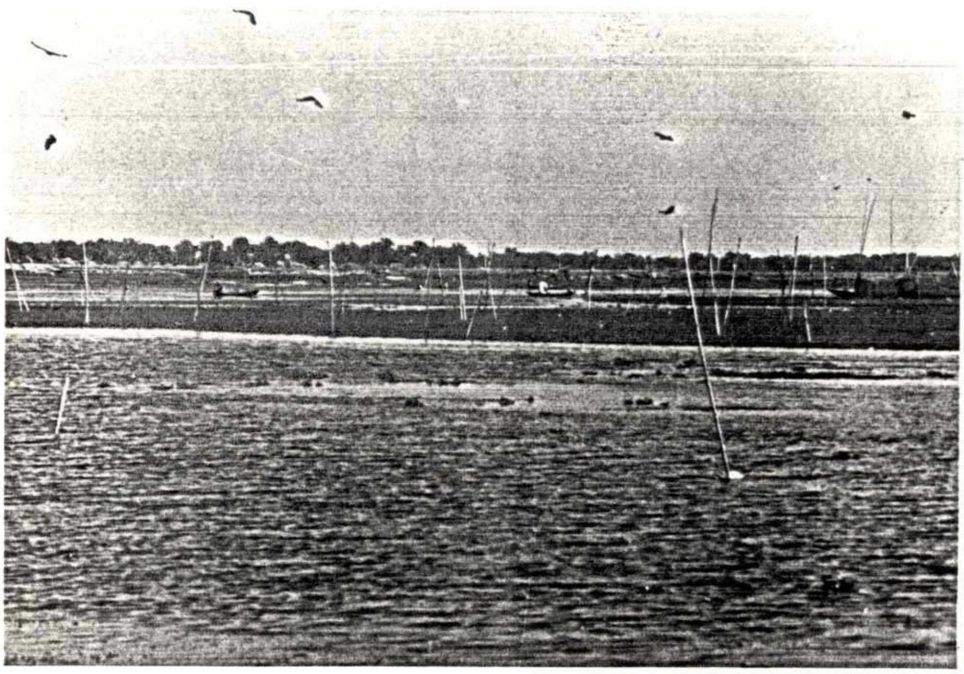

Plate 10
Chandal Beel - a major Fisheries Resource

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Plate 11
Typical large Village Pond

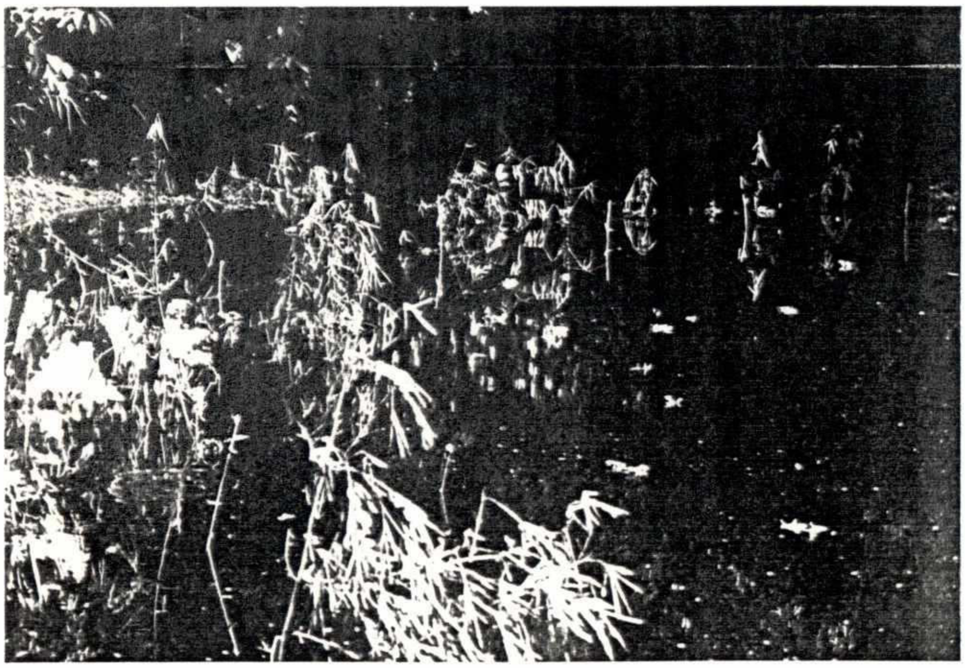

Plate 12
Small Pond with Algal Bloom

APPENDIX H.I

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APPENDIX H.II

LIAISON AND CONTACTS

LIST OF ORGANISATIONS AND INDIVIDUALS CONTACTED DURING THE COURSE OF THE STUDY

As part of the day to day work of the study, liaison has been made with the following individuals and organisations on both a formal and informal basis:

Members of the Flood Plan Co-ordination Organisation (FPCO)
Panel of Experts:
Pat Lane, Environmental Specialist
Darell Deppert, Fisheries Specialist
Steve Jones, Sociology Specialist
Saleh Mustafa Kamal, Environmental Specialist
Abdul Latif Sarker, Fisheries Advisor
Syed Waliullah, Sociologist
Mesbahuddin Ahmed, Media/Public Relations Specialist, World Bank/FPCO

UNDP
Grace Hemmings-Gapchen, Participation Specialist

BWDB
Chief Engineer

REGIONAL FAP STUDIES:

North Central Region (FAP 3)
Don Brown, Team Leader,
Ron Bastin, Social Development Specialist
Jim Scullion, Fisheries Specialist
Jean Marie Lacombe, Resident Representative, BCEOM
Shamsur Rahman, Assistant Resident Representative, BCEOM

Jamalpur Priority Project Study (FAP 3.1)
Malcolm Wallace, Team Leader
Chris Swayne, Former Team Leader
Berry Kenny, Rural Infrastructure Engineer
Jean-Louis Leterme, Sociologist
Marc Juville, Socio-Economist
Philipe Ame, Fisheries Specialist
Dr S M Latif, Environmentalist
Prof Naqui, Sociologist
Dr Raza Rahman, Land Resources Specialist

North West Region (FAP 2)
Tom Franks, Team Leader
Nic Chisholm, Agricultural Economist
Bryan Spooner, Environmental Co-ordinator

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Jim Monan, Socio-economist
Doug Cross, Ecologist

North East Region (FAP 6)
Herb Wiebe, Team Leader

FLOOD ACTION PLAN SUPPORTING STUDIES

FAP 16
Steve Minkin, Fisheries Nutrition, Vector Borne Diseases Studies
Firouz Rooyani, Environmental Planner Tangail EIA
Ron Livingstone, Environmentalist, Wetlands Studies
Dr Reaz Rahman, Human Health Specialist
A Raguib, Wildlife Specialist

FAP 14/23
Ian Todd
Paul Thompson
Mustafa Alam
Suzanne Hanchet
Dave Shewy

FAP 20 Compartmentalisation
Albert Heringa, Environmentalist
Gertjan de Graff, Fisheries Specialist

FAP 21/22 Bank Protection and River Training
Catherine Bertrand, Environmentalist
Parvin Saltana, Environmentalist

FAP 17 Fisheries
Mike Smith, Team Leader
Jim Scullion, Fisheries Ecologist
Bernie McCarton, Fisheries Biologist

FAP 25 (SWMC) Hydraulic Modelling
Alistair McDonald
Finn Hansen
Emaduddin Ahmad, Hydraulic Modelling Engineer

FAP 1 Brahmaputra Right Embankment
Mike West, Team Leader
Dave Ryman, Resettlement Specialist
Kip Warr, Sociologist
Chris Pastakia, Environmentalist

NON FAP PROJECTS AND PROGRAMMES

Jamuna Bridge Environmental Study
David Ryman, Team Leader
Doug Cross, Ecologist
Gwyn Evans, Drainage Specialist
Dr Nehal Karim

Forestry Master Plan Project
W Treygo

GOVERNMENT DEPARTMENTS AND PARASTATAL ORGANISATIONS

SPARRSO, Mr A M Chowdhury, Director

NON GOVERNMENTAL ORGANISATIONS, RESEARCH INSTITUTIONS AND SPECIALISTS

PACT
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BCAS (Bangladesh Centre for Advanced Studies)
Saleemul Huq, Executive Director
Atiq Rahman

Research and Advisory Services
Shapan Adnan
Bruce Currey

Oxfam
Alison Barrett

Action Aid Bangladesh
Robert Reitemeier, Director

Winrock International
David Seckler, Director, Center for Economic Policy Studies

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APPENDIX H.III

DRAFT TERMS OF REFERENCE FOR SUPPORTING STUDIES FOR FOLLOW-UP WORK

DRAFT TERMS OF REFERENCE FOR SUPPORTING STUDIES FOR DETAILED FOLLOW UP WORK FOR THE GUMTI PHASE II STUDY

1 INTRODUCTION

The aim of these studies would be to follow-up on the conclusions and recommendations of the Gumti Phase II 1993 study to take the following four interventions to full feasibility study and detailed design:

1A Remodelling and deepening of the Salda and Buri rivers

1B Controlled flooding in part of Zone A

2 Medium sized polder in Zone B

3 Extension of the Gumti River right embankment

7 Khal Deepening in Zone D

This would entail a programme of baseline data collection to allow a full impact assessment to be carried out according to the FAP/FPCO Environmental Guidelines and the World Bank Operational Directive 4.01. This would allow for quantification and valuation of impacts and the drawing up of an Environmental Management Plan.

In addition specific issues that require particularly close liaison with the engineering design will need to be addressed in an inter-disciplinary manner so that any impacts that can be avoided or mitigated for can be done so by adopting appropriate designs. In addition there will need to be a major component for formulation of an institutional structure for the implementation and sustainable management of the interventions, including the close involvement of local people in the detailed planning of these.

2 DETAILED DATA COLLECTION PROGRAMME

Assuming that the recommended detailed interventions are to be followed up then a highly specific and suitably phased programme of detailed data collection is required that addresses the issues raised in this preliminary environmental assessment. This requires the hydraulic modelling to be refined for the specific interventions being considered and also interfaced to a Digital Elevation Model (DEM) to automatically produce mapped outputs. In addition it is imperative that the 1991 BBS census data is made available to the study. The detailed studies need to include the following components:

- Detailed fisheries assessment, especially in Zone A and the Intervention 2 area, the Gumti river outfall flood plain 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 the Zone A and the Intervention 2 flood plain areas.

- Waterborne disease vector study, especially for diarrhoeal diseases in Zone A and Zone B.

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- 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 fuel-wood, grazing, fodder and rural energy balance survey.

- Studies of land acquisition requirements, and formulation of an appropriate compensation and resettlement strategy with significant public participation, to produce a resettlement plan under World Bank Operational Directive 4.30.

- A review of the likely direct construction impacts bearing in mind the engineering design, nature of construction contract and the experience with the BWDB implemented Coastal Embankment Rehabilitation Project.

This data collection would need to be carried out over a full 12 month period so that the seasonal variation would be apparent. In addition the results of the national supporting studies for the Flood Action Plan should by then be available so that wider issues can be addressed, particularly concerning fisheries, nutrition and waterborne diseases.

3 ENVIRONMENTAL MANAGEMENT PLAN

The above data will need to be collected so that the following issues can be addressed and form the basis for an Environmental Management Plan for the intervention areas.

- Land acquisition, compensation and resettlement plan under World Bank 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

4 STAFFING

The staff disciplines/expertise that would need to be covered include:

- Environmental Planning and Management
- Hydraulic Modelling
- Fisheries
- Health and Nutrition
- Rural Development Institutions
- Socio-Economics
- Soil and Land Resources
- Ecology

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APPENDIX H.IV

HEALTH AND NUTRITION CONSULTANTS REPORT

GUMTI PUBLIC HEALTH NUTRITION STUDY REPORT

A. Objectives of this study are to:

Below are the objectives of the Gumti Public Health Nutrition survey.

1. To assess the existing public health and nutritional status of the population in the Gumti project area

2. To identify and prioritize the environmental elements which will be improved or compromised by changes in the hydrology of the area.

B. Study area :

The study included the entire project area covering all the four zones. The major focus of the study was on taking account of the public health and nutritional problems of the area which have been affected, both positively and adversely, by the change in hydrology or habitat. To establish this, present and retrospective epidemiological data, i.e. case mortality, disease prevalence and the seasonal morbidity pattern were studied. Attempts were made to confirm its probable direct and indirect causes.

Actual field surveys were carried out in the following eight sites over a period of 4 weeks.

Zone	Thana	Union	Name of the Mouza	# of house hold in the mouza	Pop. of the mouza	# of house hold surve-yed
A	Brahmanpara	Purba Brahman.	Naighar	565	3085	36
	Debidwar	Utter Subil	Gopalnagar	1630	9186	33
B	Akhaura	Dakhin Akhaura	Nurpur	166	924	29
	Kasba	Kasba	Charnal	179	1124	26
C	Nabinager	Ibrahimpur	Ibrahim.	1668	10469	24
	Muradnagar	Akubpur	Metanagar	1435	8923	33
D	Homna	Uttar Homna	Goari Bhanga	436	2421	25
	Bancharampur	Dakhin Bancha.	Daskandi	698	4060	25

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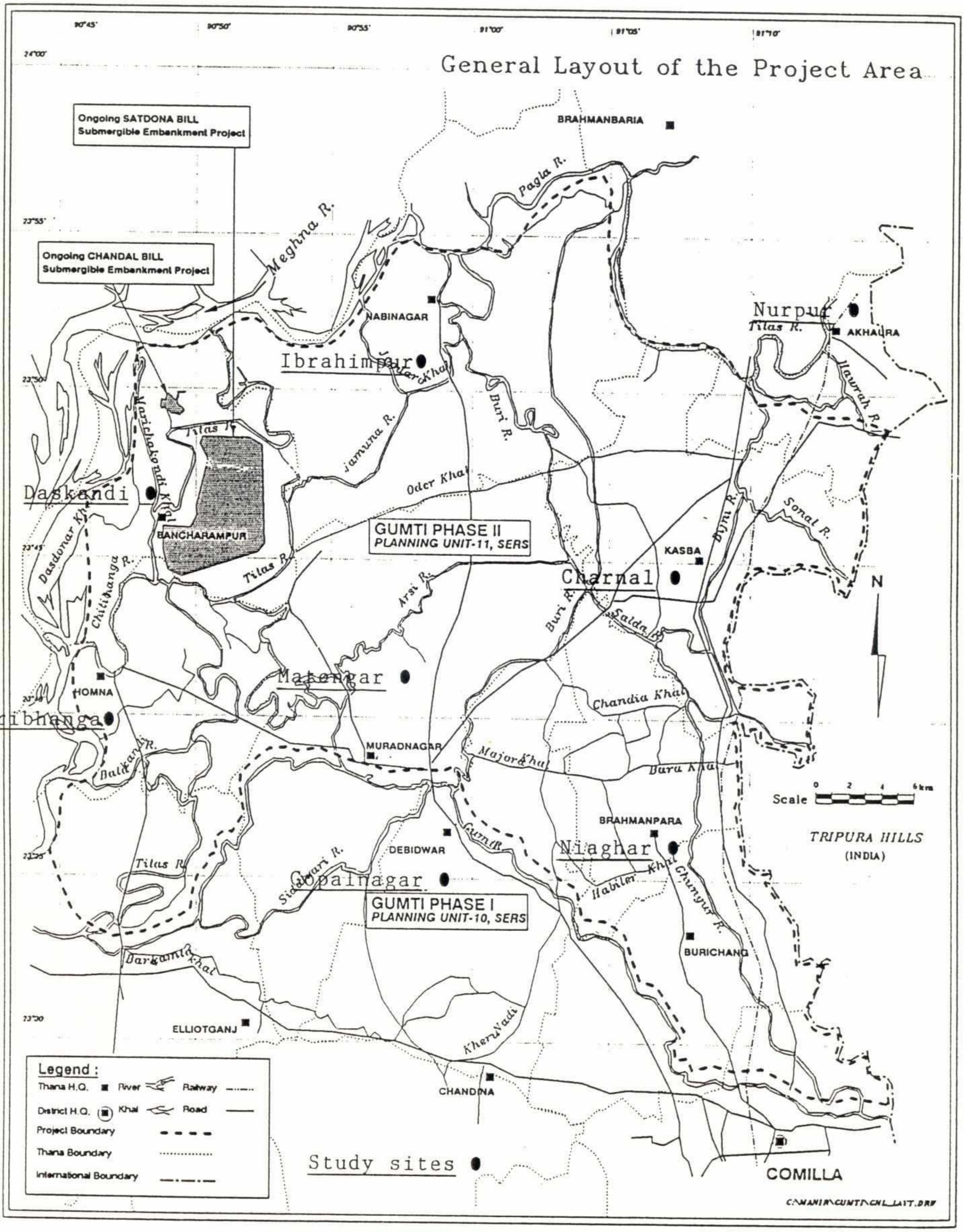


General Layout of the Project Area
Ongoing SATDONA BILL Submergible Embankment Project
Ongoing CHANDAL BILL Submergible Embankment Project
BRAHMANBARIA
NABINAGAR
AKHAURA
BANCHARAMPUR
KASBA
HOMNA
MURADNAGAR
DEBIDWAR
BRAHMANPARA
BURICHANG
ELLIOTGANJ
CHANDINA
COMILLA
Nurpur
Ibrahimpur
Daskandi
Charnal
Matengar
Goaribhanga
Niaghar
Gopalnagar
GUMTI PHASE II
PLANNING UNIT-11, SERS
GUMTI PHASE I
PLANNING UNIT-10, SERS
Meghna R.
Pagla R.
Tilas R.
Buri R.
Jamuna R.
Oder Khal
Arsi R.
Saldu R.
Bijni R.
Sonal R.
Haurah R.
Chandia Khal
Majora Khal
Buru Khal
Gumti R.
Habilas Khal
Chungur R.
Siddheswari R.
Dakatia Khal
Kheri Nadi
Dasdonar Khal
Chitibhanga R.
Balkan R.
TRIPURA HILLS
(INDIA)
N
Scale 0 2 4 6 km
Legend :
Thana H.Q.
District H.Q.
River
Khal
Railway
Road
Project Boundary
Thana Boundary
International Boundary
Study sites
C:\MANIR\GUMTI\GNL_LAYT.DRW

C. STUDY APPROACH

The study followed both the quantitative and qualitative methods. Data collected thus were compared and weighed for a balance. The methods used were document review, field observations, community survey and interviews of health service providers from the private, public and NGO sectors.

1. Document review

The study commenced with an examination of the available secondary data on the public health and nutritional problems of the project are. These were collected from the local,regional and national head quarters.

2. Field observation

For a general understanding of the nature of the people's lives and the surrounding habitat/hydrology, the survey team visited all the thanas of the project area.

3. Community Surveys

Community surveys were carried out in eight randomly selected sites of the region, two in each block A, B, C, D.

These included: - A household survey

-Under five child nutrition survey

-Focus group discussion

The purpose of the community surveys were to determine the prevalence of some selected diseases, nature of public health problems, present herbal health practice, and the current nutritional status of children.

4.Interview of Health service providers

GOB, health service providers, NGOs and selected private practitioners in Homna, Burichang, Debidar, Muradnagar, Bramamnpara, Thanas of Comilla district and Kasba, Ahkhaura, Bancharampur, Nabinagar Thanas of Bramanbaria were visited. Disease surveillance statistics with MOHFW health authorities and their prevalence/trend were reviewed.

5. Interview NGO Health Service providers

Visits were made to leading international and local NGO projects. They included the projects of Commilla Proshikha, SCF(USA), BRAC, and EDM. Information on the local public health problems and their experiences from tried NGO mitigation interventions were collected.

6. Interviewing Private Practitioners

All available private health practitioners, both qualified and traditional herbal healers, were interviewed at the four survey sites. Village elders, who are not commercial practitioners but are volunteer advisers, were also included under this category. A total of 38 village doctors, 13 kabirajes (herbal medicine practitioners), 15 religious leaders, 18 teachers and 27 farmers were interviewed for this purpose.

D. STUDY METHODS

1. Sampling

Two sites from each of the four zones were randomly selected from the sampled mouzas for other FAP- 5 surveys. Approximately 30 households were selected from survey cluster sites. A total of 231 households were surveyed. This included overall 3.4% households of the eight sites.

For the nutrition survey all children under five years were considered as the study population. Anthropometric measurements were taken for 484 children. The response rates were between 75% - 86%.

2. Study Instruments:

i. Household survey questionnaire

A questionnaire with both closed and open ended questions were used for data collection during household survey. The mother in the family, in their absence the father or an adult woman member, were interviewed.

ii. Nutritional measurement instruments

Nutritional anthropometric measurements were taken for assessing the nutritional status of the children under five years. Specially designed field survey instruments were used for this purpose. A local event calendar, for the past five years, was constructed to check, as accurately as possible, the stated ages of the children. Weights were taken using a CMS (Salter) spring scale read to the nearest 0.1Kg with the child sitting in a large plastic bowl. The scale was standardized initially and at the start of each session. Heights were taken using a purpose made vertical measuring wood stick with base incorporated (port of a QUAC stick) read to the nearest 0.5 cm.

Length measurements were taken using a baby board for children who could not stand without support. Mid-Upper Arm circumference (MUAC) measurements were taken using a non elastic tape measure read to the nearest 0.1 cm, applied to the mid point of the left arm, with the arm held relaxed at the side.

iii. Focus group discussion

For the community, problem identification and collection of historical information on epidemic outbreaks, eight focus group discussions in each survey site were held with village elders, school teachers, health practitioners and traditional herbal healers. Conversation logs and field diaries were used for recording the findings of the focus group discussions.

3. Analysis Methods

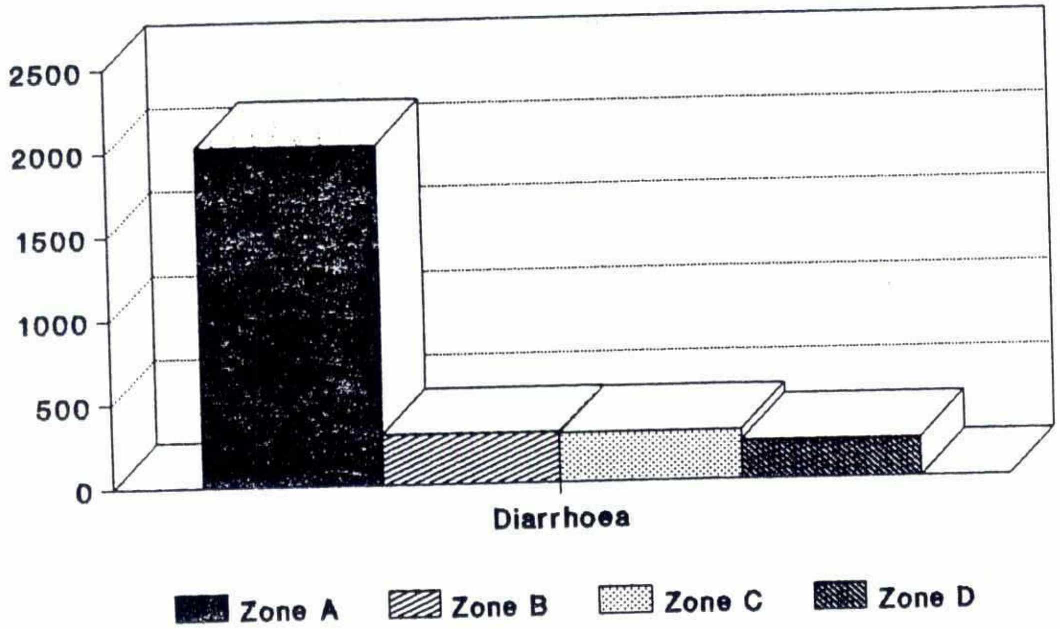
The secondary data, available mostly in a disorganized form, required a systematic analysis for establishing a comprehensive and compatible pattern.

During the analysis attempts were made to check the existence of seasonal patterns in the disease prevalence. Comparison were also made between the four zones.

Primary data were entered into a computer and analyzed using the "Epi info" computer software package. Frequencies were counted and tables prepared.

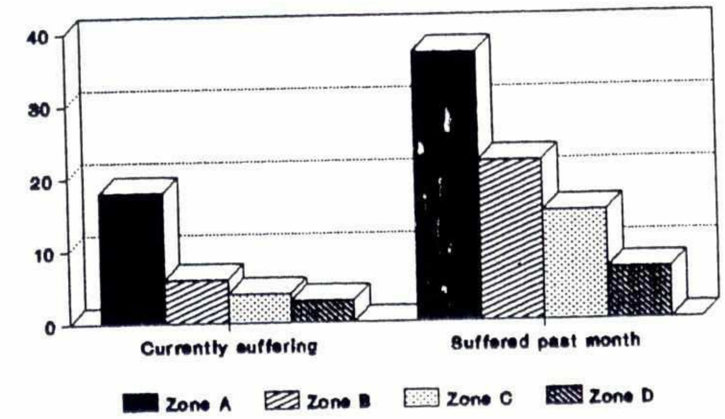
Prevalence of Diarrhoea

Number of cases for 1991
(Estimates based on zone population)



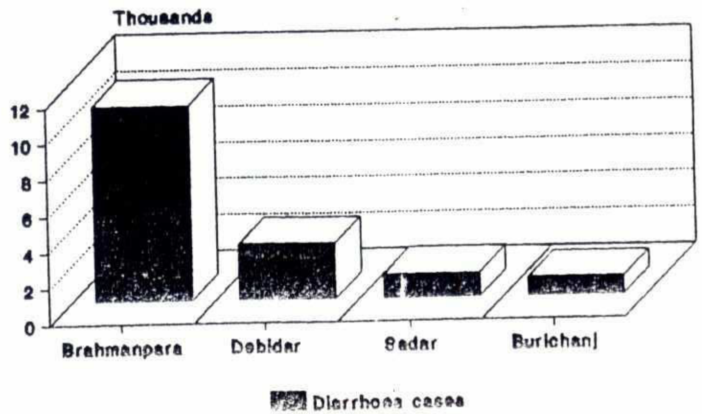
IEDCR source

Prevalence of Diarrhoea
Currently and during past month



Field survey

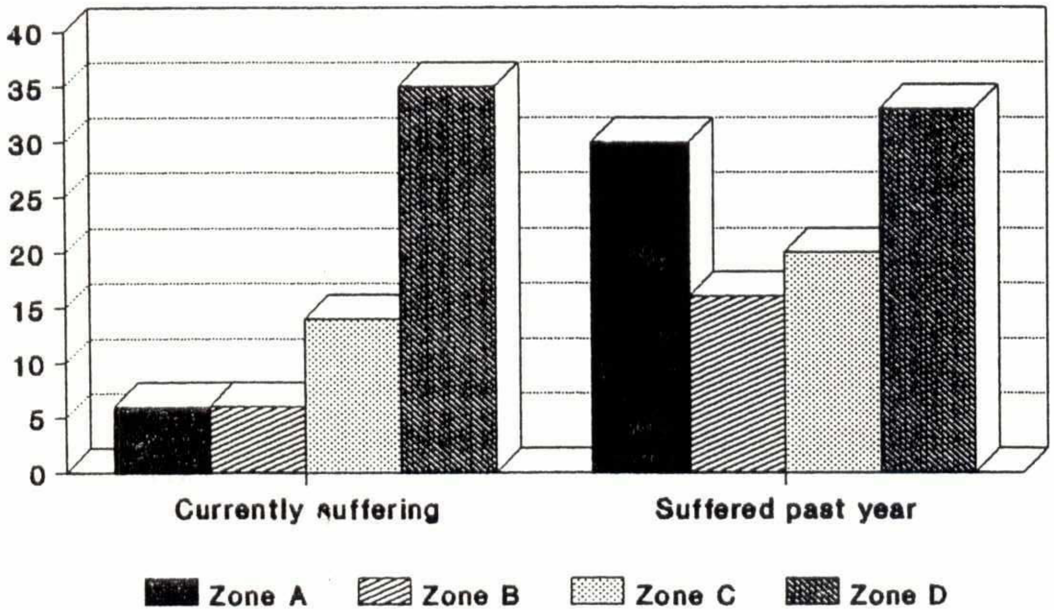
Diarrhoea during 1990
Thana wise reported cases from zone A



Civil Surgeon, Comilla

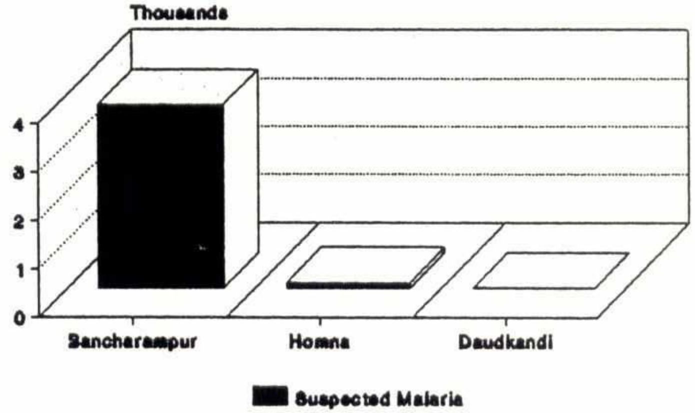
Prevalence of Malaria

Prevalence of Malaria
Currently and during past Year



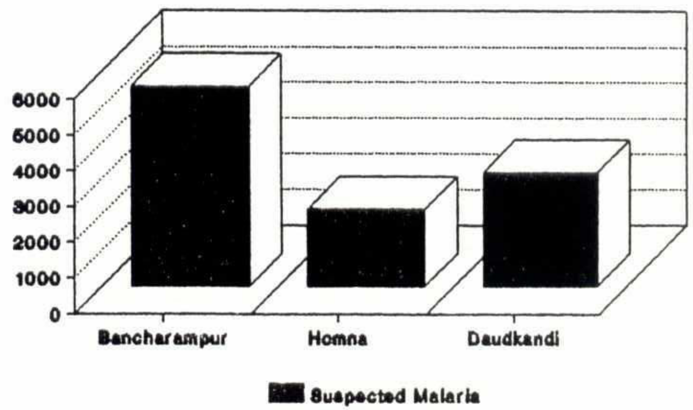
Field survey

Suspected Malaria During 1990
Thana wise reported cases from zone D



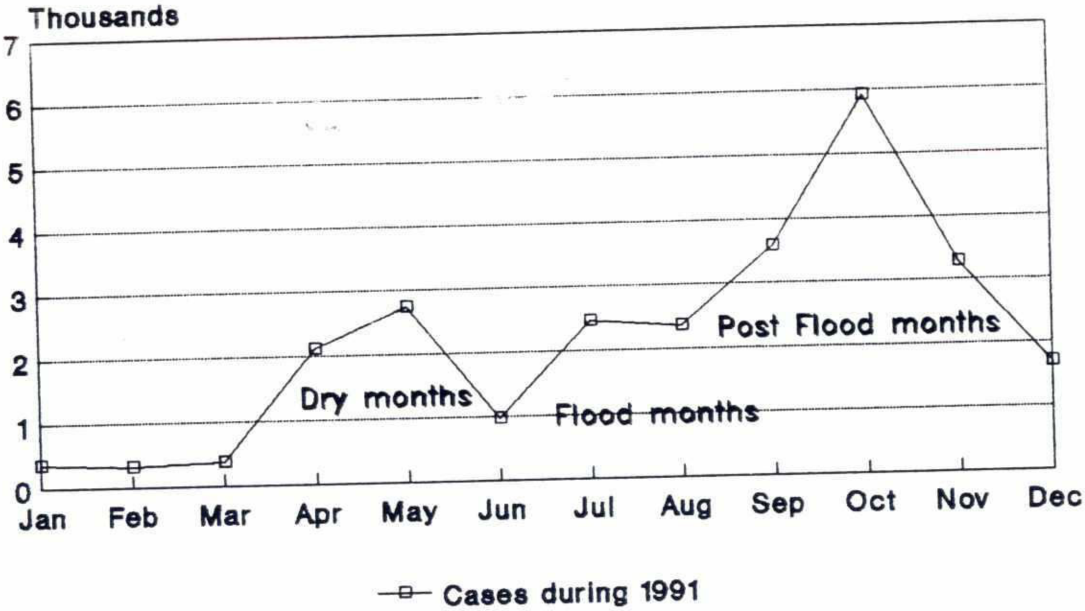
Civil Surgeon, Comilla

Suspected Malaria During 1991
Thana wise reported cases from zone D



IEDCR Source

Diarrhoea Case reporting
Comilla District



IEDCR

STUDY FINDINGS

The widespread public health problems of the country and the unacceptable high rates of acute and chronic undernutrition are also prevalent in the Gumti project. Focusing on the prevalence of waterborne diseases (diarrhoea, dysentery, cholera and skin disease), malaria, Kalazar (Leishmaniasis) and nutrition disorders which might be related to the land and water management system. This study found that the overall condition of the project area is the same as the whole nation. Below are some data on public health and nutrition status.

Prevalence rates	National (Rural)	Gumti project area This study
Diarrhoea	4.57 (Dec.,1990)	2
Night blindness	1.0% (Oct.,1992)	.62%
Severe wasting among children (MUAC <12.5 cms.)	12.0% (Oct.,1992)	19.7%
Chronic undernutrition among children(stunting)	69.7% (Oct.,1992)	59.27%
Actuate undernutrition among children (wasting)	17.6% (Oct.,1992)	10.9%

However the study found pockets of high prevailing Malaria. No Kalazar cases are reported by the GOB health MIS system. The overall prevalence rate of Goiter in the project area is 2.06%, this is much low than the average national prevalence rate (10.51%).

Use rates of Tube well water and Sanitary latrines in the project area are much higher than the national use rate. 98.7% households use of tube well water for drinking and 35.5% for washing purposes. 28.6% household have sanitary latrine (overall nationally only 7% household have sanitary latrines)

Differences are observed between the four zones in the cases of Malaria, Nutritional disorder (Iodine, vitamin A & vitamin B deficiencies), Diarrheal and skin diseases. Study findings are presented zone wise in tabular form.

Table 1: Households' landholding zone wise

Zones		Landless	Upto 0.5 Acres	.51-1.5 Acres	1.51-2.5 Acres	2.51-5.0 Acres	Above 5 Acres
A	#	11	22	17	04	07	08
	%	15.9 %	31.9 %	24.6 %	5.8 %	10.1 %	11.6 %
B	#	32	06	11	02	02	02
	%	58.2 %	10.9 %	20.0 %	3.6 %	3.6 %	3.6 %
C	#	23	11	09	04	03	07
	%	40.3 %	19.3 %	15.8 %	7.0 %	5.2 %	12.3 %
D	#	24	05	06	10	03	02
	%	48.0 %	10.0 %	12.0 %	20.0 %	6.0 %	4.0 %

The above table presented landholding by the households interviewed from the four zones, their number and percentages in different categories. Zone A appeared to be a well off area with less landless families and about 27.5% with land more than 1.51 acres. The land capability association study also depicted availability of good (class II) agriculture land in the sample area under Debidwar and Brahmanpara thanas. Zone B area has got over 70% household either landless or with land below 0.5 acres.

Table 2: Source of Drinking, washing and bathing water for the households

Zones	Drinking Water Source				Water source for Washing *				Water source for Bathing **			
	Tube well	River	Pond	Khal	Tube well	River	Pond	Khal	Tube well	River	Pond	Khal
A	98.58%	0	1.4%	0	36.23%	1.4%	66.1%	1.4%	6.56%	0	94.2%	1.4%
B	100%	0	0	0	49.1%	1.8%	52.7%	0	10.9%	0	89.1%	0
C	96.5%	0	3.5%	0	17.54%	0	78.9%	3.5%	3.5%	0	92.2%	5.3%
D	86%	0	0	14%	40%	0	0	60%	4%	20%	2%	74%

Note * Some house hold using multiple source of water for washing

** Some house hold using multiple source of water for bathing

Table 2. shows the use of water from different sources for drinking, washing and bathing purpose. Overall use of tube well water for drinking purpose in the project area is higher than national norm. However it is noticed that some 14% population from zone D are using khal water for drinking and 1.4% and 3.5% using pond water from zone A and zone B respectively

Table 3: Point prevalence of common disease among children < 5 years of age

Zones	Night Blindness	Angular Stomatitis	Anemia	Oedema
A	0	13.17 %	39.53 %	.77 %
B	1.85 %	18.54 %	18.54 %	0
C	0	10.21 %	27.73 %	.72 %
D	9.12 %	21.27 %	17.02 %	0
Overall	.62%	15.28%	26.45%	.41%

Table 3. presents the doctor's examination results (point prevalence) of some common disease among the surveyed 484 children in the four zones. Night blindness and angular stomatitis are caused due to lack of vitamin A and Vitamin B nutrient deficiencies. High prevalence of these two common nutrient deficiencies; night blindness (9.12%) angular stomatitis (21.27%) are found among the under five years population in zone D area.

The prevalence of night blindness here is almost ten times more than the national norm (1% in 1992).

To identify the causes the in depth community interviews in Zone D found less production of and use of green leafy vegetable the source of vitamins "A" and "B" here.

Table 4: Common disease in the surveyed household. Percentage of population currently suffering (point prevalence).

Zones	Diarrhoea	Dysentery	Malaria	Scabies	XN
A	3.56 %	5.74 %	1.19 %	8.12 %	3.87 %
B	1.64 %	6.83 %	1.64 %	20.49 %	.59 %
C	.99 %	5.97 %	3.48 %	12.19 %	2.70 %
D	.97 %	1.94 %	11.29 %	15.48 %	1.40 %

231 household were surveyed and disease profile of their 1583 members were asked. The above table present the sicknesses at the time of the survey. Diarrhoea in general and night blindness among under 15 years children were found at a higher rate in zone A villages. A very high rate (11.29%) of malaria in zone D and Scabies (20.49%) in zone B were notices.

Table 5: Use of Water Sealed Latrine by the Household

Area	Having Water Sealed Latrine		Using Water Sealed Latrine	
	#	%	#	%
Zone-A	20	28.98	20	28.98
Zone-B	24	43.64	24	43.64
Zone-C	13	22.80	13	22.80
Zone-D	09	18.00	09	18.00

The above table shows the use of water sealed latrine in the four zones. Despite the overall use rate of sanitary latrine in the project area being much higher than the national figure (7%) still two thirds of the households are defecating on open ground risking widespread diarrhoea and polio. The situation is particularly alarming in Zone D areas (use rate only 18%) Use rate in Zone D

Table 6: Nutritional Status of Children < 5 Years of Age.

Zones	Wt/Age <60%	Wt/Ht <80 %	Ht/Age <90 %	MUAC<12.5%
A	13.95	12.40	64.34	27.90
B	4.83	12.09	58.87	12.09
C	6.56	8.75	51.09	17.51
D	11.70	10.63	62.77	21.27

Table 6. presents the results of the anthropometric measurements of the 484 children examined in the four zones. Wt. for Age, Wt. for Ht., Ht. for age and MUAC measurements were compared with the nutritional level criterion. Figures presented are in percentage of children under each category. Higher rates of wastage (Wt. for age <60% and MUAC <12.5 cms. and stunted (Ht. for age <90%) children were found from Zone A and D.

Table 7. Food consumption (Dal, meat, Fish and Dry fish) by the household members during last week

Consumption of food items	Dal			Meat			Fish			Dry fish		
	Last meal	last 3 days	last week	Last meal	Last 3 days	Last week	Last meal	Last 3 days	Last week	Last meal	Last 3 days	Last week
Zone A	37.7	58.4	93.1	4.3	7.2	23.1	55.1	88.4	100	24.6	52.1	76.7
Zone B	32.7	54.5	74.5	1.8	10.9	23.6	58.2	85.5	91	21.8	47.2	65.4
Zone C	17.5	43.8	66.6	1.7	7	22.8	56.1	89.4	94.6	14	35	50.1
Zone D	14	24	32	0	2	14	68	96	100	14	43	65

In order to establish any possible relation between the nutritional status of the children and the food intake behaviour, consumption of animal and vegetable protein by the families were assessed.

Households were asked to mentioned intake of dal (pulse), meat, fish and dry fish during last meal, last three days and last week. The above table presents percentage of household from the four zone responded under each category.

As regards meat & Dal households of zone D have reported a very low intake. Only 14% of the household from this zone consumed meat during last week as against 22% - 23% from other zones. Consumption of Dal a cheap source of protein is also very low here. Only 32% of the households took Dal during last week while the rate of consumption of the same is two to three fold higher in other zones (66%, 74% and 93%).

Fish and vegetable were the main food items consumed in addition to a staple grain. Fish was the leading source of protein. Around 60% household reported consumption of fish during last meal, 90% within last 3 days and almost 100% within the past week.

Regular consumption of vegetable is quite high in the project area. 80% of the households from zone A, 76% from zone B, 63% from zone C and 66% from zone D have reported regular consumption of vegetable.

Table 8: Source of Fish by Household

Area	Own Pond		Market		Khal	
	#	%	#	%	#	%
Zone-A	15	21.73	55	79.71	12	17.39
Zone-B	07	12.73	49	89.09	02	03.64
Zone-C	09	15.78	51	89.47	05	08.78
Zone-D	00	00.00	33	66.00	17	34.00

Table 8 projects the source of fish for the households studied. Fishes are mostly purchased from the market. In zone A about 22% household have fish from own pond while the same is 13% and 16% respectively from zone B and C. No households from zone D reported pond as a source of their fish. About one third of the household from zone D reported khal as their source of fish.

Table 9: Source of Dry Fish By Household

Area	Home Dried		Market	
	#	%	#	%
Zone-A	02	02.89	63	91.30
Zone-B	00	00.00	55	100.00
Zone-C	07	12.28	39	68.42
Zone-D	15	30.00	35	70.00

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The above table shows the source of dry fish. Like fishes, most dry fishes were also purchased from the market. Zone A (91.3%) and B (100%) have higher dependency on market source. 12% and 30% from zone C and D respectively have home dried dry fish.

Table 10: Source of Dal By Household

Area	Own Field		Market	
	#	%	#	%
Zone-A	01	01.44	66	95.65
Zone-B	00	00.00	54	98.18
Zone-C	05	08.77	49	85.96
Zone-D	00	00.00	49	98.00

Table 10 shows that most households have to purchase Dal from market while a very insignificant number of houses (1.44% in zone A and 8.7% in zone B) gets dal from their own field.

Dal a rabi crop is grown less in the project area, in general, and in zone B and D in particular.

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APPENDIX H.V

WATER QUALITY SURVEY REPORT

APPENDIX H.V - WATER QUALITY SURVEY REPORT

1. Introduction

The Meghna, main river of the Gumti Project, carries approximately 24,000 tons of waste water per day from the Zia Fertilizer Factory effluent near Bhairab Bazaar and flows into the Bay of Bengal passing across the south-eastern zone of the country. This river also suffers much navigation activities near Daudkandi and at Chandpur. Other two rivers, Gumti and Salda, carry huge amounts of silt and sands along with flash floods from the Tripura Hills in India and flows to the main River Meghna passing behind most of the thanas of the Comilla district.

Titas and some other sub-rivers of the Meghna such as Jamuna, Arsi, etc. have constructed a cross drainage system within the project boundary and most of these rivers are connected with khals, canals, beels, flood lands, ponds and tanks. The Titas River is connected with Chandal beel which is the only perennial beel of the project area and three other flood water fed beels such as Satdona beel, Kunigara beel and Korikandi beel. All these surface water bodies make a major contribution to the general economy of the Comilla district by providing facilities in different sectors like irrigation, navigation, fisheries, livestock, etc. Development in all these sectors is mostly bound by fresh water availability in all of these rivers, khals, beels, etc. It is therefore of prime importance to maintain fresh water ecological conditions to ensure sustainable development and safe environment in the concern areas.

2. Review of Data

Department of Environment, Government of Bangladesh has been monitoring water quality of Meghna-Dakatia confluence near Chandpur town as a part of their monthly environment pollution control programme. Water quality parameters covered for this work are temperature, pH, electrical conductivity (EC), total alkalinity (TA), total solids (TS), suspended solids (SS), total dissolved solids (TDS), total volatile solids (TVS), total dissolved volatile solids (TDVS), dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), chloride, ammonia, nitrate, chromium, turbidity and *coli* colonies. ICDDR,B, Matlab, Chandpur also conducted some microbiological tests for Meghna River water in some seriously diarrhoea affected areas in and around the Matlab thana of Chandpur district as a part of their diarrhoeal disease research programme in Bangladesh. However, data for the above parameters are not enough for water quality study of the Meghna River in environmental perspectives of Bangladesh as because some important determinants such as phosphate and silica as nutrients, potassium and zinc as micro-nutrients, iodine, and residual organo-chlorine pesticides were not included in any of these studies. Moreover, no data is available for the Rivers Gumti, Salda, Hawrah and Bijni, those coming from the Tripura Hills of India and sub-rivers of the Meghna such as Titas, Madhurupi, Arsi, Havatia, etc. and some others. Water quality of other surface water channels such as beels, flood lands, canals, khals, ponds, tanks, etc. of the Gumti Project is completely non-existent.

3. Work Programme

This work programme aims at water quality study for the main river Meghna in the upstream and downstream areas, Rivers Gumti and Salda at entering points near the Indian border, internal rivers and khals, confluences of main river and internal rivers, beels and flood lands from areas of potential agrochemical pollution, ponds and tanks, etc.

A total number of twenty water bodies, as listed in Table 1 and Table 2, were included for this study. Exact location of all the water bodies, and study area for the Gumti Phase II are shown in Figure 1. Water samples were collected from all the sampling sites during the month of October and November and then analysed for parameters as in Table 1 for wet season water quality data. Seasonal variation was also measured for some selected water bodies by collecting another set of samples during the month of February and March from exactly the same locations and analysing the parameters as in Table 2 for dry season water quality data.

4. Methodology

Grab sampling method (WHO, 1987) was followed for collection of samples and water samples were taken at a depth of 1 feet from the surface of the water body. A hand operated pump made of G.I. pipe was used for this purpose. All collected samples were filled in 1 litre polyethylene bottles except those for organochlorine pesticides analysis where 1 litre amber glass bottles were used. Standard washing procedure (WHO, 1987) was followed for cleaning sample bottles before filling with water samples. All collected samples were stored at 4^0C in ice-boxes for laboratory analysis within 6 hrs. from the time of collection.

Temperature and conductivity were recorded on-site using a portable WTW Microprocessor Conductivity Meter LF 196. pH, DO and CO_2 were also measured on-site with the help of HACH Water Quality Test Kit, Model FF-1A, USA. Measurement of nitrate and phosphate was conducted following UV - Visible spectrophotometric method (APHA - AWWA - WPCF, 1980). Iodine was determined by ion-selective electrode method (Billah, M., Tarfdur, S.A., and Hadi, A., 1989). Parameters like potassium, zinc and iron were measured following atomic absorption spectrophotometric method (APHA - AWWA -WPCF, 1980). Silica and sulphate were determined by gravimetric method (ASTM, 1987). Determination of $CaC0_3$ and NaCl was completed following EDTA and silver nitrate titrimetric methods, respectively (APHA - AWWA - WPCF, 1980). Microbiological analysis was completed following faecal coliform membrane filter procedure (APHA - AWWA - WPCF, 1980). Analysis of residual pesticides was conducted at the Institute of Food and Radiation Biology, AERE, Savar using PU 4500 gas chromatography (DFG, 1987).

5. Results and Discussion

Results of water analysis for the wet season and dry season are presented in Table 1 and Table 2, respectively. Water quality standards for Bangladesh (Department of Environment, 1991) are also put under each parameter for comparison.

It is seen from Table 1 that the recorded temperatures for different surface water channels varied from 26^0C to 30^0C during the wet season i.e., a difference of 4^0C is measured. Dry season temperature measurements (Table 2) also showed a difference of 3.4^0C between the maximum and minimum recorded temperatures of 25.6^0C and 22.2^0C, respectively. These variations in temperature measurements were mainly due to time difference during sampling period. However, the recorded values lie within the standard limit for Bangladesh.

Results of pH measurements for the wet season indicated that water samples from most of the ponds had higher values ranging from 7.7 to 8 in comparison to the rivers and beels. Out of all the rivers, water quality for the Gumti River was found to be more alkaline in nature with pH values 7.6 and 7.7 for sample codes 12 and 19, respectively.

Figure 1

Site Locations for Water Quality Data Collection

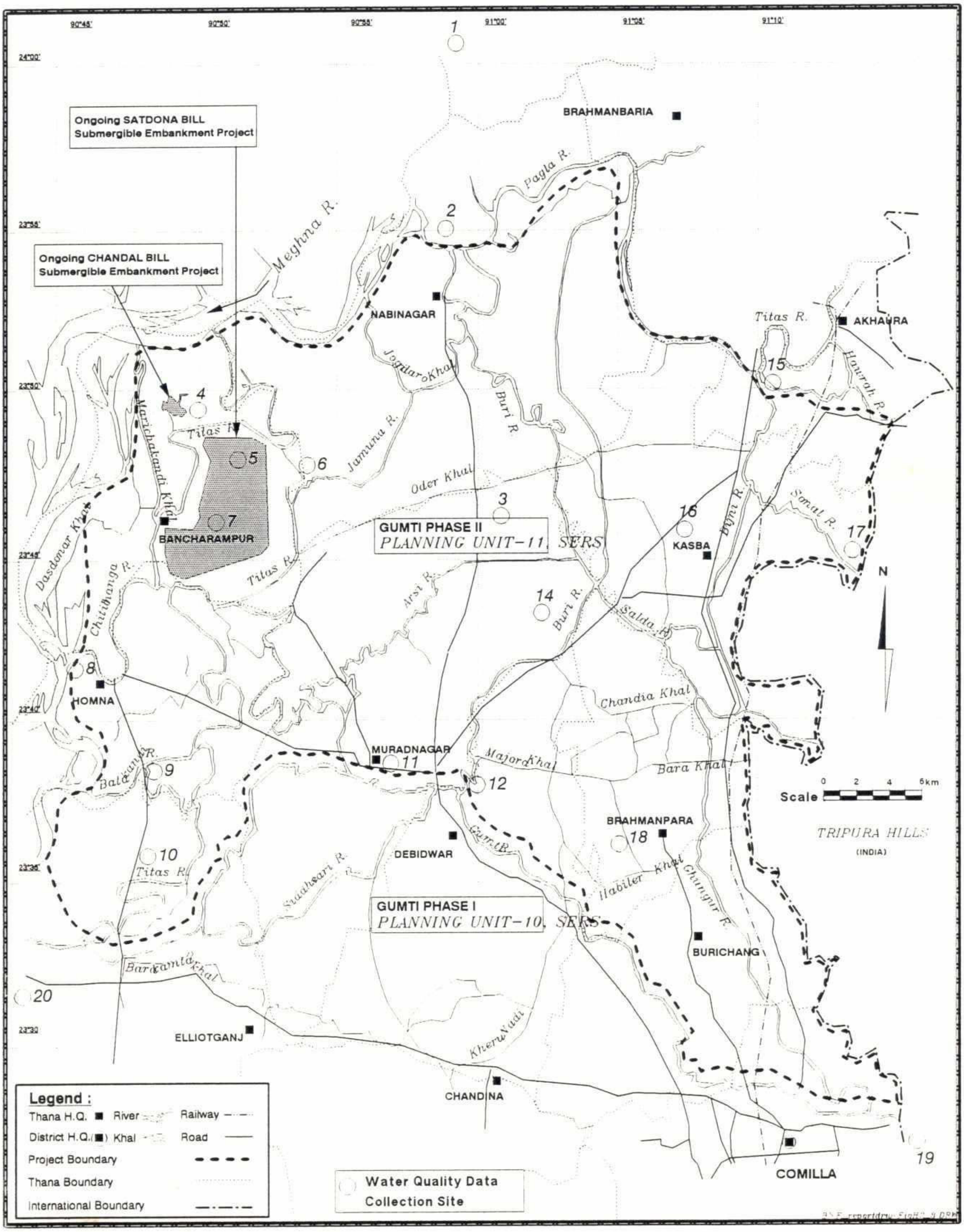

TABLE 1 SPREADSHEET FOR WET SEASON (OCT – NOV, 1992)

Sl. No.	Name of the Water Body	Sample Code	Description	Date/ Time	Temperature degree	pH	DO mg/l	CO2 mg/l	CaC03 mg/l g/l	Nitrate mg/l	Phosphate mg/l	Iodine mg/l	Silica mg/l	Potassium mg/l	Zinc µg/l	Sulphate mg/l	Iron mg/l	NaCl mg/l	Total Coliform n/100 ml.	Faecal Californ n/100 ml.	Total Bacterial Count/ml	DDT µg/l	DDE µg/l
							CHEMICAL ANALYSIS												MICROBIOLOGICAL ANALYSIS			RESIDUAL PESTICIDES ANALYSIS	
1.	Arsi River	13	Slowly running water; Slightly brown colour; Water hyacinth partly; Sunny morning.	25.10.92 08:30 Hrs.	27.5	7.4	10	14	35	Lost	1.9	<0.01	21.6	2.5	8.3	0.33	0.59	30	3000	3000	>1000	?	?
2.	Dalpar Beel (Flood land)	14	Stagnant water; Greenish brown colour; Submerged vegetation; Sunny morning	25.10.92 10:40 Hrs.	28.5	7.4	12	10	32	Lost	0.93	<0.01	8.4	2.8	23.3	0.49	0.45	25	800	600	>1000	?	?
3.	Madrasa Masji Pond	11	Stagnant water; Pale green colour; Green algae partly; Domestic use; Sunny morning.	26.10.92 07:45 Hrs.	28	7.7	8.5	15	85	Lost	2	0.01	9.6	8	15.1	5.3	0.37	200	4000	3400	>1000	?	?
4.	Ruhitar Beel (Pond)	8	Stagnant water; Pale green colour; Fishing pond; Sunny day.	26.10.92 11:15 Hrs.	29	6.8	9	12	17	Lost	1.9	<0.01	12	1.3	13	4.1	0.07	20	180	70	>1000	?	?
5.	Thana Head Quarter Pond	7	Stagnant water; Greenish brown colour; Green algae partly; Domestic use; Sunny morning.	27.10.92 09:15 Hrs.	29	8	11	12	70	Lost	6.5	0.01	19.6	5.1	15.1	1.5	0.19	100	2000	410	>1000	?	?
6.	Chanduna Beel	4	Stagnant water; Pale blue colour; Sunny day.	27.10.92 10:00 Hrs.	29	7.5	10	8	30	Lost	3.8	0.02	2.4	1.4	6.2	1.3	0.45	35	210	100	>1000	?	?
7.	Titas River	6	Running water; Slightly brown colour; Water hyacinth partly; Sunny day.	27.10.92 11:00 Hrs.	28.5	7.4	11	9	23	Lost	4.8	<0.01	12.4	1.3	16.7	0.66	1	55	2000	1000	>1000	?	?
8.	Satdona Beel	5	Stagnant water; Pale green colour; Slightly turbid; Water hyacinth mostly; Sunny day.	27.10.92 12:15 Hrs.	30	7.5	8.5	10	31	Lost	4.1	0.01	11.2	1.1	12.5	0.33	0.4	42	2000	100	>1000	?	?
9.	Havatia River	9	Slowly running water; Slightly brown colour; Clear water; Sunny day.	28.10.92 10:30 Hrs.	28.5	7.1	8	12	38	Lost	4.2	<0.01	6.8	1.5	11	1.7	0.45	58	3000	1000	>1000	?	?
10.	Korikandi Bee (Flood land)	10	Slowly running water; Greenish brown colour; Clear water; Sunny day.	28.10.92 11:45 Hrs.	29	7.4	9	11	46	Lost	3.8	<0.01	8.4	0.82	13.9	1.2	0.27	36	4000	3000	>1000	?	?
11.	Meghna River	20	Running water; Slightly brown colour; Navigation use; Sunny day	28.10.92 12:50 Hrs.	28.5	7.2	9	12	30	Lost	4.7	<0.01	20.4	1.3	9	1.3	0.68	42	8000	5000	>1000	?	?
12.	Confluence of Titas, Bijni & Hawrah Rivers	15	Slowly running water; Slightly brown colour; Sunny morning.	8.11.92 08:00 Hrs.	26	7.1	13	15	42	10	8.6	<0.01	27.2	2.8	10.5	0.82	2.2	70	840	720	>1000	?	?
13.	Kunigara Beel (Flood land)	3	Stagnant water; Slightly brown colour; HYV crops cultivation; Sunny day;	8.11.92 11:00 Hrs.	28	7.4	10.5	10	26	8.8	10	<0.01	23.6	1.6	18.3	1.2	2.1	38	20	5	>1000	?	?
14.	Meghna River	1	Running water; Greenish brown colour; Navigation use; Sunny day.	8.11.92 12:15 Hrs.	28	7.5	11	8	32	8.8	6.3	0.01	5.6	1.2	22.1	1.7	0.5	40	200	240	>1000	?	?
15.	Titas River	2	Running water; Pale green colour. Water hyacinth partly; Sunny day.	8.11.92 12:30 Hrs.	28	7.5	11	7	32	5.6	9.2	<0.01	9.2	1.4	13.1	1.7	0.45	40	580	480	>1000	?	?
16.	Gumti River	19	Running water; Slightly brown colour; Partly turbid; Sunny morning.	9.11.92 08:10 Hrs.	26	7.7	13	10	65	9	5.4	<0.01	33.2	2.3	17	1.3	0.51	35	1040	900	>1000	?	?
17.	Naigor Beel	18	Stagnant water; Slightly brown colour; Water hyacinth; HYV crops Cultivation; Sunny da	9.11.92 10:00 Hrs.	28	7.1	10.5	12	31	13.8	3.9	<0.01	16.8	2.2	11.6	1.7	0.86	38	1080	1000	>1000	0.006	0.1
18.	Salda River	17	Slowly running water; Deep brown colour; Partly turbid; Sunny day.	9.11.92 11:45 Hrs.	27	7.4	11	11	22	7.5	2.9	<0.01	36	3	13.3	1.3	1.1	36	1420	1200	>1000	?	?
19.	Kallayan Saga (Pond)	16	Stagnant water; Pale green colour Green algae partly; Domestic use; Sunny day.	9.11.92 12:30 Hrs.	29	7.7	13.5	8	16	6.9	4	0.01	8.8	3.6	11.6	1.2	0.76	45	5520	2200	>1000	?	?
20.	Gumti River	12	Slowly running water; Slightly brown colour; Sunny day.	9.11.92 13:30 Hrs.	27	7.6	11.5	10	50	10	1.3	0.01	32.4	2.2	8.2	1.5	0.52	40	2120	1360	>1000	?	?
	ENVIRONMENTAL QUALITY STANDARDS (EQS) FOR BANGLADESH, JULY 1991		Recreational Water		20-30	6-9.5	4-5	NYS	NYS	NYS	6	NYS	NYS	NYS	NYS	NYS	NYS	NYS	200	NYS	?	0	?
			Fishing Water		20-30	6.5-8.5	4-6	6	80-120	NYS	10	NYS	NYS	NYS	10000	NYS	NYS	NYS	5000	NYS	?	NYS	?
			Irrigation Water		20-30	6-8.5	5	NYS	NYS	NYS	10	NYS	NYS	NYS	5000	1000	NYS	NYS	1000	10	?	NYS	?
			Drinking Water		20-30	6.5-8.5	6	NYS	200-500	10	6	NYS	NYS	12	5000	400	0.3-1	NYS	2	0	?	0	?

LEGEND:

DO = Dissolved Oxygen; CaCo3 = Calcium Carbonate; CO2 = Carbon-dioxide; NaCl = Sodium Chloride; DDT = Dichloro Diphenyi Trichloroethane; DDE = Dichloro Diphenyl Ethylene Dichloride; NYS = Not Yet Specified.

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TABLE 2 SPREADSHEET FOR DRY SEASON (FEB – MARCH, 1993)

Sl. No.	Name of the Water Body	Sample code	Description	Date/ Time	Temper ture degree C	pH	DO mg/l	CO2 mg/l	EC µS/cm	CaCO3 mg/l	CHEMICAL ANALYSIS Ni-trate mg/l	Phos-phate mg/l	Iodine mg/l	Silica mg/l	Potassium mg/l	Zinc µg/l	Sulphate mg/l	Iron mg/l	NaCl mg/l	MICROBIOLOGICAL ANALYSIS Total coliform n/100ml	Faecal coliform n/100ml	Total Bacterial Count/ml	RESIDUAL PESTICIDES ANALYSIS DDT µg/l	DDE µg/l
1	Arsi Rever	13	Stagnant water; Pale brown colour; Sunny day.	13-02-93 10:00 Hrs.	23.2	8	10	20	387	188	12.7	?	?	?	?	?	?	?	125	4000	1000	>1000	?	?
2	Dalpar Beel (Flood land)	14	Completely dry	12-02-93 10:10 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
3	Madrasa Masjid Pond	11	Stagnant water; Pale green colour; Domestic use; Sunny day.	8-02-93 15:30 Hrs.	25.6	8	9.5	22	445	119	1.5	2	0.02	13.2	13.5	15	6.2	0.14	230	1850	800	>1000	?	?
4	Ruhitar Beel (Pond)	8	Stagnant water; Slightly brown Colour Fishing pond; Sunny day.	8-02-93 11:50 Hrs.	25	7.1	10	10	46	15	5.5	?	?	?	?	?	?	?	60	850	750	>1000	?	?
5	Thana Head Quarter Pond	7	Stagnant water; Green colour; Domestic use; Sunny morning.	10-02-93 09:35 Hrs.	22.5	8.8	11	6	169	54	9.3	4.1	?	?	?	?	?	?	130	15000	3000	>1000	?	?
6	Chanduna Beel	4	Stagnant water; Pale blue colour; Sunny day.	10-02-93 11:30 Hrs.	24.7	8	14	8	161	102	2.5	1.3	0.01	2	1.6	10	2.2	0.21	65	90	60	>1000	?	?
7	Titas River	6	Running water; Pale green colour; Water hyacinth; Sunny day.	10-02-93 12:00 Hrs.	23.5	7.7	12	16	206	119	12.5	?	?	?	?	19	?	?	70	1700	1450	>1000	?	?
8	Satdona Beel	5	Mostly dry and covered with hyacinth.	10-02-93 13:30 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
9	Havatia River	9	Running water; Greenish brown colour Water hyacinth partly; Sunny morning	8-02-93 10:30 Hrs.	22.2	7.5	11	12	113	70	4.5	?	?	?	?	?	?	?	50	2750	2200	>1000	?	?
10	Korikandi Beel (Flood land)	10	Completely dry.	8-02-93 10:00 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
11	Meghna River	20	Running water; Greenish brown colour Navigation use; Sunny day.	8-02-93 13:05 Hrs.	24.1	7.6	10	15	97	48	1	1.8	0.01	10.4	1.9	14.8	5.6	0.54	70	1450	1050	>1000	?	?
12	Confluence of Titas, Bijni & Hawrah Rivers	15	Stagnant water; Greenish brown colour Sunny morning.	12-02-93 10:50 Hrs.	23.2	7.7	13.5	18	257	120	?	1.4	?	?	?	?	?	0.6	60	1000	30	>1000	?	?
13	Kunigara Beel (Flood land)	3	Completely dry	13-02-93 11:10 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
14	Meghna River	1	Slowly running water; Pale green colo Sunny day.	13-02-93 11:50 Hrs.	23.3	7.7	11.5	8	99	52	?	?	?	?	?	7.5	?	?	58	101	80	>1000	?	?
15	Titas River	2	Slowly running water; Pale green colo Sunny day.	13-02-93 12:25 Hrs.	24	7.7	11	7	98	51	4.7	1.3	0.02	2.5	0.73	19.5	6.8	0.32	60	650	590	>1000	?	?
16	Gumti River	19	Slowly running water; Pale brown colo Sunny day.	15-02-93 12:40 Hrs.	25.5	7.8	13	9	93	45	?	?	?	?	?	?	?	?	50	8000	3000	>1000	?	?
17	Naigor Beel	18	Mostly dry and irrigated	15-02-93 10:45 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
18	Salda River	17	Slowly running water; Brown colour; Very turbid; Sunny day.	12-02-93 12:05 Hrs.	24	7.6	12	16	155	66	?	?	?	34	?	?	?	?	65	25000	10000	>1000	?	?
19	Kallayan Sagar (Pond)	16	Stagnant water; Greenish brown colour Water hyncinth partly; Sunny day.	12-02-93 13:00 Hrs.	25.5	7.8	14	6	62	16	4.7	?	?	?	?	?	?	?	70	7000	5000	>1000	?	?
20	Gumti River	12	Slowly running water; Brown colour; Sunny day.	8-02-93 16:10 Hrs.	23.2	7.7	12	10	91	40	5	2.7	0.01	13.6	2.1	11	3.6	0.17	50	800	600	>1000	?	?
ENVIRONMENTAL QUALITY STANDARDS FOR BANGLADESH, JULY 1991			Recreational Water		20-30	6-9.5	4-5	NYS	500	NYS	NYS	6	NYS	NYS	NYS	NYS	NYS	NYS	NYS	200	NYS	?	0	?
			Fishing Water		20-30	6.5-8.5	4-6	6	800-1000	80-120	NYS	10	NYS	NYS	NYS	10000	NYS	NYS	NYS	5000	NYS	?	NYS	?
			Irrigation Water		20-30	6-8.5	5	NYS	2000	NYS	NYS	?	NYS	NYS	NYS	5000	1000	NYS	NYS	1000	10	?	NYS	?
			Drinking Water		20-30	6.5-8.5	6	NYS	?	200-500	10	6	NYS	NYS	12	5000	400	0.3-1	NYS	2	0	?	0	?

LEGEND:

DO=Dissolved Oxygen; CO2=Carbon-dioxide; EC = Electrical Conductivity; CaCO3 = Calcium Carbonate; NaCl=Sodium Chloride; DDT=Dichloro Diphenyl Trichlor oethane; DDE=Dichloro Diphenyl Ethylene Dichloride; NYS=Not Yet Specified.

This might be due to huge amount of silt and sand coming into this river from the flash floods of Tripura Hills near the Indian border. Water quality for the Rivers Meghna and Titas in the upstream areas and those for the Chandal beel and Satdona beel were also alkaline as represented by the average pH of 7.5. pH value for the Meghna River near Daudkandi (code 20) was measured unexpectedly low (pH = 7.2). Water quality of this location might have affected by the effluent discharges from the cold storage near the sampling site. pH value for the rest water bodies varied from 6.8 to 7.4 showing an average alkaline trend for the whole project area. Data for dry season indicated an overall increase in pH from those for the wet season and ranged in between 7.1 and 8.8. None of the measured values exceeded the standard set by the Government of Bangladesh.

Dissolved oxygen (DO) concentration for all the sampling locations was measured sufficiently high in respect of 4-5 mg/l of Bangladesh standard. Maximum values for dry and wet season were recorded as 14 mg/l and 13.5 mg/l, respectively. Complete saturation of atmospheric oxygen into the surface water layer was responsible for the higher values. Increasing trend in DO during the dry season was due to increased solubility of atmospheric oxygen at slightly lower temperatures during that period.

Measurement of free carbon-dioxide varied from 7 mg/l to 15 mg/l and 6 mg/l to 22 mg/l during the wet season and dry season, respectively. No Bangladesh standard has yet settled for recreational water for this parameter. However, a maximum of 6 mg/l of carbon-dioxide has been recommended for fishing water and most of the measured values are quite high compared to this standard.

Electrical conductivity for the different water samples could not be measured during the wet season. However, those for the dry season have been measured and results of measurement (Table 2) showed that the main River Meghna has an average EC of 98 μS/cm which is approximately one fifth of 500 μS/cm Bangladesh standard. In case of sub-rivers, which had less water flow and those which were found in stagnant water conditions, EC values varied from 91 μS/cm to 206 μS/cm and 257 μS/cm to 387 μS/cm, respectively. Electrical conductivity for beel and pond waters were measured very low (46 μS/cm - 169 μS/cm) except in case of Madrasa Masjid Pond with sample code 11. Al the measured values are expected to decrease further during the wet season due to dilution effect of rain fed water.

Wet season data for calcium carbonate measurements showed values of 85 mg/l and 70 mg/l for two pond waters in the south-central and north-western part of the project area with sample codes 11 and 7, respectively. So, water quality for these two ponds is regarded as medium-hard. Water samples from the Gumti River (codes 12 and 19) were found to be soft water and medium-hard water as represented by 50 mg/l and 65 mg/l of $CaCO_3$, respectively. All other water bodies including the main River Meghna, sub-rivers, beels, etc. showed hardness value less than 50 and those were soft waters. Data for dry season measurements indicated that all the estimated values were below 121 mg/l of $CaCO_3$, except in case of Arsi River with code 13. Hardness data for this river water was estimated 188 mg/l in place of 35 mg/l for the wet season and this increase in $CaCO_3$ concentration was expected due to evaporation effect during the dry season. Bangladesh standard for $CaCO_3$ hardness for recreational water has not yet settled. However, the experimental data depicted an average soft to medium-hard water for the Gumti Project.

Nitrate in water for wet season could not be determined for all locations and for dry season it was measured only for some selected water bodies. However, results for wet season measurements showed that Naigor beel having sample code 18 contained the highest concentration of nitrate (13.8 mg/l). This was probably due to leachate of nitrogeneouos fertilizer from HYV crops field surrounding this beel. Nitrate for the River Gumti and confluence of Titas, Bijni and Hawrah Rivers was measured 10 mg/l, whereas for the Meghna and all other water bodies it varied from 5.6 mg/l to 9 mg/l. Data in Table 2 shows a decreasing trend in nitrate concentration for sample codes 2, 16 and 12. This might be due to denitrifying bacterial action into those water bodies during the dry season. It is also seen from Table 2 that, Arsi River (code 13) and Titas River (code 6) contained higher values of nitrate, 12.7 mg/l and 12.5 mg/l, respectively and the minimum concentration (1 mg/l) was measured for the Meghna River. However, analysis of data in Table 1 and Table 2 shows that average nitrate concentration for the wet season and dry season was 8.9 mg/l and 5.8 mg/l, respectively which are below the drinking water quality standard for Bangladesh (10 mg/l) and these figures give clear indication for nitrate deficiency in the surface water channels of the studied project.

Results of phosphate determination for the wet season showed that water samples from Rivers Meghna and Titas in the upstream areas and that from the confluence of Titas, Bijni, and Hawrah Rivers contained higher concentration of phosphate in comparison to 6 mg/l of Bangladesh standard. Phosphate concentration for other rivers ranged in between 1.3 mg/l and 5.4 mg/l. In case of beel and pond waters most of the samples exhibited lower value usually less than 6 mg/l. Data for dry season indicated a decrease in almost all locations and an average concentration of 2 mg/l of phosphate has been recorded.

Water samples were examined for low iodine content and results of examination for wet season showed very low values usually less than 0.01 mg/l of iodine for most of the river and beel waters. But for pond waters, slightly higher concentration (0.01 mg/l) was measured. The maximum value was 0.02 mg/l for the Chandal beel water with sample code 4. Data for dry season indicated slight increase in iodine content with an average of 0.014 mg/l for the river, beel and pond waters.

Wet season data for silica measurements indicated that river waters contained higher concentrations of silica than beel and pond waters. Tidal effect in rivers was probably the main reason for those higher concentrations. Among the rivers, variation in silica concentration was from 5.6 mg/l to 36 mg/l with the maximum value recorded for Salda River (code 17) near the Indian border. Gumti River also showed higher values with an average concentration of 32.8 mg/l. Higher silica in these two rivers was due to inflow of sandy materials from the Indian hills adjacent to the border. Confluence of Titas, Bijni and Hawrah Rivers, Arsi River, and the main River Meghna near Daudkandi also showed slightly higher values ranging from 27.2 mg/l to 20.4 mg/l of silica. Silica content in beel and pond waters ranged from 2.4 mg/l to 23.6 mg/l and 8.8 mg/l to 19.6 mg/l, respectively. In case of beels, the minimum value was recorded for Chandal beel (code 4). This beel is a perennial beel with very clear and pale blue water. Minimum silica content in this beel water is therefore quite expected. Data for dry season measurements (Table 2) clearly indicates a decrease in silica content for the river and beel waters. This might be due to less water flow and ultimate sedimentation of silica compounds during the dry season.

It is seen from wet season data that concentration of potassium in river and beel water varied from 1.2 mg/l to 3 mg/l and 0.82 mg/l to 2.8 mg/l, respectively. It is also seen that pond water contained slightly higher concentrations compared to those for river and beel waters with the minimum and maximum values of 1.3 mg/l and 8 mg/l for Ruhitar beel (code 8) and Madrasa Masjid Pond (code 11), respectively. Analysis of data in Table 1 indicates that river and beel waters from the north-western region have slightly higher trend in potassium content in respect to those from the other areas. Type of soil in the concern areas might be the reason for this fact. Results of dry season measurements revealed that potassium content in the Madrasa Masjid Pond increased from 8 mg/l to 13.5 mg/l and this was the only measured value which closely approximated the Bangladesh drinking water standard of 12 mg/l. All other measured figures for both wet and dry season were well below the standard figure and these facts clearly predicts potassium deficiency in the surface water bodies of the Gumti Project.

Results of zinc measurement in river waters for the wet season showed a wide variation ranging from 8.2 $\mu g/l$ to 22.1 $\mu g/l$ with an average concentration of 12.9 $\mu g/l$. Data for beel waters also exhibited much variations from 6.2 $\mu g/l$ to 23.3 $\mu g/l$. But those for pond waters did not vary too much and ranged in between 11.6 $\mu g/l$ to 15.1 $\mu g/l$. For dry season, all measured data showed slight increase in zinc concentrations except that for the Meghna upstream area and the average concentration is calculated as 13.8 $\mu g/l$. However, none of the measured values approximated water quality standards for Bangladesh and all are several hundred times below than the Bangladesh standard. Surface water quality of the studied area is therefore extremely poor in zinc as a micronutrient.

Data in Table 1 and Table 2 showed that sulphate content in the river and beel waters varied from 0.33 mg/l to 1.7 mg/l and from 2.2 mg/l to 6.8 mg/l for the wet season and dry season, respectively. But in case of pond water, slightly higher concentrations ranging from 1.2 mg/l to 5.3 mg/l and 6.2 mg/l of sulphate has been measured. Comparison of wet season and dry season data clearly predicts increased sulphate concentrations during the dry season for all the measured locations and this was expected due to the effects of seasonal variations. However, most of the measured values were several hundred times less than the drinking water standard of 400 mg/l.

Wet season data for iron concentration in river, beel and pond waters indicated very little variation and all the figures were within the limit of 0.3 mg/l to 1 mg/l, except in cases of sample codes 15, 17, 10, 3, 8 and 7. Among all river water samples that from the confluence of Titas, Bijni and Hawrah rivers (code 15) contained the highest iron of 2.2 mg/l and those from rivers Titas (code 2) and Havatia (code 9) had the lowest of 0.45 mg/l. For beel waters, highest (2.1 mg/l) and lowest (0.27 mg/l) values were observed in case of Kunigara beel (code 3) and Korikandi beel (code 10), respectively. In case of pond water, Kallayan Sagar (code 16) showed the highest concentration of 0.76 mg/l whereas the lowest of 0.07 mg/l was noted for Ruhitar Beel (code 8). Results of dry season measurements showed a decreasing trend for all the measured locations and the values varied from 0.14 mg/l to 0.6 mg/l of iron. However, average of all the wet and dry season measured values (0.61 mg/l) satisfied well with the drinking water quality standard for Bangladesh (0.3 - 1 mg/l).

Analysis of water for sodium chloride showed that river waters usually contained higher concentrations than the beel and flood land waters. Data for river waters varied from 30 mg/l to 70 mg/l and 50 mg/l to 125 mg/l for the wet and dry season, respectively. Confluence of Titas, Bijni and Hawrah Rivers (code 15) showed the maximum concentration among wet season measurements whereas for dry season maximum value was obtained in case of Arsi River (code 13). Sodium chloride concentration is beel and flood land waters was measured in between 25 mg/l and 42 mg/l for the wet season and 65 mg/l in case of Chandal beel (code 4) during the

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dry season. But for pond waters, a wide variation in sodium chloride content ranging from 20 mg/l to 200 mg/l and 60 mg/l to 230 mg/l during the wet season and dry season, respectively has been observed. Madrasa Masjid Pond water (code 11) showed unusually high values whereas the minimum was obtained for Ruhitar beel (code 8). Standard limit for sodium chloride concentration in recreational water has not yet settled for Bangladesh. However, 600 mg/l of chloride has been set as a standard limit. For comparison of the measured values with this standard (600 mg/l), all figurers obtained as Nacl mg/l were converted to chloride mg/l by multiplying with the factor 0.6 and it was found from the calculated data that minimum and maximum concentration for chloride were 12 mg/l and 138 mg/l for codes 8 and 11, respectively. These values are well below than the standard of 600 mg/l of chloride and revealed insufficient amount of sodium and chloride ions in the surface water of the studied area.

Results of microbiological analysis as presented in Table 1 and Table 2 gave clear indication of bacterial pollution for almost all water samples. Data for wet season showed that total number of coliforms per 100 ml of water sample in rivers, beels and ponds varied in between 240 to 8000, 20 to 4000 and 180 to 5520, respectively. River waters contained more coliform bacteria than the beel and pond waters with the maximum and minimum count for the Meghna River in the downstream (sample code 20) and upstream (sample code 1) areas, respectively and none of the river water data satisfied the recreational water standards of 200 total coliform per 100 ml of sample. Maximum coliform count in the downstream of the Meghna River is naturally due to accumulation of all bacterial microorganisms from different sub-rivers and canals into this main stream. In case of beel and flood land waters, maximum and minimum number of coliforms were counted for sample codes 10 and 3, respectively. Highest coliform count in Korikandi beel (code 10) was normally expected and the lowest count in Kunigara beel (code 3) might be due to huge amount of pesticides used in this beel area. Total coliform count in Chandal beel, which is the only perennial beel of the project area, closely approximated the Bangladesh standard. All pond water samples, except only one with code 8, exhibited higher values for total coliform count, usually 10 to 27.6 times higher than the Bangladesh standard, and those were due to frequent discharges of human faeces into those pond waters from a number of hanging latrines along side the ponds. Data for dry season indicated a decreasing trend for the main River Meghna and some other sub-rivers, whereas in case of Salda, Gumti, and few other rivers an opposite trend was observed. Total coliform bacteria for the Salda River (code 17) and Gumti River (code 19) was counted as high as 25000 and 8000, respectively. However, comparison of all dry season data for rivers, beels and ponds with the Bangladesh standard showed that water samples from almost all locations, i.e., 18 samples out of total 20 samples, exceeded the limit of 200 coliform bacteria per 100 ml of sample.

Results of faecal coliform count clearly depicted faecal contamination during both wet and dry season for all river, beel and pond water samples when compared to the drinking water standard for Bangladesh.

Result of residual pesticides analysis for the Naigor beel water (sample code 18) indicated the presence of DDT and DDE in very trace amounts, 0.006 μg/l and 0.1 μg/l, respectively and those concentrations were found within standard limits.

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6. Conclusions

Water quality study for the Gumti Project revealed that average water temperature in rivers, sub-rivers, canals, beels, flood lands, ponds, tanks, etc. was 28.1°C and 23.9°C during the wet season and dry season, respectively.

Pond waters usually showed higher pH values than the river and beel waters with an overall pH range of 6.8 to 8 for the wet season. Water quality for the Gumti River was more alkaline (pH = 7.7) than the main River Meghna and other sub-rivers. Dry season data showed increased pH values and ranged from 7.1 to 8.8.

DO concentration for all the water bodies was very high and the maximum values for the wet and dry season were 13.5 mg/l and 14 mg/l, respectively. Carbon-dioxide content varied from 7 mg/l to 15 mg/l and 6 mg/l to 22 mg/l during the wet season and dry season respectively.

Rivers with less water flow and those in stagnant water conditions usually showed higher EC (91 μS/cm to 257 μS/cm) than the beels and ponds 46 μs/cm to 445 μs/cm) than the beels and ponds (46 μS/cm to 445 μS/cm). Average EC for the main River Meghna was very low (98 μS/cm).

Water quality in most of the rivers, beels and ponds including the main River Meghna was soft with few exceptions like Gumti River near the border zone, two ponds in the south-central and north-western areas, Arsi River, etc., where those were medium-hard to very hard. Reasonable concentrations of nitrate (> 10 mg/l) and phosphate (6 mg/l) were obtained in case of few rivers (codes 13, 6, 15, 1 and 2), beels (codes 18 and 3), and a pond (code 7). But average concentration of these two determinants was very low (nitrate 7.2 mg/l; phosphate 3.8 mg/l) to satisfy the standard value and revealed nutrient deficiency in most of the water bodies.

Level of iodine was measured very low usually <0.01 mg/l for most of the rivers, beels and ponds. Chandal beel and Madrasa Masjid Pond (sample codes 4 and 11) waters dominated in average iodine content.

River waters exhibited higher contents of silica than the beel and pond waters. Salda River (code 17) showed the highest average concentration of 35 mg/l silica whereas Chandal beel (code 4) had the lowest value of 2.2 mg/l.

All water samples contained very poor concentrations of potassium and zinc as a micronutrient. Only one pond water sample (code 11) for the dry season satisfied the drinking water standard of 12 mg/l potassium whereas the others had an average concentration of 1.9 mg/l.

All the measured zinc concentrations ranged from 6.2 μg/l to 23.3 μg/l and the average value (13.5 μg/l) was several hundred times less than the Bangladesh standard of 5000 μg/l. Sulphate concentration was also measured very low and a few hundred times below than the drinking water standard.

Iron concentration in most of the water bodies ranged within the drinking water standard limit (0.3 - 1 mg/l) showing a lower trend for pond water samples.

Analysis of water samples for sodium chloride concentration indicated insufficient salt content for all the surface water channels during both wet and dry seasons.

All water bodies, except three beels and one river (codes 3, 4, 8 and 1), suffered severe bacterial pollution. Downstream of the Meghna River (code 20) showed the maximum total coliform count of 8000/100 ml of sample during the wet season. But in the dry season, maximum was counted for Salda River with sample code 17 (25000 total coliforms/100 ml sample). This unusual high count for the Salda River water near the Indian border may be an important topic for further study.

Water samples from all rivers, beels, and ponds were faecally contaminated. Analysis of Naigor beel water (code 18) for residual pesticide chemicals detected very trace quantities of DDT (0.006 $\mu g/l$) and DDE (0.1 $\mu g/l$) and these concentrations were within standard limits. Detailed investigation on residual pesticides in water covering most of the beels, flood lands, canals and the main River Meghna may be an issue for next study.

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