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

South East Region
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BGD/86/037

FAP-5

Noakhali North Drainage and Irrigation Project
Feasibility Study
Volume 7 - Annex H
Environmental Impact Assessment

October, 1993

Sir M MacDonald and Partners Limited, UK
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NOAKHALI NORTH DRAINAGE AND IRRIGATION 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 Noakhali North Feasibility Study Report was prepared by the Consultant Environmental Specialist. It was drawn up in June and July 1993 following a programmed input of 2.5 months spread over the period September 1992 to June 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 assessment for a highly specific proposal for improving the drainage in the southern part of the study area which was drawn up as a result of previous work carried out as part of the FAP 5 Regional Plan. The impact assessment has allowed a recommendation to be made as to the likely overall levels of impacts and proposed a programme of supporting studies for a subsequent Detailed Design Phase if a decision is taken to follow-up the study. This would allow a full EIA to be produced along the lines of the World Bank Operational Directive 4.01 and the FAP Environmental Guidelines.

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK PROGRAMME

SUMMARY

The aim of the environmental component of the study was to carry out an environmental impact analysis of the proposed drainage intervention. Due to the limited resources provided it was decided to concentrate on the likely negative impacts and see how serious these were likely to be, both in terms of spatial and social variation and when compared to the predicted benefits of the proposed intervention. The work 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 form this data collection work indicated that the study area is not anything like as uniform as would have perhaps been expected. There are variations in the nature and availability of resources and hence the human use of these. The present flooding pattern of the area was shown to develop in a spatially variable manner and have very different durations but similar peak extents in different flood event probabilities. A considerable part of the study area is inundated at the peak of the monsoon season and the main constraint to drainage would seem to be the water level in the main Meghna river at the drainage outfalls from the area. All of the inundation is due to local rainfall run-off and not inflow into the area. Most of the homesteads in the study area are already flood proofed above a 1 in 20 year flood and there would appear to be little loss of life from flooding. There is significant erosion and accretion in the main Meghna river channel and the historical patterns of this have been greatly influenced by human intervention, major changes in river hydrology and the effects of seismicity.

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. Some of the 1991 BBS data is available for the south east of the study area and using this data in mapped form the spatial variation in population density and some trends in this could be seen. The high levels of population density in all but the recently accreted land in the south west of the study area, have been prevalent in the area for some considerable time. These have resulted in intensive use of the natural resources of the area. The levels of water supply provision in the area recorded in 1981 were low, although the limited 1991 BBS data shows this to have improved in some parts of the study area. This appears to have contributed to the problems with diarrhoeal and skin diseases and many people in two zones expressed the opinion that adequate safe drinking water provision was a higher priority than flood control, drainage and irrigation.

The proposed drainage improvement intervention and its resulting promotion of irrigated agriculture was modelled and its effects analyzed. The main effect was the significant reduction of the seasonally flooded area, which whilst this could be beneficial for agriculture (depending upon timing and how this fits the cropping calendar) is likely to result in losses to floodplain fisheries production. In addition there were likely to be localised problems caused by the need for land acquisition for the construction work.

CONCLUSIONS

The environmental component to the study has attempted to assess the proposed drainage and irrigation intervention to gauge its overall effect on both the natural and human environment. The broad conclusions are that overall the predicted agricultural benefits are high with a 25% increase in rice production. This is valued at TK 351 m/annum and this is estimated to provide an extra 4.3million person days of agricultural labour. The main dis-benefits are the nearly 50% loss to the floodplain fisheries system which are estimated to be 3645tonnes within the study area and a further 737 tonnes outside it when compared to a without project situation six years after completion of construction. The value of this lost fisheries production is estimated to be Tk 47.5 m/annum and the loss in fisheries labour is 0.9million person days per annum, (some 21% of the agricultural labour gains due to the intervention). Although the floodplain losses are high in percentage terms, they are predicted to constitute only 34% of the total fisheries production at present and 27% in the comparative without project situation. The major implication of this is the loss of "common good" directly consumed fish to, at the most some 20 850 occasional fishing households. A maximum of some 4 660 full and part-time fishing households are expected to have their livelihoods jeopardised to some degree as a result of the intervention and this represents some 1% of the total study area population. The resulting nutritional losses could be mitigated by targeting the increased wage paid labour to non-farming occasional fishermen, allowing them to earn sufficient cash to buy fish produced by expanded aquaculture programmes that could be targeted to the effected full time fishing households. There is some evidence that this is already happening in one part of the study area, but further, more detailed studies are required on this. Concern must be expressed that the fisheries dis-benefits in Zone D and the immediate adjacent areas may not be fully matched by agricultural benefits in these areas and this could be socially divisive unless mitigation measures are implemented in this zone.

There are likely to be localised issues of land acquisition for permanent construction works, and in all some 76 ha are required for this purpose. In addition land will be required for disposal of excavated spoil, either 457ha permanently or 3633 ha temporarily. The latter is slightly more expensive but is on principle to be preferred on socio-economic grounds. The need for land acquisition raises issues of compensation and possible resettlement. Under the World Bank Operational Directive 4.30 a resettlement and compensation plan needs to be drawn up. This requires detailed cadastral, fixed asset and household livelihood surveys so that a resettlement strategy that maximises effected peoples choices, can be drawn up. However the numbers of people that are likely to be effected are very small when compared to the total population of the study area and the likely beneficiaries. It is however vital that this work is carried out in close co-operation with the effected households and that compensation is seen to be fair, equitable and timely.

There are other less serious negative impacts but these do not detract from the major issues which concerns the justification for increasing agricultural production (specifically rice) by some 25% and valued at Tk 351 m at the expense of the Tk 47.5m value of lost fish production. In the process a maximum of 25 500 fish dependent households (some 6% of the population) are likely to be dis-benefitted to some degree although targeted mitigation programmes could address this to a great degree. This also raises the issue of likely changes in future rice prices and if these will remain at the levels used in the economic analysis for the study, especially bearing in mind the recent falls in these due to increased output.

RECOMMENDATIONS

From the impact assessment work carried out so far it can be seen that the intervention has significant predicted increases in agricultural production, and the losses due to dis-benefits, whilst significant to 6% of the households in the study area, appear to be heavily outweighed by the cash value of the increased agricultural production. With targeted mitigation programmes it is considered that the major dis-benefits can be overcome. However detailed and highly specific follow-up studies are required over a minimum 12 month data collection period to obtain suitable information to address the design of mitigation interventions and provide baseline monitoring data.

The decision to proceed with the following Detailed Design phase of the study therefore is a matter of policy priorities. Should the floodplain fishing system of Noakhali north, which has already been negatively impacted by past FCD/I interventions, be reduced still further to provide increased agricultural production, specifically rice? Based upon the economic analysis it would appear that due to the relatively simple nature of the intervention, along with significant social benefits that could result during its construction, the Noakhali North area seems to present a better place than many in Bangladesh to promote the development of agriculture.

FUTURE WORK PROGRAMME

Assuming that the proposed intervention is found to be justifiable, then a highly specific programme of detailed data collection is required that addresses the issues raised in this impact assessment. Data needs to be collected and tabulated using newly delineated impact zone boundaries. It is imperative that the 1991 BBS data and SRDI soil chemistry data is made available to the study before it commences. The detailed studies need to cover a full 12 month period and include the following components:

- A detailed fisheries study, including a catch assessment concentrating on the flood plain area inside and outside the designated study area. A study of fish migration and species mix in the floodplain area and how this is likely to change as a result of floodplain reduction and changing inundation patterns. A detailed Socio-economic survey of fishing households aimed at trying to ascertain income levels, the degree of dependency on fishing and the split in this between capture and culture fisheries.

- Nutrition surveys particularly concentrated on the occasional fishing households dependent on the floodplain and also targeted households in Zones A and D.

- A detailed field cadastral survey of the areas for permanent land acquisition, plus a full inventory of immovable assets and a household livelihood assessment. A reconnaissance level assessment of temporary land acquisition requirements. This work should provide sufficient data to produce a resettlement planning and compensation strategy.

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

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

- A baseline socio-economic survey to ascertain the future income generation capability of irrigated agriculture, construction operations and aquaculture in the area. The 1991 BBS data is required before this can be designed.

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

- Soil structure and chemistry monitoring in areas of likely irrigation and drainage areas. This will need access to the existing SRDI chemistry data.

- Detailed flora and fauna surveys of all impacted areas.

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

The above data will need to be collected so that the following issues can be addressed in the next stage of the study and form the basis for an Environmental Management Plan:

- Land acquisition, compensation and resettlement plan under OD 4.30.

- Management of stocked Khals in the irrigation area

- Professional Fishermen re-training, probably capture fishermen into pond aquaculture

- Targeted income generation for occasional fishing households aimed at providing sufficient income to purchase replacement protein, probably pond aquaculture fish.

- Targeted income generation programmes for maximising opportunities for wage paid labour from irrigated agriculture and construction employment

- Social forestry programme

- Health programme including water supply, sanitation and health education

- Soil management guidelines

- Flora and fauna management guidelines

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

H.1 INTRODUCTION

H.1.1 Aims and Objectives

Environmental Impact Assessment for proposed development programmes attempts to place any considered interventions within a context of environmentally sound and sustainable development. The aim of the environmental component to the Noakhali North Drainage and Irrigation Study was to review a proposed intervention that had already been put through a selection screening process as part of the FAP 5 Regional Study work. The aim was to see if this proposal was basically sound from a broad environmental standpoint, and investigate possible dis-benefits to see how severe these might be and how they could differ across and outside the study area. Proposals were then to be made as to ways of avoiding or mitigating any likely major negative impacts within the framework of an Environmental Management Plan.

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 initial baseline assessment work carried out in the study area. The predicted outcomes of the main drainage improvement and irrigation intervention include a range of issues and these can be rated in terms of perceived and policy priorities. The likely nature and severity of impact, both positive and negative, needs to be considered in terms of which particular social groups of people will be effected, where and when. The impacts can be judged in relative terms and, if the data already exists or can be collected, quantified and if appropriate valued, either in relative or economic terms. However some of the impacts may be difficult to quantify let alone value and in any case they need to be judged against policy priorities, both nationally and regionally, along with an indication as to how these are to be interpreted locally.

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 3 and parts of numbers 2 and 5 in the South East Region and this regional context is given in Figure H.1.2. The study area was defined by the nature of the proposed intervention which was formulated as part of a water and land development plan for the region drawn up as part of the work of FAP 5. The proposed intervention was for a drainage programme centred around deepening and widening of the existing Khal system associated with a proposal to enlarge and modify the operational regime of the outfall regulator to the Meghna river at Rahmatkhali. The revised regulator operation would include allowing water inflow from the Meghna river during high tides so that this could be made available for irrigated farming. The environmental situation in the Regional Study area was outlined in Annex IV of the FAP 5 Regional Plan Report and was considered when drawing up the proposed intervention.

The proposed intervention has direct hydraulic consequences on an area much larger than the proposed Khal deepening works. For this reason the study area includes those areas where it was thought likely there would be impacts. The study boundaries are shown on the Study Area map in Figure H.1.3. The northern limit is the Dakatia river and the western is the Chandpur project eastern embankment. The southern boundary follows the

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Figure H.1.1

National Location Map

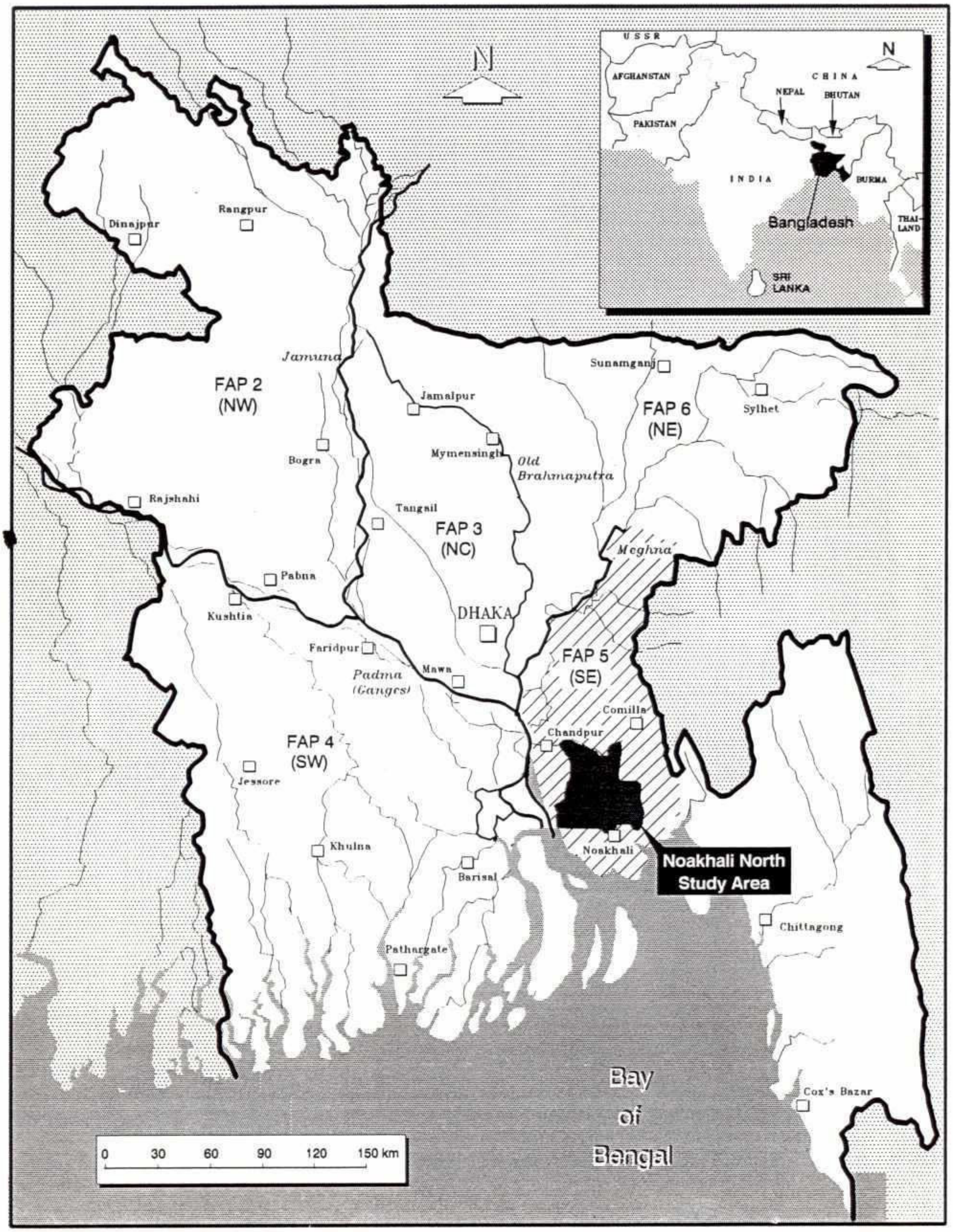

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Figure H. 1.2

Regional Planning Context Map

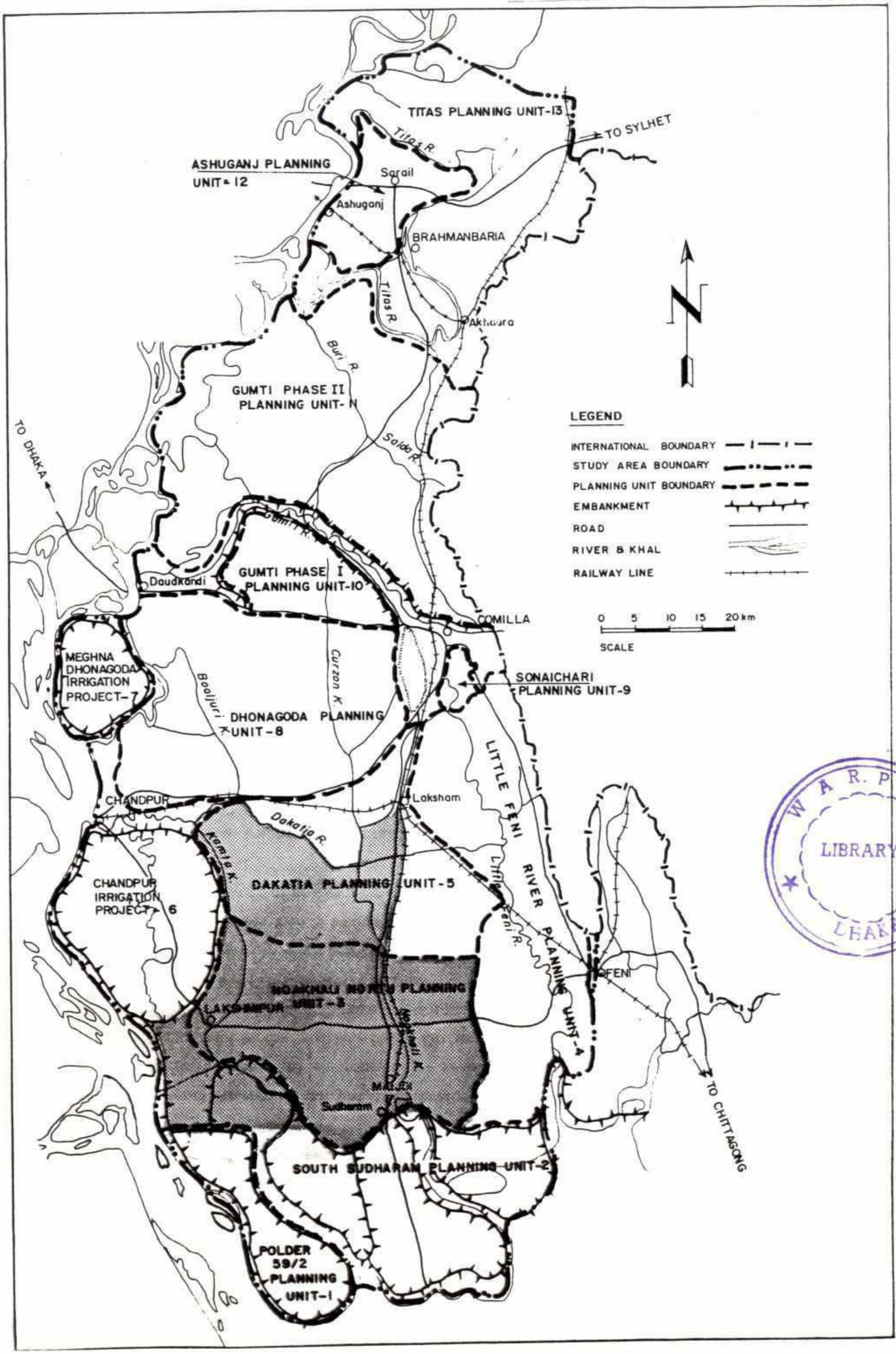
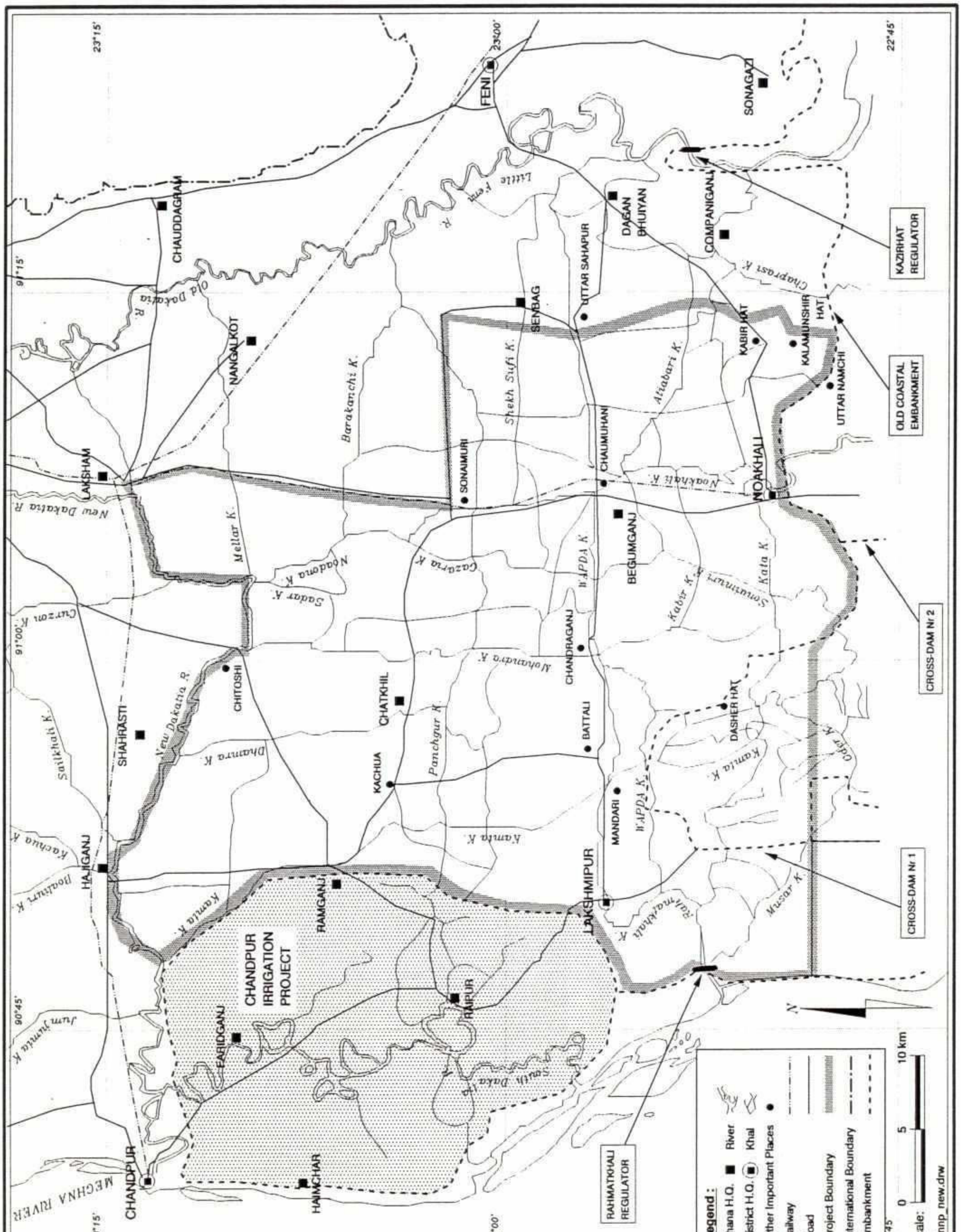


Figure H.1.3
Project Area Base Map



old coastal protection embankment, which was the coastline prior to the construction of long cross-dams which resulted in major coastal accretion. There is however a small piece of the study area in the south west which lies south of the old coastal embankment and is newly accreted land. The eastern boundary is essentially the watershed line of the Feni river system. However as a result of the hydraulic modelling of the proposed intervention it has become apparent that the extent of the hydraulic impacts spreads further eastwards than the Feni watersheds, as due to the shallow hydraulic gradients it moves the catchment boundary eastwards. An immediately adjacent external area has therefore been included in the impact analysis. Similarly the hydraulic modelling indicated that the right (north) bank of the Dakatia was affected by the intervention and all the way westwards to the Meghna river. This area has also been considered as an adjacent external impact area.

The study area was split into four planning zones (given in Figure H.3.1) based upon existing 1988 FAO agro-ecological and MPO flood mapping. However the output of the hydraulic modelling indicated that the boundary between Zones A, B and C has been misaligned using seasonal flood plain extent as a criteria. However by this time it was too late to adjust the boundaries as all the agro-socio-economic survey data and fisheries catch assessment had been collected in the field using the delineation. This has thus made the comparative assessment of spatial differentiation of impacts less useful than it could have been as B and C are two mixed zones rather than one having primarily flood plain reductions and the other primarily irrigation benefits.

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 (DofE) 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 Action Plan programme (NEMAP). The Noakhali North feasibility study environmental component followed the spirit of these Guidelines as far as was possible and appropriate within the very severe constraints of time and resources allowed for the study. The study thus identifies the major issues and where possible quantifies these and makes recommendations as to mitigation measures and the format for detailed studies so an Environmental Management Plan can be put together, including a Resettlement Plan under World Bank Operational Directive 4.30, in the following detailed studies phase, if a decision is taken to proceed further with the proposed project.

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

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

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

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 differentiation of these aspects are the four planning zones shown in Figure H.3.1 delineated using a range of criteria including ago-ecological zone, MPO flooding zone and topography.

H.2.2 The Natural Environment

H.2.2.1 Mapping and Topography

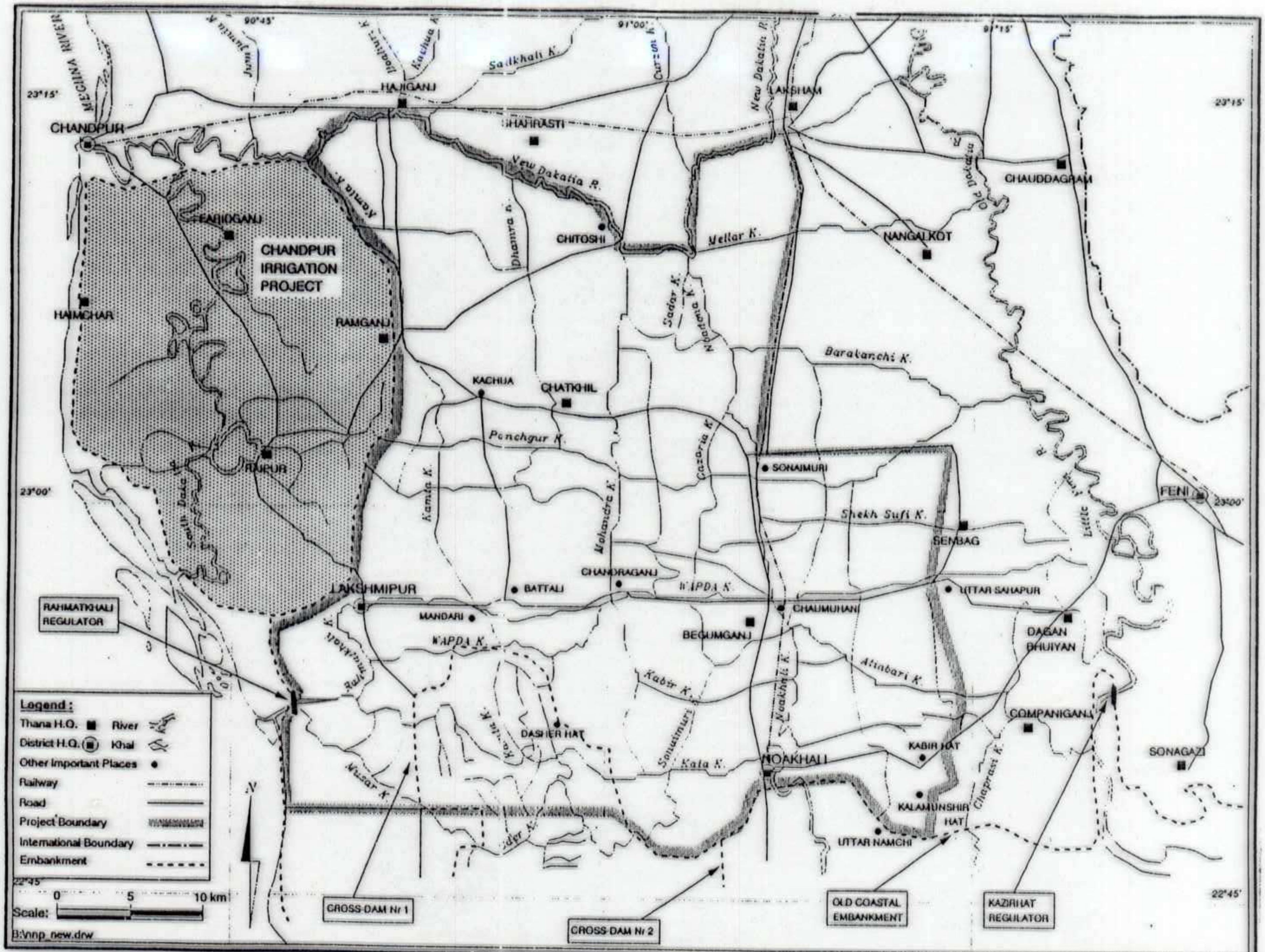
There is limited detailed topographic mapping available for the study area, however due to the time and resource constraints to the study it has proved adequate for the work so far. More detailed mapping is in preparation for possible subsequent phases of the work. This is to be constructed from 1990 air photography to produce orthophoto mosaics. It is imperative that the topographic data is made available in digital elevation model format so that it can be interfaced with the hydraulic model to automatically produce mapped outputs of flood extents, depths and durations. For the present study the model outputs had to be plotted by hand using the 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 and there were insufficient study funds to purchase the available wet season imagery which would have been invaluable in giving the extent of wet season flooding. 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.2.9.

There is also a map dated 1893-1916 with some slight revision in 1931. This was re-scaled to fit the study area base map to assess changes over time and is shown in Figure H.2.15.

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 preliminary data available to obtain an understanding of the flood pattern in the area was the MPO data shown in Figure H.2.4. This work has been completely reworked by mapping the output of the MIKE 11 hydraulic model for each 10 day period, using a water level at that time for each of the 32 modelling cells which cover the study area. This then used the best topographic data (0.5m contours) that could be sensibly handled quickly to give A3 sized map outputs on clear polyester sheets. This was carried out for both a 1 in 2 "normal" year and a 1 in 5 high "normal" year, firstly for the present without intervention situation and latterly for each of


MEGHNA RIVER
CHANDPUR
HAJIGANJ
SHAHRASTI
LAKSHAM
CHAUDDAGRAM
FARIDGANJ
CHANDPUR IRRIGATION PROJECT
HAIMCHAR
RAMGANJ
CHITOSHI
NANGALKOT
KACHUA
CHATKHIL
RAIPUR
SONAIMURI
SENBAG
FENI
LAKSHMIPUR
BATTALI
CHANDRAGANJ
MANDARI
CHAUMUHANI
UTTAR SAHAPUR
BEGUMGANJ
DAGAN BHUIYAN
COMPANIGANJ
DASHER HAT
NOAKHALI
KABIR HAT
KALAMUNSHIR HAT
UTTAR NAMCHI
SONAGAZI
New Dakatia R.
Mellar K.
Baratanchi K.
Ponchgur K.
Shekh Sufi K.
WAPDA K.
Kabir K.
Atinbari K.
Kala K.
Chaprasi K.
Noakhali K.
Sonaimuri K.
Kamta K.
Mohandra K.
Gazaria K.
Sadar K.
Noaroma K.
Dhamra K.
Sadkhali K.
Curzon K.
Kachua K.
Old Dakatia R.
Little Feni R.
Musar K.
South Dakatia
RAHMATKHALI REGULATOR
CROSS-DAM Nr 1
CROSS-DAM Nr 2
OLD COASTAL EMBANKMENT
KAZIRHAT REGULATOR
Legend :
Thana H.Q.
District H.Q.
River
Khal
Other Important Places
Railway
Road
Project Boundary
International Boundary
Embankment
Scale:
0
5
10 km
N
90°45'
91°00'
91°15'
23°15'
23°00'
22°45'
B:\nnp_new.drw

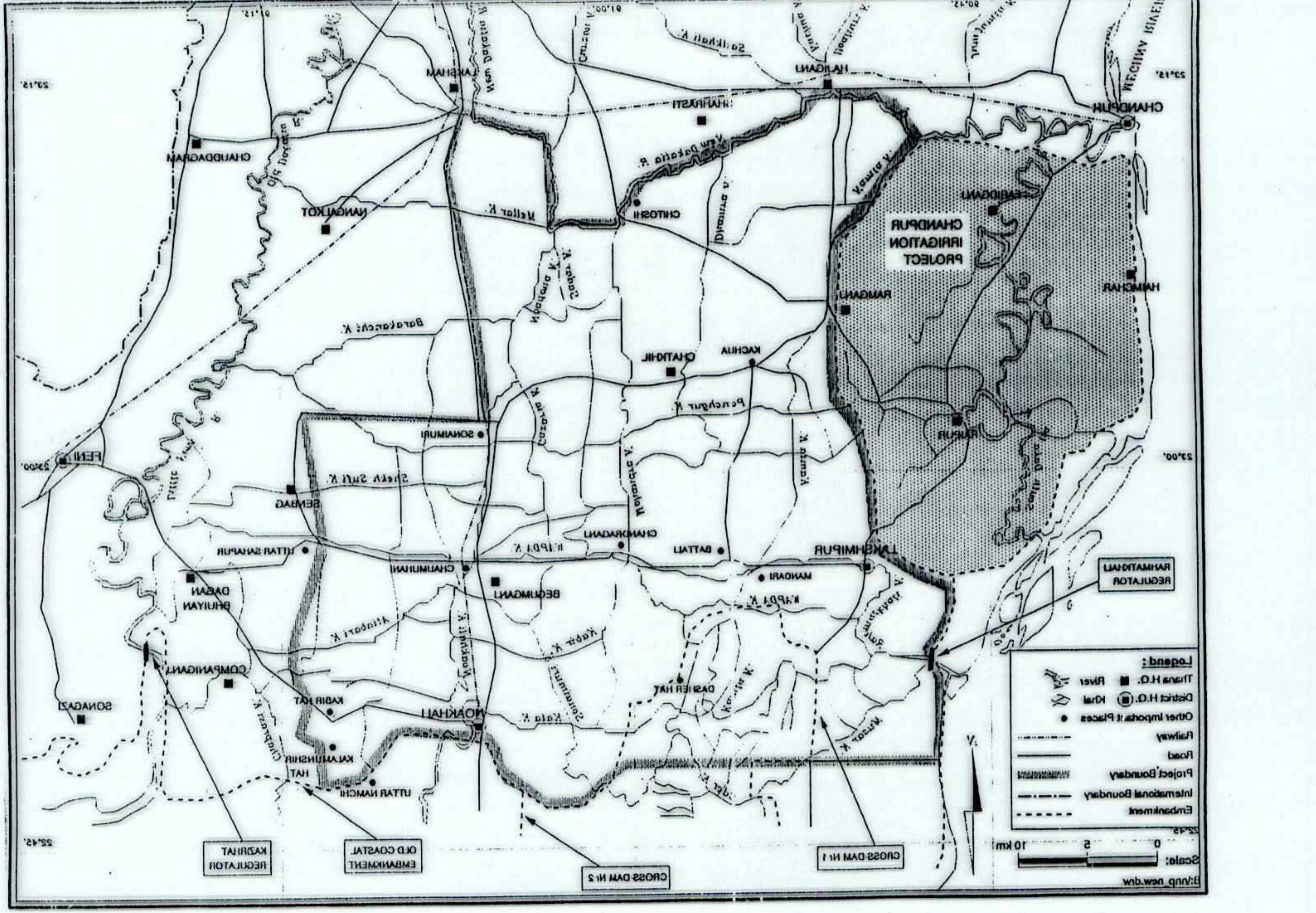

CHANDPUR
IRRIGATION
PROJECT
CHANDPUR
HAIMCHAR
FARIDGANJ
RAMGANJ
RAIPUR
HAJIGANJ
SHAHRASTI
LAKSHAM
CHAUDDAGRAM
NANGALKOT
CHITOSHI
KACHUA
CHATKHIL
SONAIMURI
FENI
SENBAG
CHANDRAGANJ
BATTALI
LAKSHMIPUR
MANDARI
UTTAR SAHAPUR
CHAUMUHANI
BEGUMGANJ
DAGAN
BHUIYAN
COMPANIGANJ
SONAGAZI
KABIR HAT
NOAKHALI
DASHER HAT
KALAMUNSHIR
HAT
UTTAR HAMCHI
RAHMATKHALI
REGULATOR
KAZIRHAT
REGULATOR
OLD COASTAL
EMBANKMENT
CROSS DAM Nr 2
CROSS DAM Nr 1
MEGHNA RIVER
New Dakatia R.
Old Dakatia R.
Little Feni R.
Bhulua K.
Dakatia
Legend :
Thana H.O.
River
District H.O.
Khal
Other Important Places
Railway
Road
Project Boundary
International Boundary
Embankment
Scale:
0
5
10 km
B:\nnp_new.drw
23°15'
23°00'
22°45'
90°45'
91°00'
91°15'
N

Figure H.2.1

SPOT Satellite Image of the Project Area, February 1989, with overlay

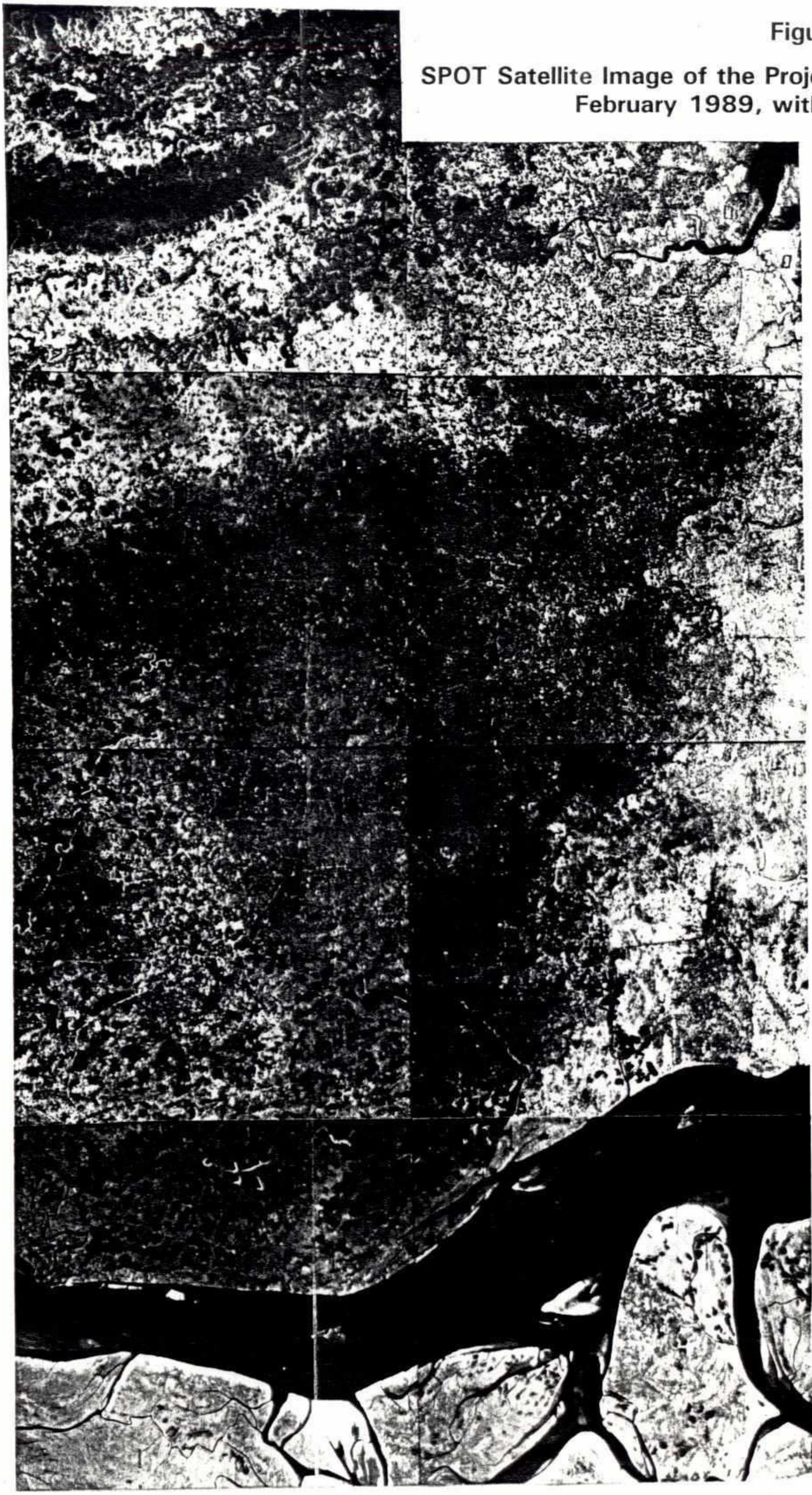


Figure H.2.2

Topography

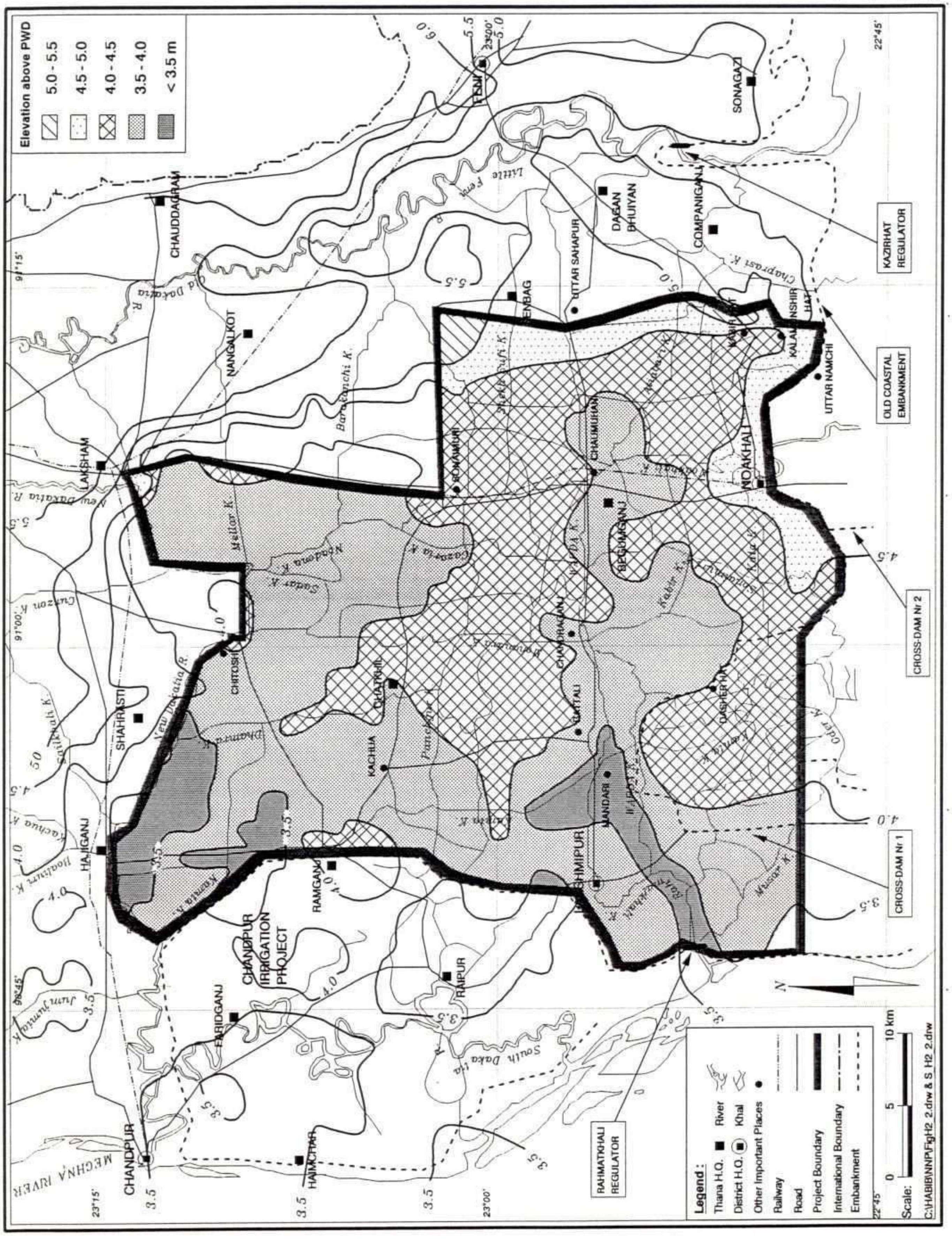


Figure H.2.3

Climatic Norms at Noakhali

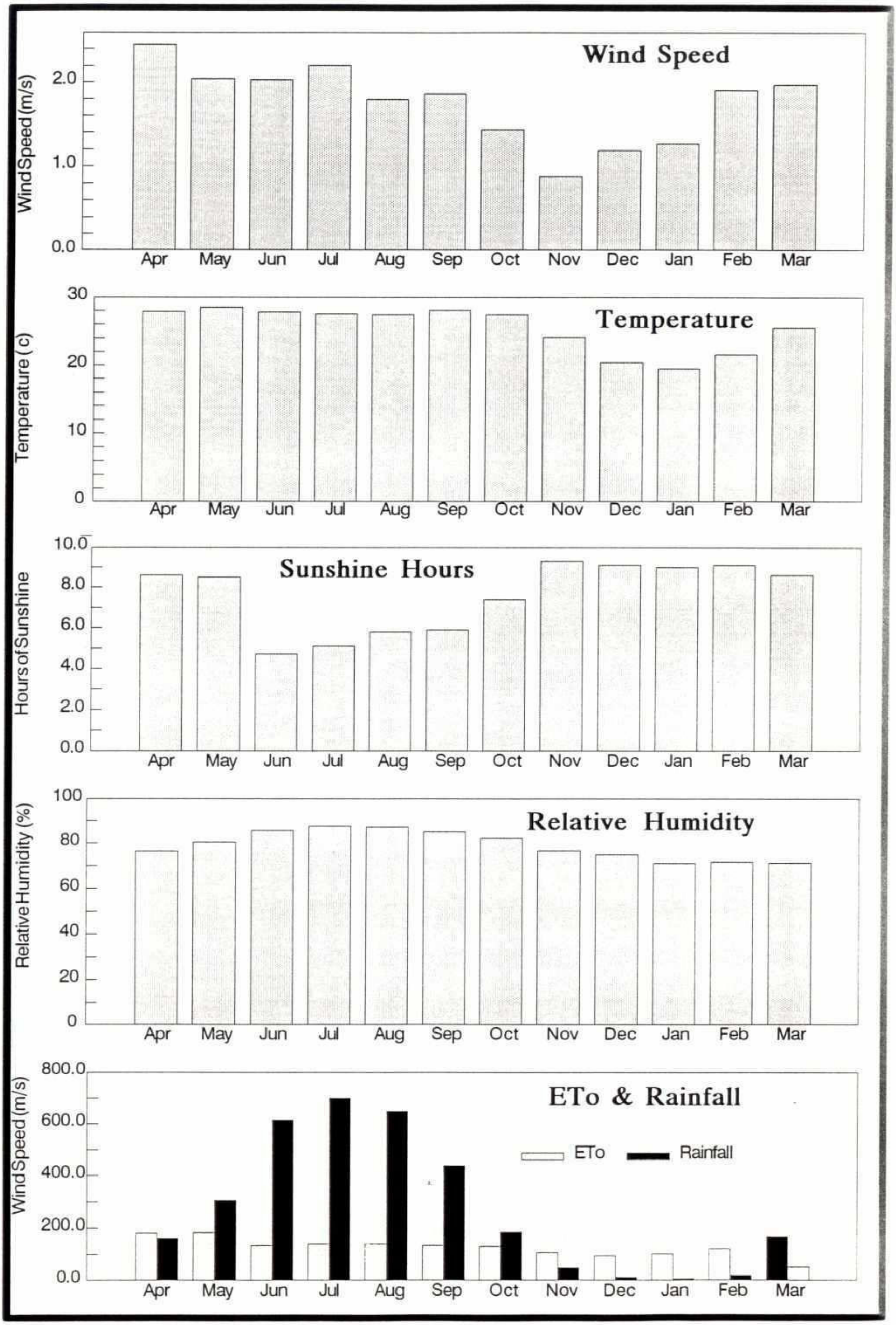


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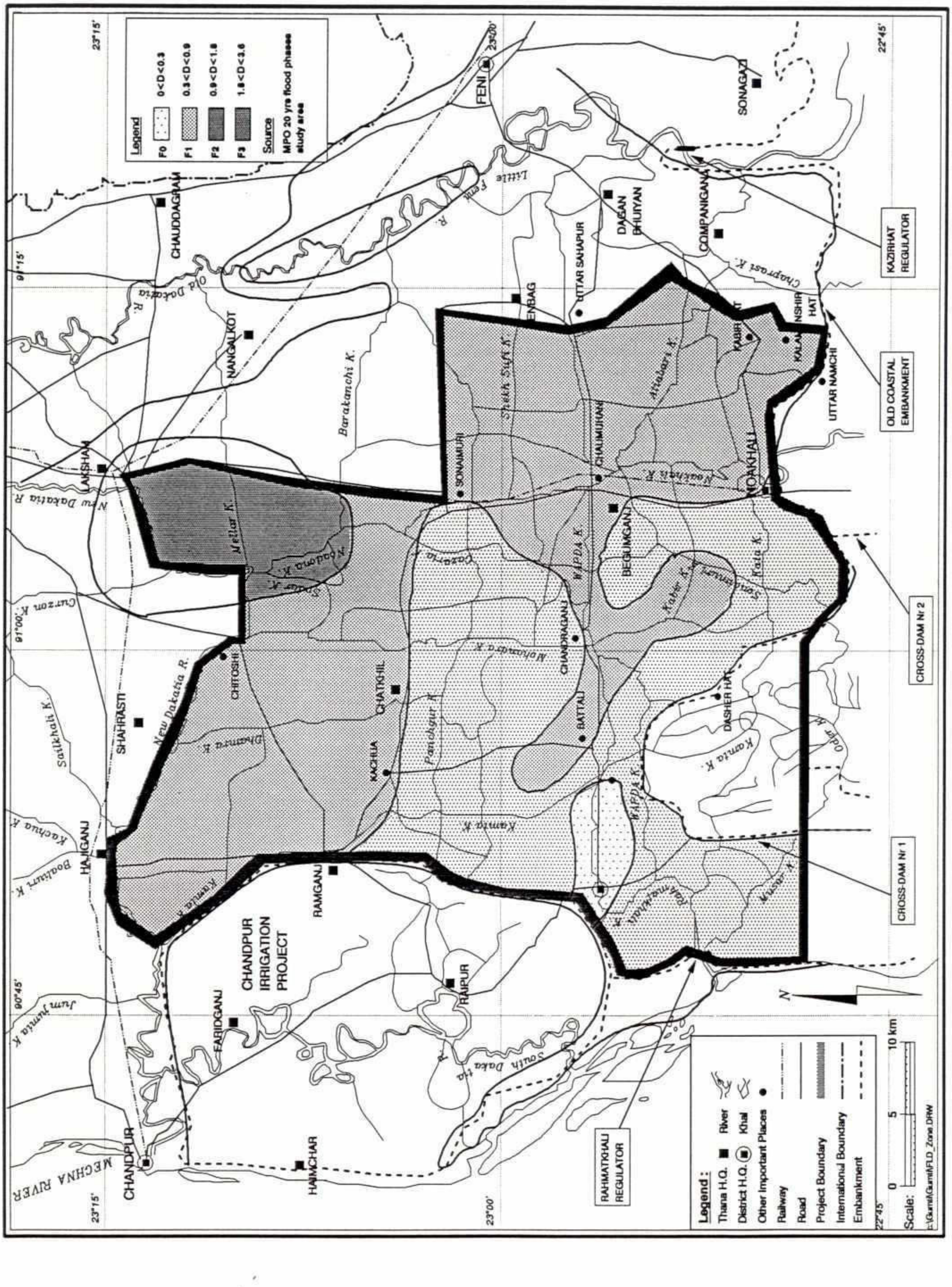
Figure : H 2.4
MPO Flood Zones



the post construction situations for the strategies under consideration. The modelled outputs for the 1 in 2 year flood of the present situation are shown in Figure H.2.5 for a rising flood and Figure H.2.6 for a falling flood. The equivalent maps for the 1 in 5 year situation are shown in Figures H.2.7 and H.2.8.

The mapped outputs of the present flooding situation in the study area were some what surprising as they indicated that most of the study area goes under seasonal flood water even in a 1 in 2 "normal" year. This was not expected as impressions gained during the field study period were of more limited flooding. The reason for this was that although the field studies started at the end of the monsoon (September) it was an exceptionally dry year with very few floodplain areas. This has significant implications for the ability of the fish catch survey work to accurately reflect floodplain fisheries for a normal year. The overall picture that emerges is that there is no flooding into the study area from outside and the flood pattern is almost entirely dependent upon local rainfall and topography. The climatic norms at Noakhali, including the mean seasonal rainfall distribution, are shown in Figure H.2.3.

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

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

- The middle and lower Dakatia combined with the north western part of Zone D adjacent to the Chandpur eastern embankment. This would possibly seem to have been created or worsened by the construction of the Chandpur embankment restricting outflow.

- The south west corner of Zone D

- The eastern part of part of Zone D which is combined by the corridor through Zone C to the flooded area covering all of the northern half of Zone B.

By the first decad of August all these flooded areas have combined to form one large flood plain area covering all of Zones B and D, except the very southern central part of Zone D and the southern edge of Zone B. In addition the eastern half of zone C is also flooded. The peak extent of flooding is reached in the first decad of September and covers virtually all of Zones B and D, the eastern 60% of Zone C and quite extensive areas

Figure H.2.5
Extent of Rising Flood, 1 in 2 Year

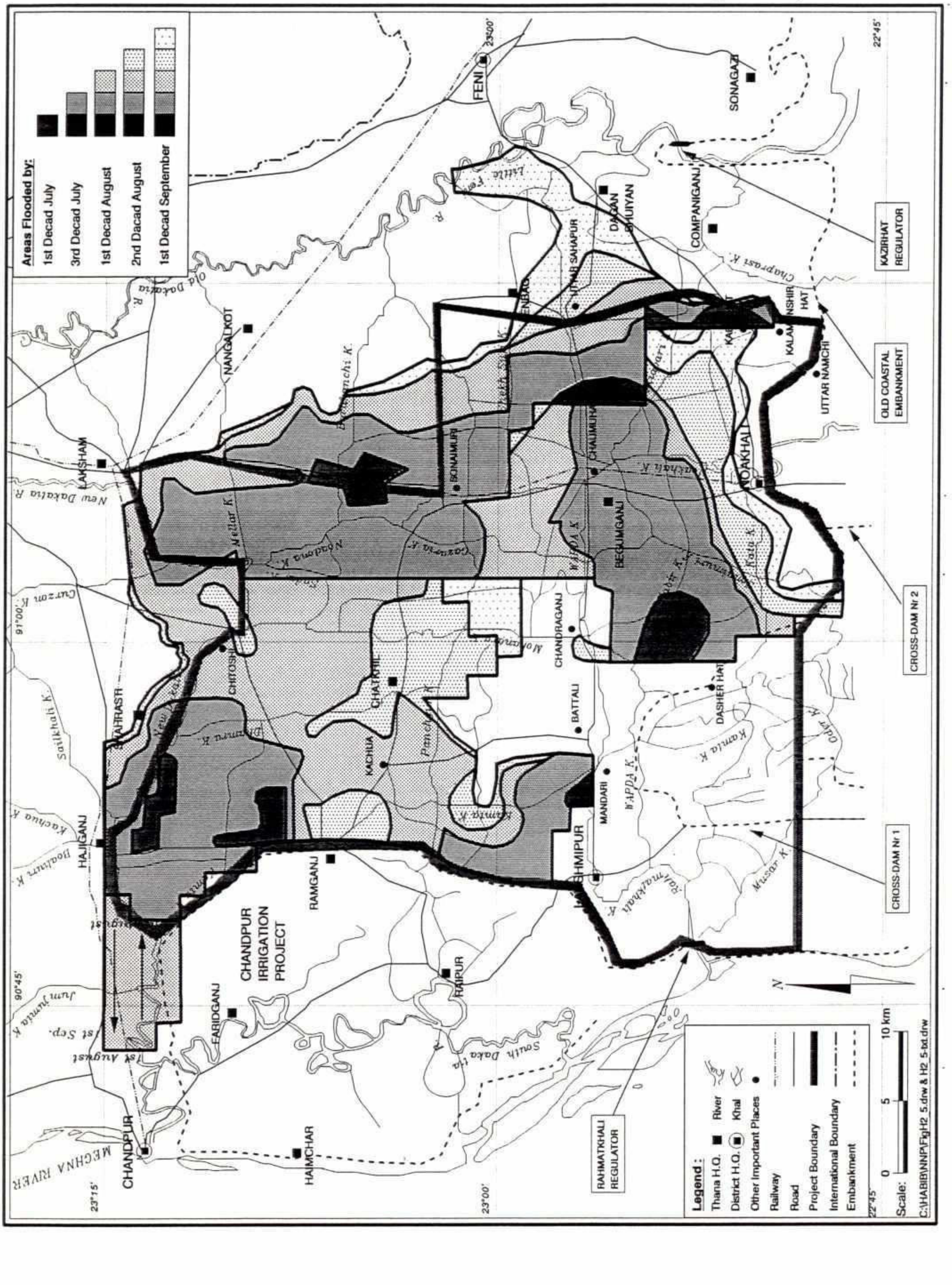


Figure H.2.6
Extent of Falling Flood, 1 in 2 Year

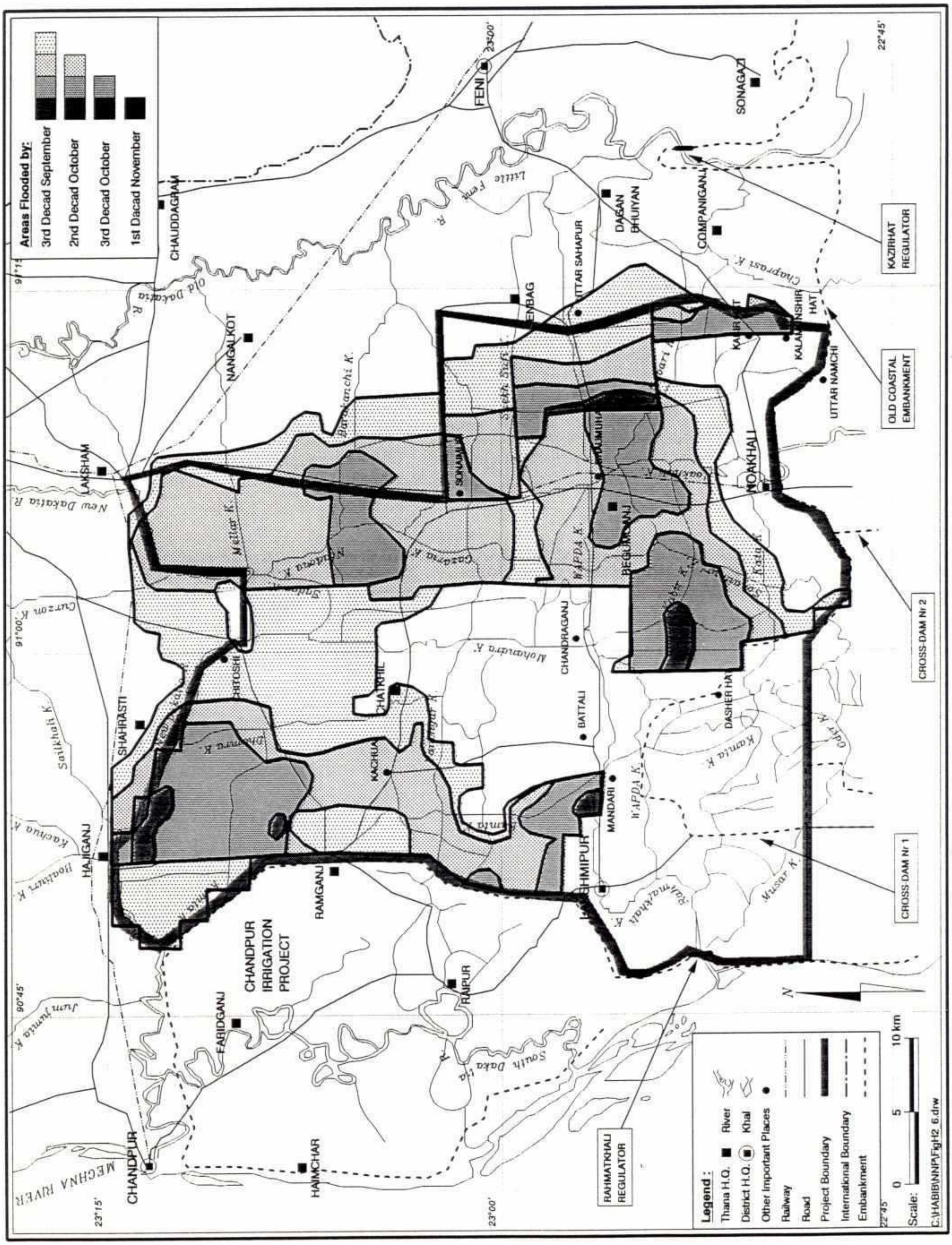


Figure H.2.7
Extent of Rising Flood, 1 in 5 Year

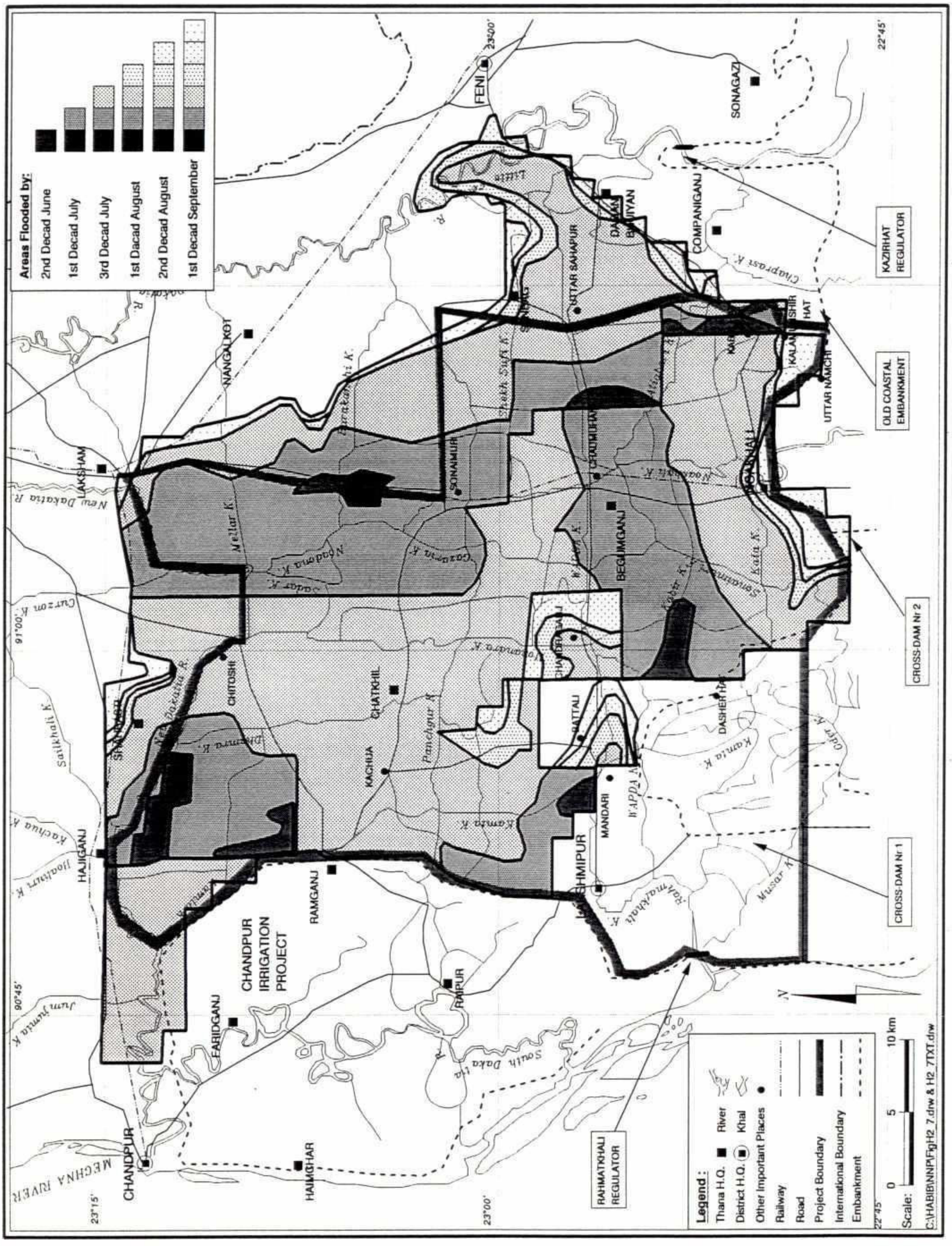
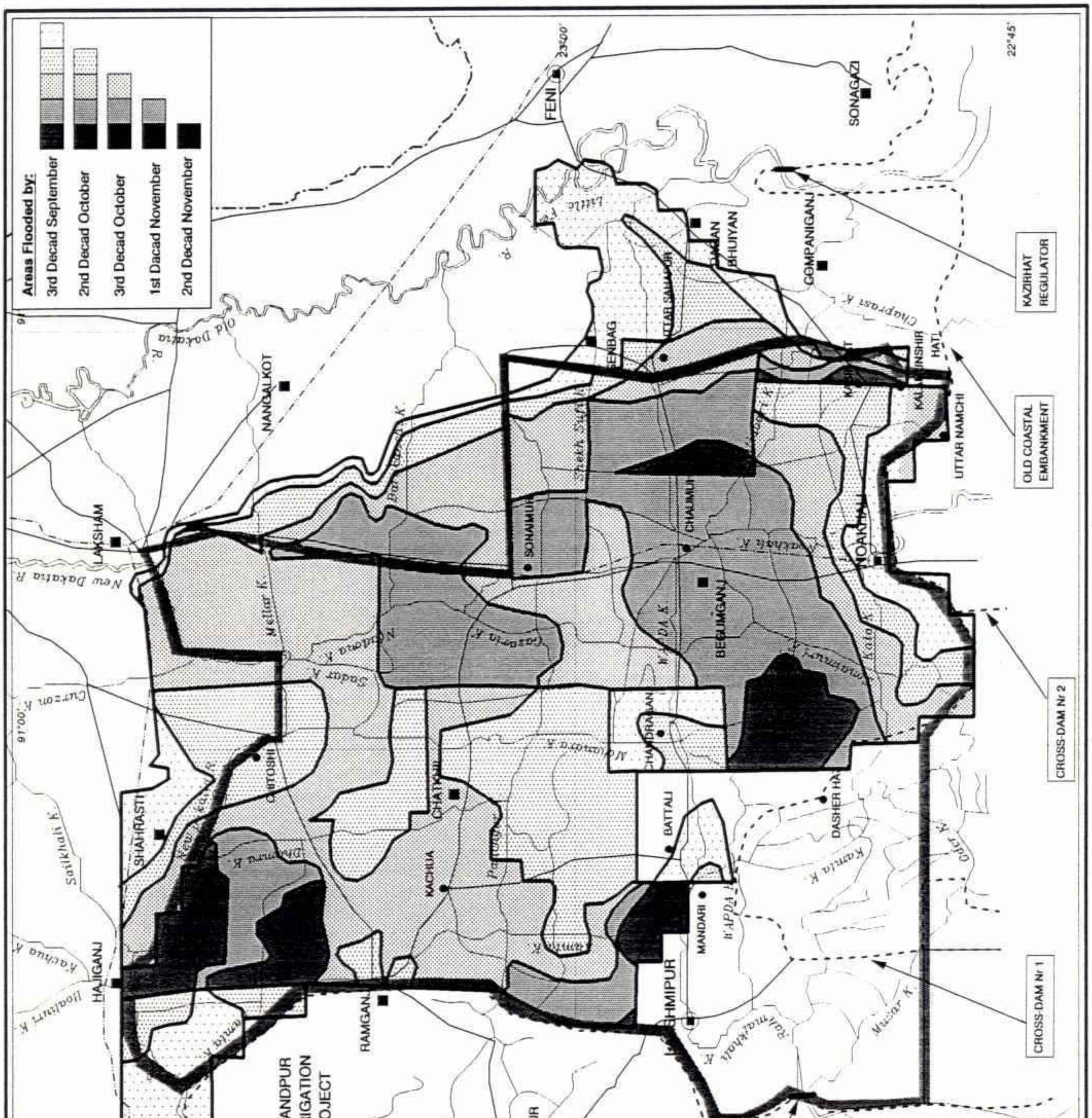


Figure H.2.8
Extent of Falling Flood, 1 in 5 Year



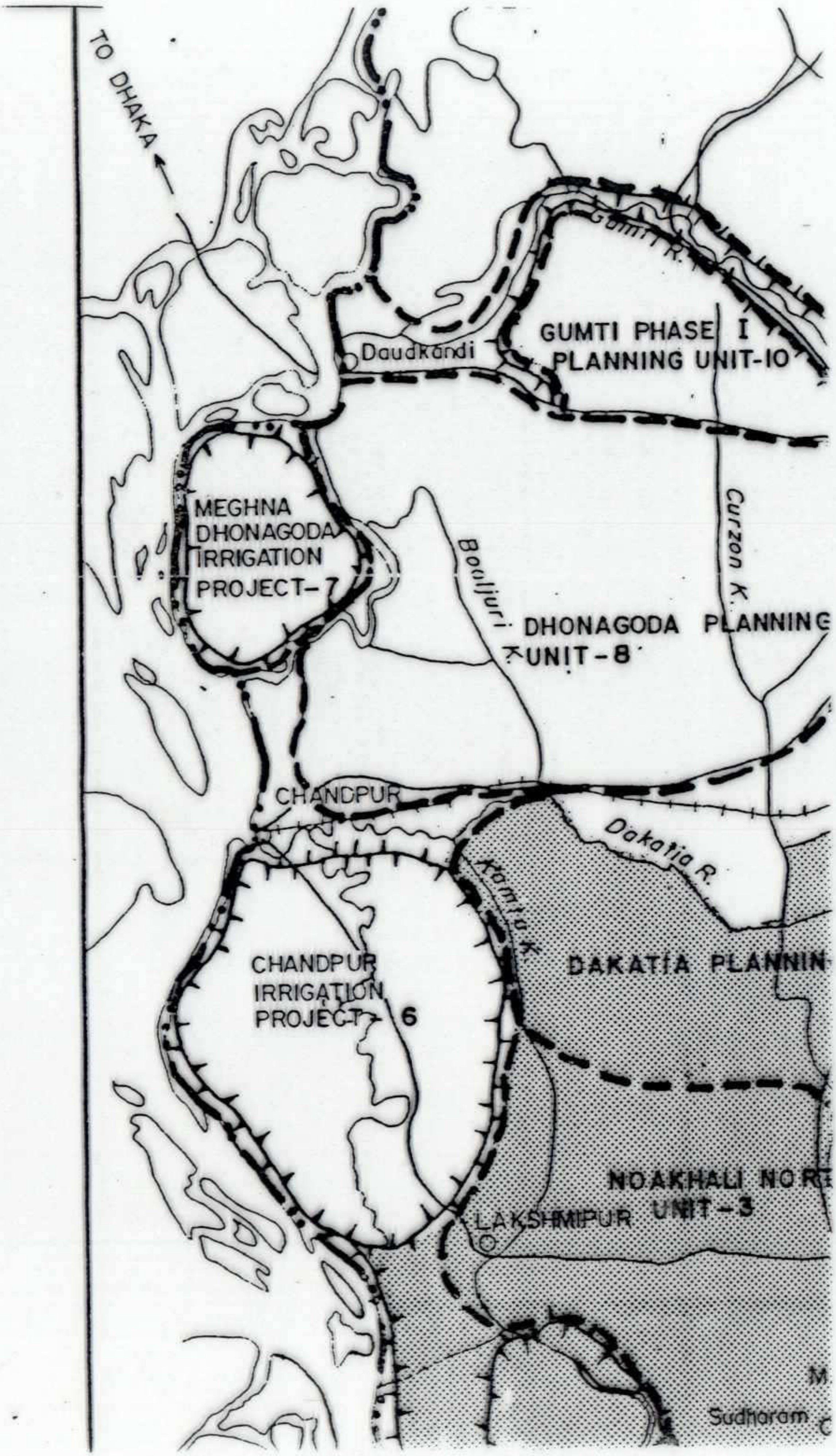
outside the eastern and northern limits of the study area including the Dakatia floodplain. However it would appear that this peak flood extent is very short-lived in a 1 in 2 "normal" flood, lasting no more than 20 days when compared to 50 days for a 1 in 5 high "normal" flood.

The falling flood pattern for a 1 in 2 "normal" year is mapped in Figure H.2.6 and shows that the present drainage system is more effective in reducing flood extents in the southern part of the study area than the north. The main constraints to reductions in flood extent and duration appear to be the capacity of the drainage system (presently reduced due to siltation) and the water levels in the main Meghna river. The latter factor includes issues of daily and lunar cycle fluctuations due to the tidal back up effect in the Meghna river and seasonal water level variations due to monsoon run-off through out the Brahmaputra, Ganges and Meghna basins. In a "normal" year the falling flood appears to take slightly longer to clear from the peak than the rising flood takes to go from dry to its peak extent (50 days as opposed to 60 days). The spatial extents of the falling flood pattern indicate that the flooded area remains as one waterbody up until the second decad of October when it breaks into two major areas, one in the west of zone D and the other in the east of zone D extending southwards through Zone C to include the northern half of Zone B. This is a similar spatial pattern as the rising flood. By the third decad of October it breaks up into at least seven discrete water bodies inter connected only by the drainage channels. By the first decad of November only small localised depressions remain flooded.

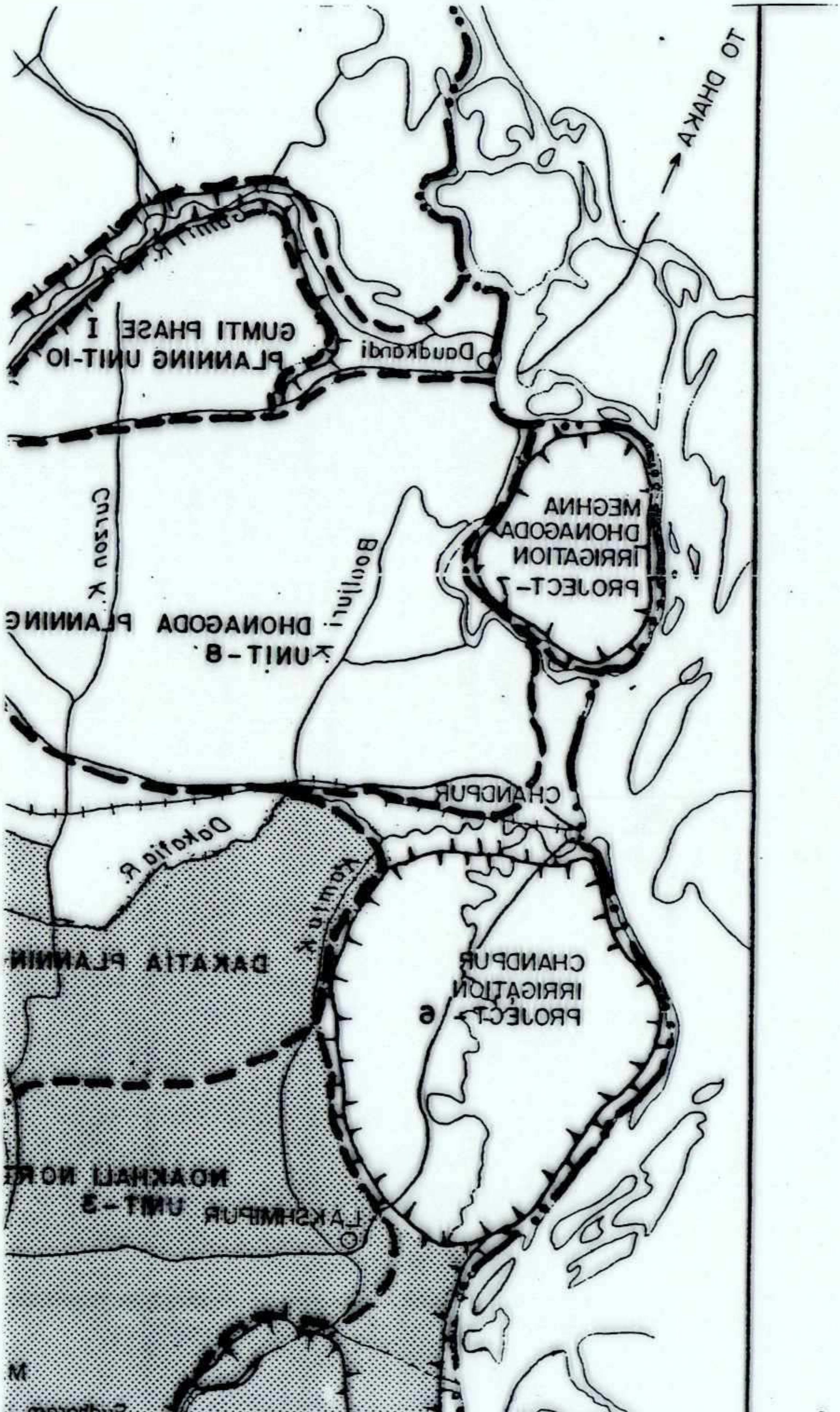
The flooding situation for a 1 in 5 high "normal" flood situation is shown for the rising flood in Figure H.2.7 and a falling flood in Figure H.2.8. The major differences between the high "normal" flood and the "normal" flood are that the high "normal" flooding starts 20 days earlier (second decad of June) and the peak flood extent is reached by the third decad of July rather than the first decad of September. The high "normal" flood thus starts 20 days earlier, rises quicker and hence reaches its peak extent 40 days before a "normal" flood. However the spatial extent of the high "normal" peak flood is no different than a "normal" flood but it remains at this extent for much longer (50 days instead of a maximum of 20 days), only starting to fall after the third decad of September. However it falls much more quickly than a "normal" flood, (40 days instead of 60) and this would seem to confirm that the major drainage constraint to the area is the water level in the Meghna river. It must however be remembered that although the inundation of the flood plains is considered a constraint to agriculture, there are benefits to fisheries production. The spatial variation and timing of the flooding is crucial both to crop planting dates and fish migration, spawning and growth. The balance between these two production systems and an understanding of how this varies according to the flood return period is crucial in considering and assessing any proposed intervention which changes this, both in terms of flood extent, duration and timing.

H.2.2.3 River Morphology

Main river erosion and accretion patterns derived from digital analysis of time series Landsat imagery over the last 20 years are shown in Figure H.2.9. This shows that the only major problem is main bank erosion on the Meghna in Zone A estimated to have been 13m per year since 1989. The longer term trend can be seen by study of the 1931 map overlain with the present situation in Figure H.2.15.

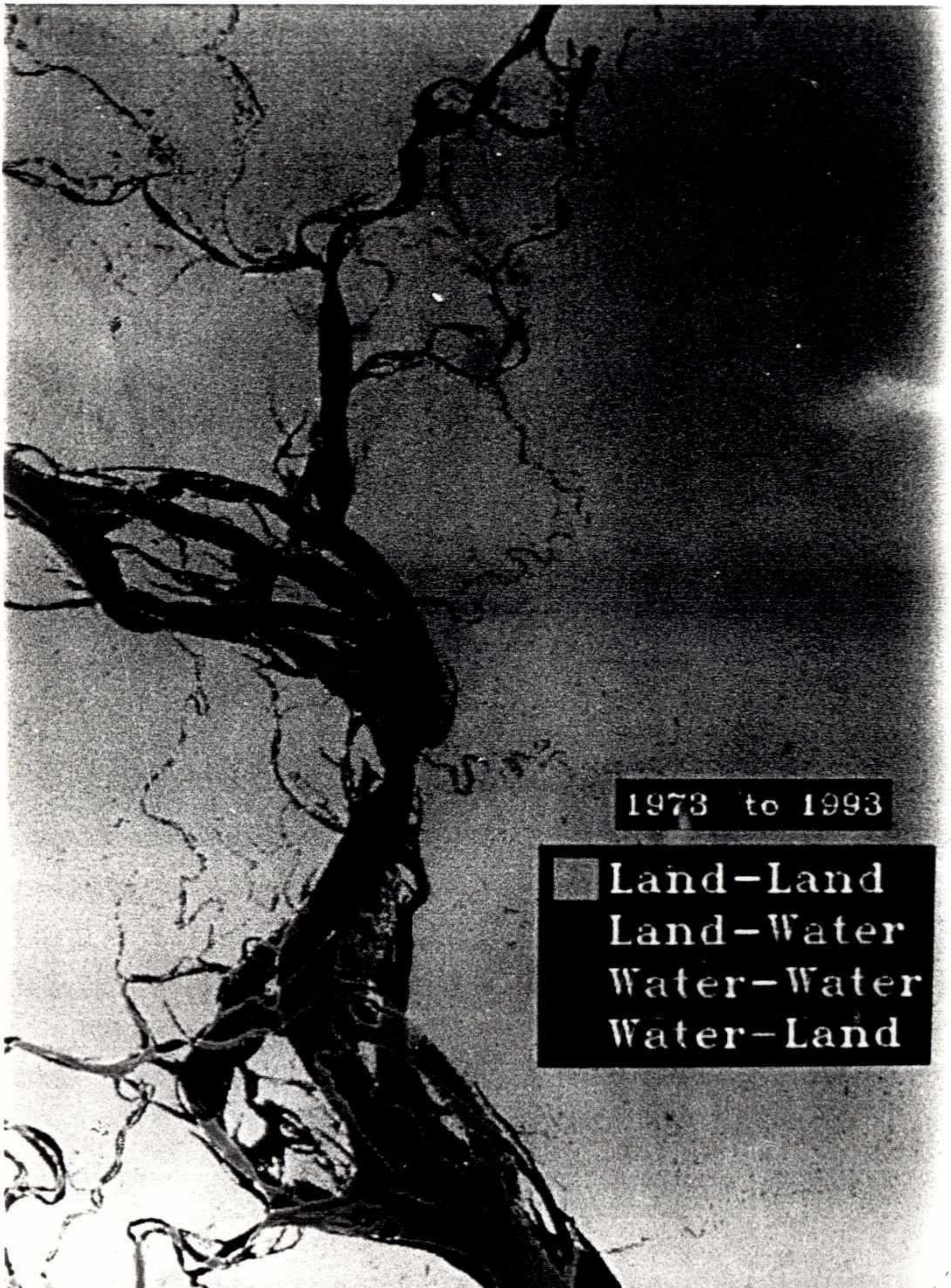


TO DHAKA
Gumti R.
GUMTI PHASE I
PLANNING UNIT-10
Daudkandi
MEGHNA
DHONAGODA
IRRIGATION
PROJECT-7
Boaljuri
Curzon K.
DHONAGODA PLANNING
UNIT-8
CHANDPUR
Dakatia R.
Kamta K.
CHANDPUR
IRRIGATION
PROJECT-6
DAKATIA PLANNIN
NOAKHALI NORT
UNIT-3
LAKSHMIPUR
Sudharam



GUMTI PHASE I
PLANNING UNIT-10
Daudkandi
TO DHAKA
MEGHNA
DHONAGODA
IRRIGATION
PROJECT-7
DHONAGODA PLANNING
UNIT-8
CHANDPUR
Dakatia R.
CHANDPUR
IRRIGATION
PROJECT-6
LAKSHMIPUR
UNIT-3
Sudharam

Figure H.2.9
Erosion and Accretion Mapping 1973-1993



SOURCE: FAP 19 - ISPAN

H.2.2.4 Sedimentation and Erosion

The time series Landsat imagery analysis shown in Figure H.2.9 and the historical map in Figure H.2.15 show that although the study area itself has been quite stable, there have been great erosion and accretion influences on it over time. The most recent major change was as a result of constructing the coastal cross dams from the 1950's onwards. These have resulted in very significant coastal accretion, rendering the study area an inland depression rather than a coastal facing one protected by an embankment. This has resulted in the drainage lengths and gradients from the area to be changed and caused the drainage problems that the study seeks to address. The south west part of the study area is newly accreted land from that time, although historically it may have previously been land and then eroded away.

H.2.2.5 Groundwater

The situation with regard to groundwater has been outlined in Annex C and summarised in Section 2.3 of the Main Report. This work includes aspects of groundwater quality. There are major constraints to groundwater development in the area, especially for irrigated agriculture. These include salinity levels, restricted availability of shallow groundwater and the depth to good quality water which renders it difficult and uneconomic for agricultural use. It would thus seem advisable to reserve groundwater abstraction for potable use and there is a need to continue the provision of safe drinking water throughout the study area and particularly the south west.

H.2.2.6 Water Quality

The situation with regard to surface water quality, in both the wet and dry seasons in the study area, is shown from field data collection results displayed in Tables H.2.1 and H.2.2 with the locations of these being shown in Figure H.2.10. This data is interpreted below and in more detail in Appendix H.V. The results are compared with the national standards for water quality shown at the bottom of the two tables. The situation in terms of groundwater quality has already been outlined in Section 2.1.5 of the main report and also in Annex C.

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

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

Figure H.2.10
Water Quality Sampling Sites for Noakhali North Project

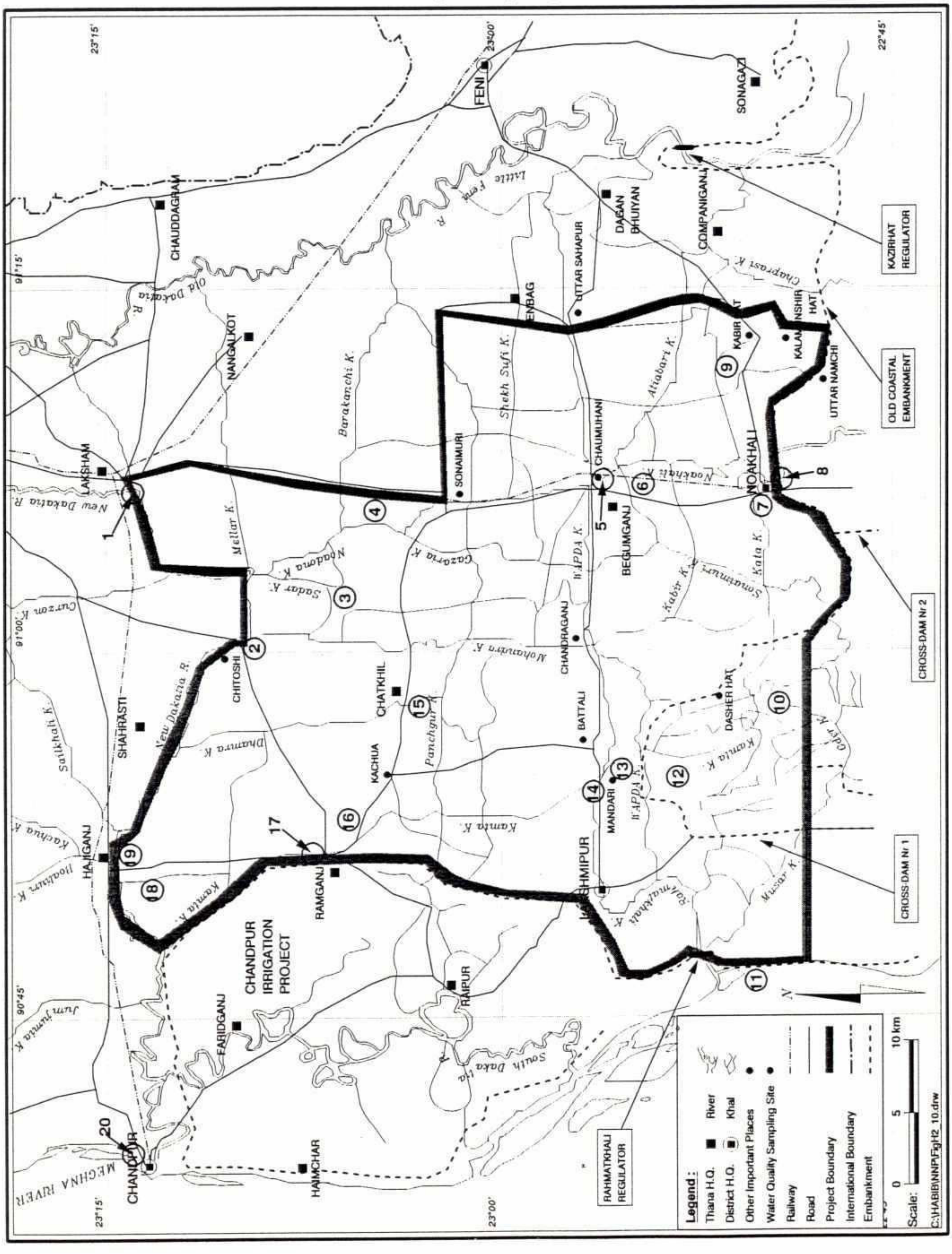


TABLE H.2.1

Spreadsheet for Wet Season (Oct.–Nov.) Water Quality of Noakhali North Project

Sl. No. Name of the Water Body	Sample Code	Description	Date/ Time	Temperature degree C	pH	DO mg/L	CO2 mg/L	CaC03 mg/L	CHEMICAL ANALYSIS: 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	MICROBIOLOGICAL ANALYSIS: Total Coliform n/100 ml.	Faecal Coliform n/100 ml.	Total Bacterial Count/ml	RESIDUAL PESTICIDES ANALYSIS: DDT µg/L	DDE µg/L
1. Gabua Beel (Flood land)	6	Stagnant water; Greenish brown colour; Floated algae partly; Sunny morning.	10.11.92 09:40 Hrs.	26.5	7.4	12	10	50	13	0.25	0.05	1.2	0.68	6	1.3	0.18	90	200	50	>1000	?	?
2. Datta Dighi (Pond)	7	Stagnant water; Greenish brown colour; Domestic use; Sunny day.	10.11.92 10:10 Hrs.	28	7.3	11.5	7	15	10.5	0.7	0.01	10	2	29	0.82	0.71	100	2450	1300	>1000	?	?
3. Noakhali Khal	8	Stagnant water; Brown colour; Very turbid; Water hyacinth partly; Sunny day.	10.11.92 10:30 Hrs.	26.5	7.9	11	26	408	11	0.75	0.05	34.4	2.7	31.8	61	1	1600	150	100	>1000	?	?
4. Masjid Pond	9	Stagnant water; Deep greenish brown colour; Domestic use; Sunny day.	10.11.92 11:15 Hrs.	28	7.6	9	15	47	9	1.2	0.01	5.6	3	12.5	1.2	1.4	140	4100	3250	>1000	?	?
5. Oder Khal	10	Slowly running water; Brown colour; Slightly turbid; Sunny day.	10.11.92 13:10 Hrs.	29	8.2	11.5	22	204	7.5	0.95	0.05	11.2	3.2	6.3	3.3	1.4	600	800	600	>1000	?	?
6. Noakhali Khal	5	Slowly running water; Pale brown colour; Submerzed vegetation; Water hyacinth; Sunny morning	12.11.92 07:30 Hrs.	26	7.4	11	15	118	10	0.35	0.02	6.4	1.2	19.6	2.5	0.41	450	1800	1450	>1000	?	?
7. Meghna River	11	Running water; Pale brown colour; Navigation use; Sunny day.	12.11.92 09:30 Hrs.	27	8	12	12	68	9	1.2	0.01	30.4	1	8.2	2.2	0.7	60	750	550	>1000	?	?
8. Chokidar Dogi (Flood land)	13	Stagnant water; Pale browsn colour; Floated algae; Submerzed vegetation; Sunny morning.	12.11.92 11:00 Hrs.	28	7.3	11.5	11	85	6	0.6	<0.01	2.8	1.3	15.1	1.2	0.75	200	1450	1100	>1000	?	?
9. Dohadar Dogi (Flood Land)	12	Stagnant water; Pale brown colour; Covered with paddy field; Completely dries in mid Jan.; Sunny day.	12.11.92 11:50 Hrs.	28.5	7.7	7	26	204	10	0.45	<0.01	14.4	1.1	15.7	2	0.74	270	450	320	>1000	?	?
10. Rahmatkhali Khal	14	Slowly running water; Blackish brown colour; Covered with water hyacinth; Sunny day.	12.11.92 12:30 Hrs.	26	7	6.5	22	136	3.5	0.95	0.02	6.8	1.9	17.6	0.82	0.6	350	10400	2400	>1000	?	?
11. East Kazir Khil Dighi (Pond)	16	Stagnant water; Greenish brown colour; Red algae partly; Domestic use; Sunny day.	16.11.92 13:40 Hrs.	28	7.6	13.5	8	35	14.5	2.7	<0.01	9.6	2.6	3.4	2.8	0.23	40	2150	1600	>1000	?	?
12. Ramgonj Khal	17	Slowly running water; Pale brown colour; Water hyacinth partly; Domestic use; Partly Cloudy weather.	16.11.92 14:15 Hrs.	25.5	7.6	10	26	152	10	3.2	0.03	26.4	5.1	1	0.82	0.1	160	6000	1250	>1000	?	?
13. Dakatia River	19	Slowly running water; Deep green colour; Water hyacinth partly; Navigation use; Cloudy afternoon.	16.11.92 16:40 Hrs.	25	7.2	9.5	11	48	3.3	3.7	0.01	10.8	1.8	8	1.3	0.23	110	3200	2700	>1000	?	?
14. Aral Beel	18	Stagnant water; Deep brown colour; Water hyacinth mostly; Cloudy evening.	16.11.92 17:20 Hrs.	23	7	9	18	46	11	1.8	<0.01	21.6	0.75	4.5	1.7	0.1	70	5100	4250	>1000	?	?
15. Meghna River	20	Running water; Pale green colour. Water hyacinth partly; Navigation use; Sunny morning.	17.11.92 07:15 Hrs.	25.5	7.8	12	7	65	3	3.4	<0.01	29.2	1.7	3	5.1	0.18	40	3050	2400	>1000	?	?
16. Birendra Khal	15	Stagnant water; Blackish brown colour; Covered with hyacinth; Animals slaughtering site; Cloudy morning.	18.11.92 10:00 Hrs.	22	6.9	5	24	66	3	0.45	<0.01	5.6	2.7	6.1	0.49	1.5	60	1100	300	>1000	?	?
17. Nather Petua Shajir Dighi (Pond)	4	Stagnant water; Pale green colour; Water hyacinth partly; Domestic use; Cloudy day.	18.11.92 11:10 Hrs.	24	7	10	13	30	3	1.8	0.01	8	1.1	10.3	0.99	0.2	36	2600	1750	>1000	?	?
18. Confluence of Dakatia River and Laksham Khal	1	Running water; Pale green colour; Water hyacinth partly; Slightly turbid; Cloudy afternoon.	18.11.92 13:30 Hrs.	24	7.6	10.5	22	86	3	0.25	0.04	29.6	4.7	3.8	1.8	0.31	50	38000	13000	>1000	?	?
19. Nateshor Dighi (Pond)	2	Stagnmant water; Green colour; Fishing pond; Water hyacinth partly; Cloudy afternoon.	18.11.92 15:40 Hrs.	24.5	6.6	10.5	6	15	5	0.9	<0.01	5.6	0.96	2.7	1.7	0.12	40	2100	1300	>1000	?	?
20. Uttorer Dogi (Flood land)	3	Stagnmant water; Pale brown colour; Partly covered with paddy field; Floated algae; Fogy morning.	19.11.92 07:00 Hrs.	21.5	6.9	8	11	30	6	0.2	0.01	14.4	2	6.9	1.7	0.62	25	20000	7200	>1000	0.0196	0.00046
ENVIRONMENTAL QUALITY STANDARDS 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; C02 = Carbon–di–Oxide; Nacl = Sodium Chloride; DDT = Dichloro Diphenyi Trichloroethane; DDE = Dichloro Diphenyl Ethylene Dichloride; NYS = Not Yet Settled.

c:habib nnp\TabH2_1

TABLE H.2.2

Spread Sheet for Dry Season (Feb.–Mar.) Water Quality of Noakhali North Project

Sl. No.	Name of the Water Body	Sample Code	Description	Date/ Time	Temperature degree C	pH	DO mg/L	CO2 mg/L	EC µS/cm	CaCo3 mg/L	Nitrate mg/L	Phosphate mg/L (CHEMICAL ANALYSIS)	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. (MICROBIOLOGICAL ANALYSIS)	Faecal Caliform n/100 ml.	Total Bacterial Count/ml	DDT µg/L (RESIDUAL PESTICIDES ANALYSIS)	DDE µg/L
1.	Gabua Beel (Pond)	6	Mostly dry and irrigated.	21.02.93 14:18 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
2.	Datta Dighi (Pond)	7	Stagnant water; Deep brown colour; Domestic use; Sunny morning.	24.02.93 09:45 Hrs.	22.6	7.2	12	10	103	35	?	?	?	?	?	?	?	?	85	8000	7000	>1000	?	?
3.	Noakhali Khal	8	Stagnant water; Pale brown colour; No tidal effect since two months; Cloudy day.	21.02.93 11:45 Hrs.	25	7.8	12	13	3010	512	4	0.8	0.05	12	15.2	26.8	166	0.12	1870	42000	30000	>1000	?	?
4.	Masjid Pond	9	Stagnant water; Greenish brown colour; Partly cloudy day.	21.02.93 10:55 Hrs.	25	7.7	11	9	261	62	?	?	?	?	?	?	?	?	168	22000	16000	>1000	?	?
5.	Oder Khal	10	Stagnant water; Brown colour; Sunny morning.	21.02.93 08:40 Hrs.	22.2	7.7	12	11	2280	393	?	?	?	?	?	?	?	?	1260	27000	12000	>1000	?	?
6.	Noakhali Khal	5	Stagnant water; Deep brown colour; Partly turbid; Hyacinth partly; Cloudy day.	21.02.93 13:10 Hrs.	24.5	7.7	11.5	15	2520	411	3	1	?	?	?	?	?	?	1455	12000	9000	>1000	?	?
7.	Meghna River	11	Running water; Pale green colour; Sunny morning.	26.02.93 09:20 Hrs.	23.5	8.1	12.5	10	184	103	3.5	2.6	?	?	3.5	15.5	?	?	70	120	90	>1000	?	?
8.	Chokidar Dogi (Flood land)	13	Completely dry & irrigated.	26.02.93 12:18 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
9.	Dohadar Dogi (Flood Land)	12	Completely dry & irrigated.	26.02.93 13:40 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
10.	Rahmatkhali Khal	14	Stagnant water; Blackish brown colour; Water hyacinth; Sunny morning.	26.02.93 11:00 Hrs.	25	7.6	10.5	30	1683	380	?	0.55	?	?	?	?	29.5	?	930	10000	8000	>1000	?	?
11.	East Kazir Khil Dighi (Pond)	16	Stagnant water; Deep brown colour; Domestic use; Sunny day.	24.02.93 13:20 Hrs.	27	8.6	14	5	54	22	4	?	0.01	?	3.6	?	?	?	70	2000	1000	>1000	?	?
12.	Ramgonj Khal	17	Stagnant water; Deep brown colour; Hyacinth mostly; Sunny day.	24.02.93 13:45 Hrs.	23	7.4	11	28	650	220	?	1.4	?	?	?	?	?	?	314	9000	9000	>1000	?	?
13.	Dakatia River	19	Slowly running water; Pale green colour; Hyacinth partly; Sunny day.	19.02.93 12:50 Hrs.	28.3	7.5	11	16	198	103	4	2	<0.01	19.2	4.4	20.2	14.7	0.4	84	16000	5000	>1000	?	?
14.	Aral Beel	18	Completely dry.	19.02.93 13:22 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
15.	Meghna River	20	Running water; Pale green colour. Navigation use; Sunny day.	19.02.93 14:30 Hrs.	25.5	8	11.5	10	175	100	7.5	1.9	<0.01	18.8	13.8	10.7	17.6	0.08	66	10000	6000	>1000	?	?
16.	Birendra Khal	15	Stagnant water; Deep Blackish brown colour; Water hyacinth; Sunny day.	24.02.93 12:10 Hrs.	22	7.1	8	35	777	223	?	?	?	?	28.7	?	9.3	2.1	335	36000	25000	>1000	?	?
17.	Nather Petua Dighi (Pond)	4	Stagnant water; Pale green colour; Water hyacinth; Sunny day.	24.02.93 11:00 Hrs.	22.5	7	11	10	72	36	3.5	1.2	<0.01	6.8	0.92	29	3.8	0.4	70	250000	200000	>1000	?	?
18.	Confluence of Dakatia River and Laksham Khal	1	Stagnant water; Grey colour; Partly turbid; Sunny morning.	19.02.93 08:45 Hrs.	25	7.5	10.5	12	246	68	6	4.2	0.02	58	9.1	17.1	16.7	3.6	136	135000	93000	>1000	?	?
19.	Nateshor Dighi	2	Stagnmant water; Pale green colour; Water hyacinth; Fishing pond; Sunny day.	19.02.93 11:20 Hrs.	27	6.5	12	7	19	15	?	?	?	?	?	?	?	?	42	35000	17000	>1000	?	?
20.	Uttorer Dogi (Flood land)	3	Completely dry & irrigated.	24.02.93 11:40 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
	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	750	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; C02 = Carbon–di–Oxide; EC = Electrical Conductivity; CaCo3 = Calcium Carbonate; Nacl = Sodium Chloride; DDT = Dichloro Diphenyi Trichloroethane; DDE = Dichloro Diphenyl Ethylene Dichloride; NYS = Not Yet Settled.

C:habib nnp TabH2_2.fmt

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

H.2.2.7 Agro-Ecological Zones

The FAO 1988 agro-ecological zone mapping of the study area is given in Figure H.2.11. When superimposed on the March 1989 SPOT satellite imagery they fit reasonably well in the south but not very well elsewhere. These agro-ecological 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 within a conceptual framework. The agro-ecological zones were one of the criteria used for drawing up the planning zones of the study area.

H.2.2.8 Soil Resources

The available soil information for the Noakhali study area includes the SRDI data collected as part of a systematic programme for the whole country during the 1960's and 1970's. 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.2.11. 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. Soil type mapping is summarised in Figure H.2.12 and derived land capability in Figure H.2.13.

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 none of the project area 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
Phosphorous (P) PPM/millimetre Soil	<13	13-25	26-75
Sulpher (5) PPM/millimetre Soil	<13	13-25	26-75
Boron (Bo) PPM/millimetre Soil	<0.2	0.21-0.50	0.51-4.0
Copper (Cu) PPM/millimetre Soil	<1.1	1.1-3.0	3.1-10
Iron (Fe) PPM/millimetre Soil	<2.1	2.1-40	41-200
Manganese (Mn) PPM/millimetre Soil	<5.1	5.1-10	11-50
Zinc (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	<0.8	0.81-2.0	2.1-9
Potassium (K) Milliequivalent/100 millimetre Soil	<0.2	0.21-0.40	0.41-1.8
Calcium-Magnesium Ratio	<1.3	1.3-1.7	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 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 avoided. The balanced use of suitable fertilizers on almost all the soils would appear to be a requirement in order to maintain high yields, particularly from new varieties. This is part of the complex interlinked chain by which the traditional availability and use of organic fertilizer is changing as animal dung is diverted for use as domestic fuel due to wood becoming scarcer. This is compounded by the increasing difficulties in keeping livestock due to common access grazing land area being reduced as a result of agricultural intensification. In addition fodder availability from crop residuals for stall fed animals declines as it competes with use as a domestic fuel and building material source and this is made worse by short stalk HYV varieties producing nutritionally poorer and less volumes than traditional ones. 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.

Figure H.2.11

Agroecological Zones

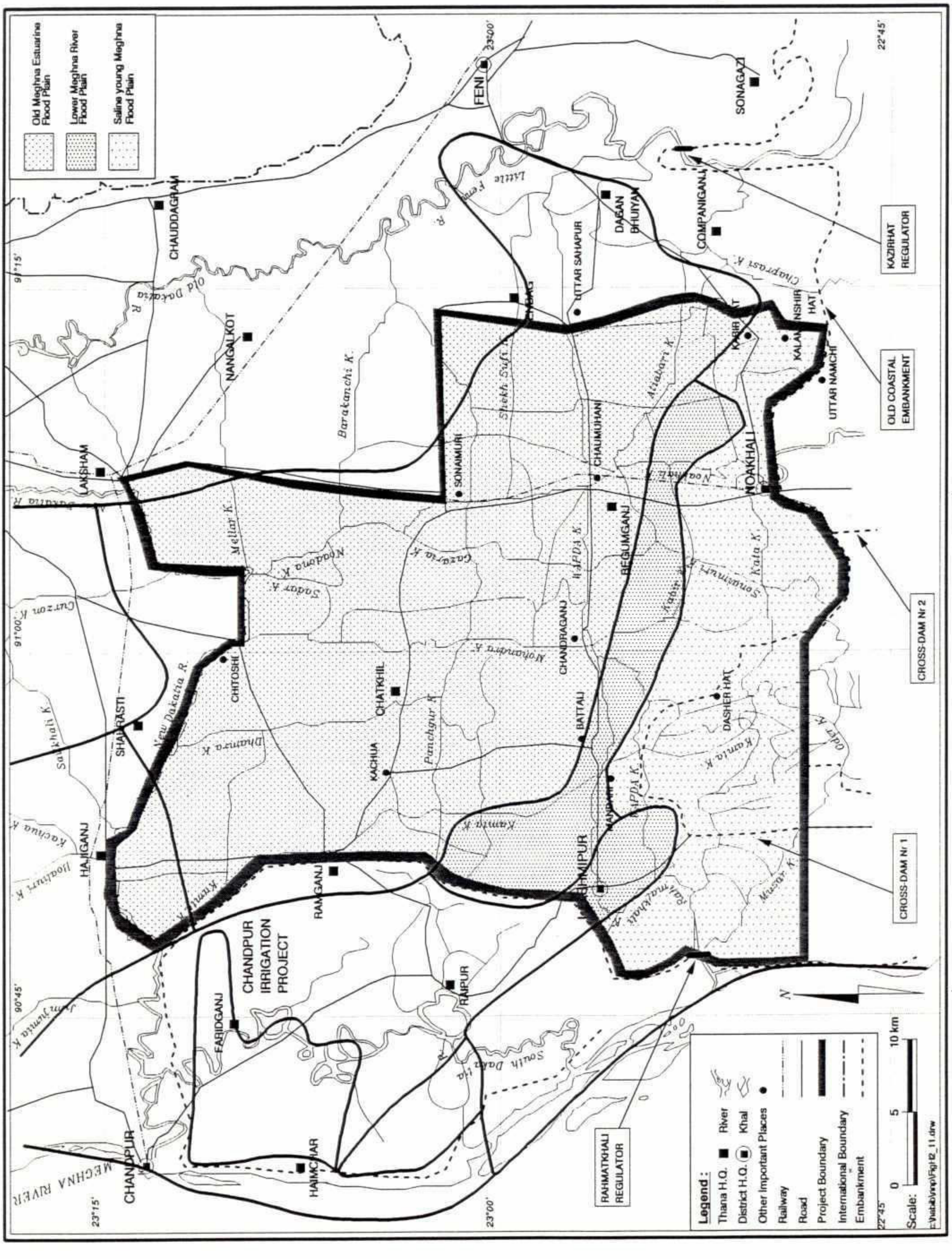


Figure H.2.12

Soil Type

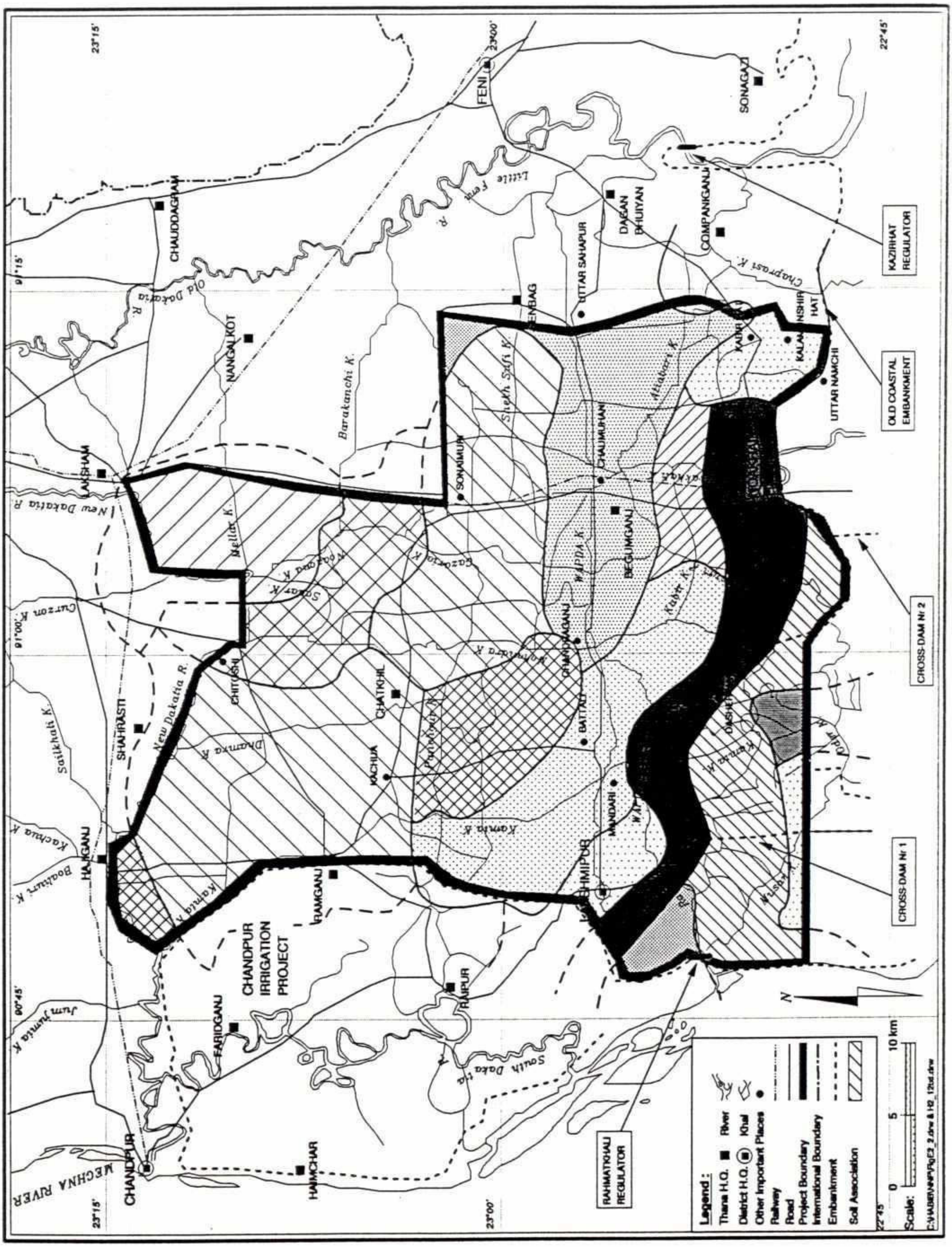
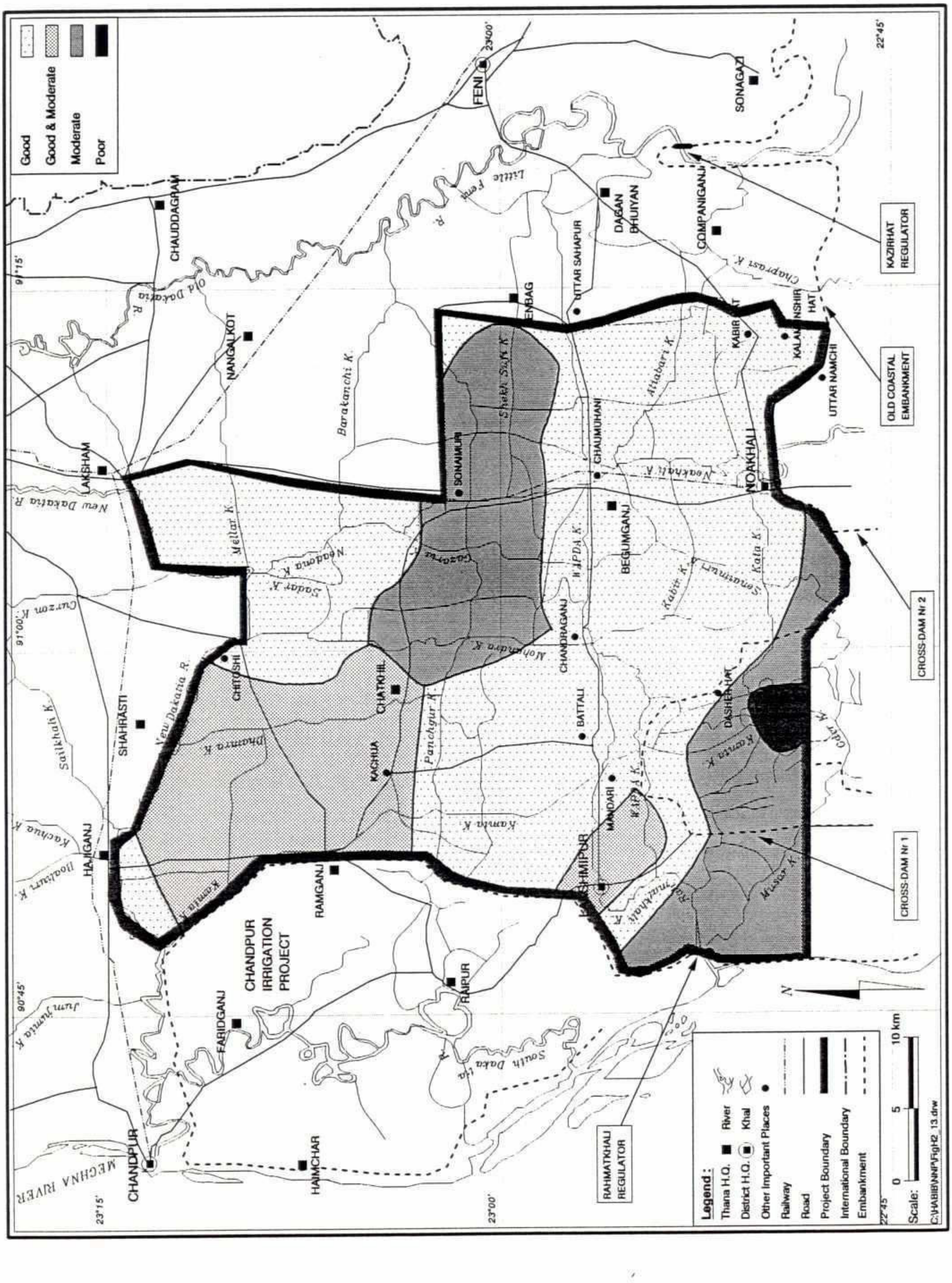


Figure H.2.13
Land Capability



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 reduced 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 dry season water rather than soil conditions. 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

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

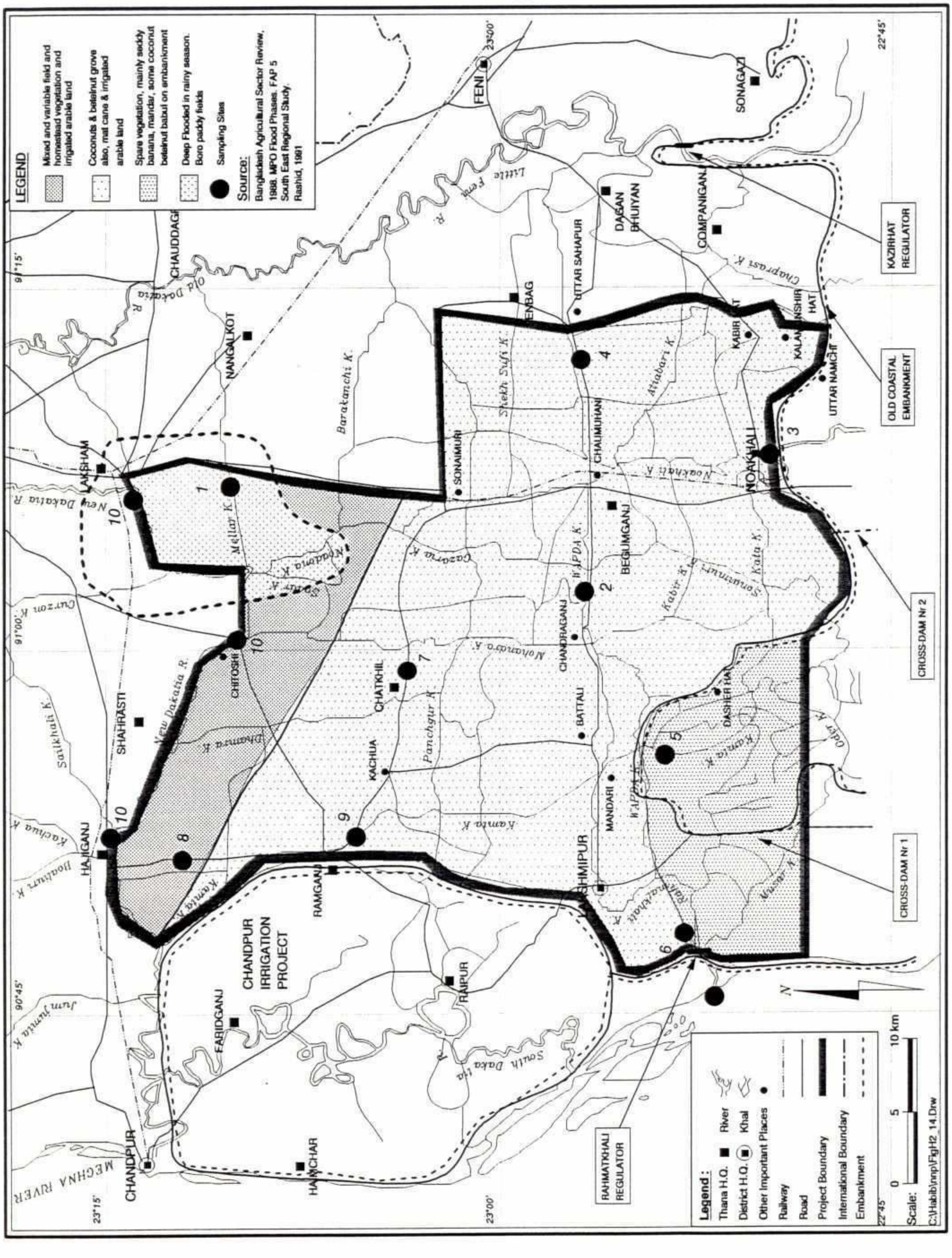
There has been growing local and international awareness in recent years that the effects of these developments can be very significant and in some cases detrimental to the point when they question the viability of the intervention. For this reason it is important to assess the current ecological status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

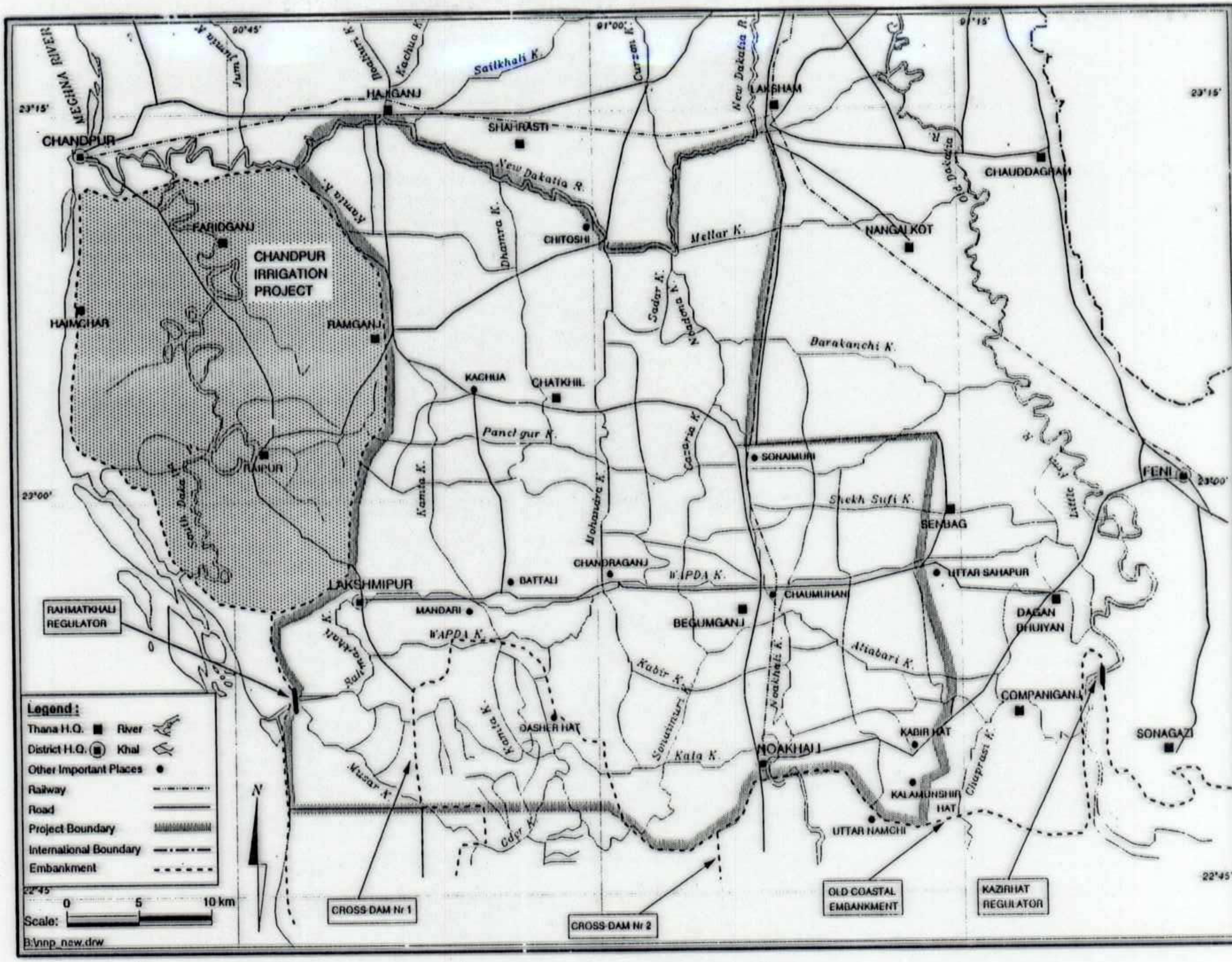
The most useful information outlining the historical situation with regard to the occurrence of aquatic and terrestrial flora and fauna in the area was gained from the Noakhali District Gazetteer, the previous edition (upon which much of the information was based) being dated 1911. A short field programme was devised to gather information on the present and past distribution, abundance and species diversity for both the wet and dry seasons. The data collection exercise also relied upon interviewing inhabitants of the area who displayed considerable indigenous knowledge, both on species availability and their use and importance to local people. This aimed to identify habitat zones in the area and, using the hydraulic modelling work, see how these were likely to be changed as a result of any proposed intervention. The 10 major sampling sites were chosen to provide appropriate coverage across the study area in all planning zones (shown in Figure H.3.1) and possible broad ecological habitat types (originally based on the FAO 1988 Agro-ecological Zone mapping given in Figure H.2.11) as shown in Figure H.2.14. The results from the survey work are given in detail in Appendix D.

The study area has already been heavily impacted by human intervention, especially the construction of the old coastal embankment which forms the southern boundary of the area. The exception is a small part in the south west corner which is recently accreted land, as can be seen in Figure H.2.15. In addition the encircling

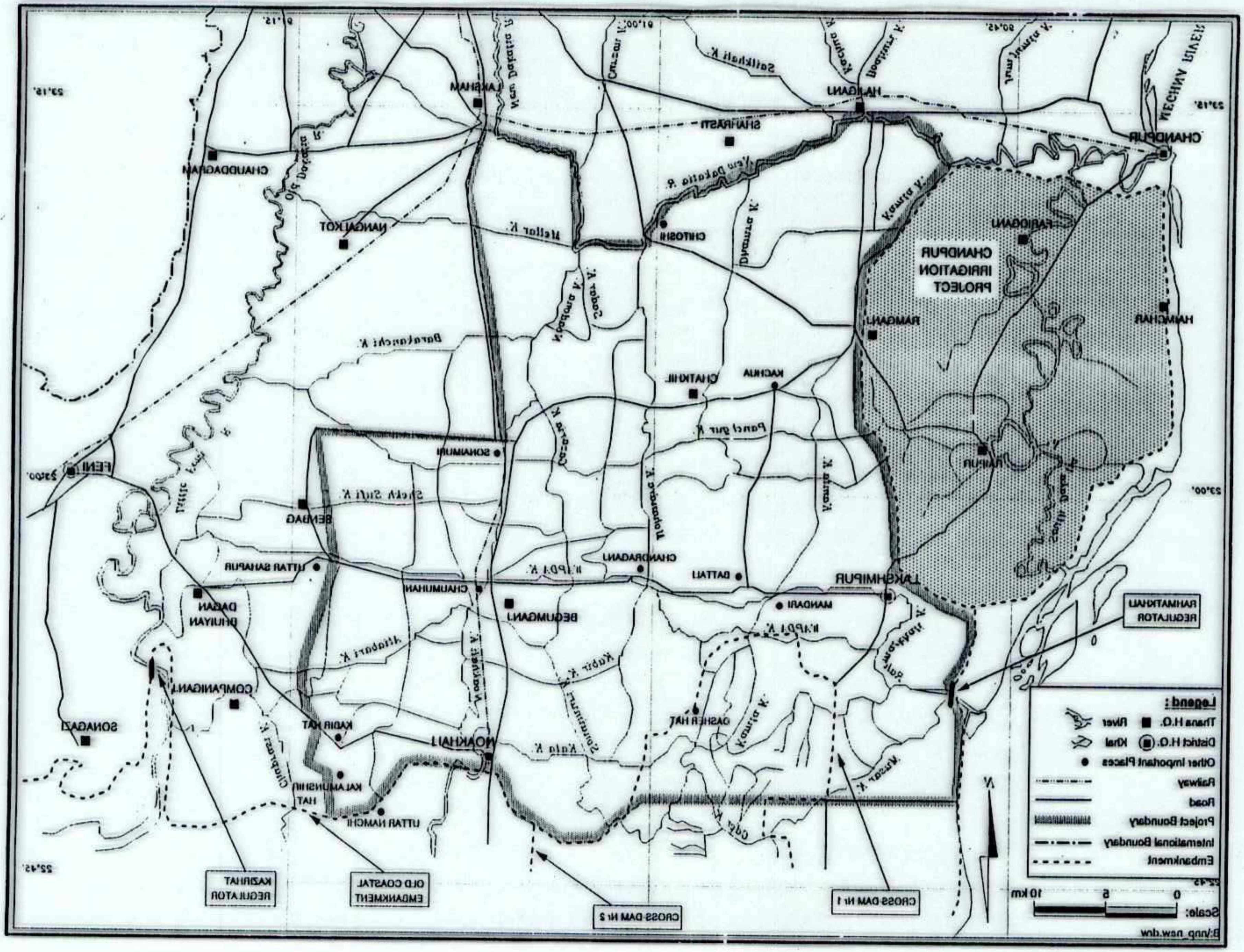
Figure H.2.14

Ecology Habitat Zones and Sampling Sites





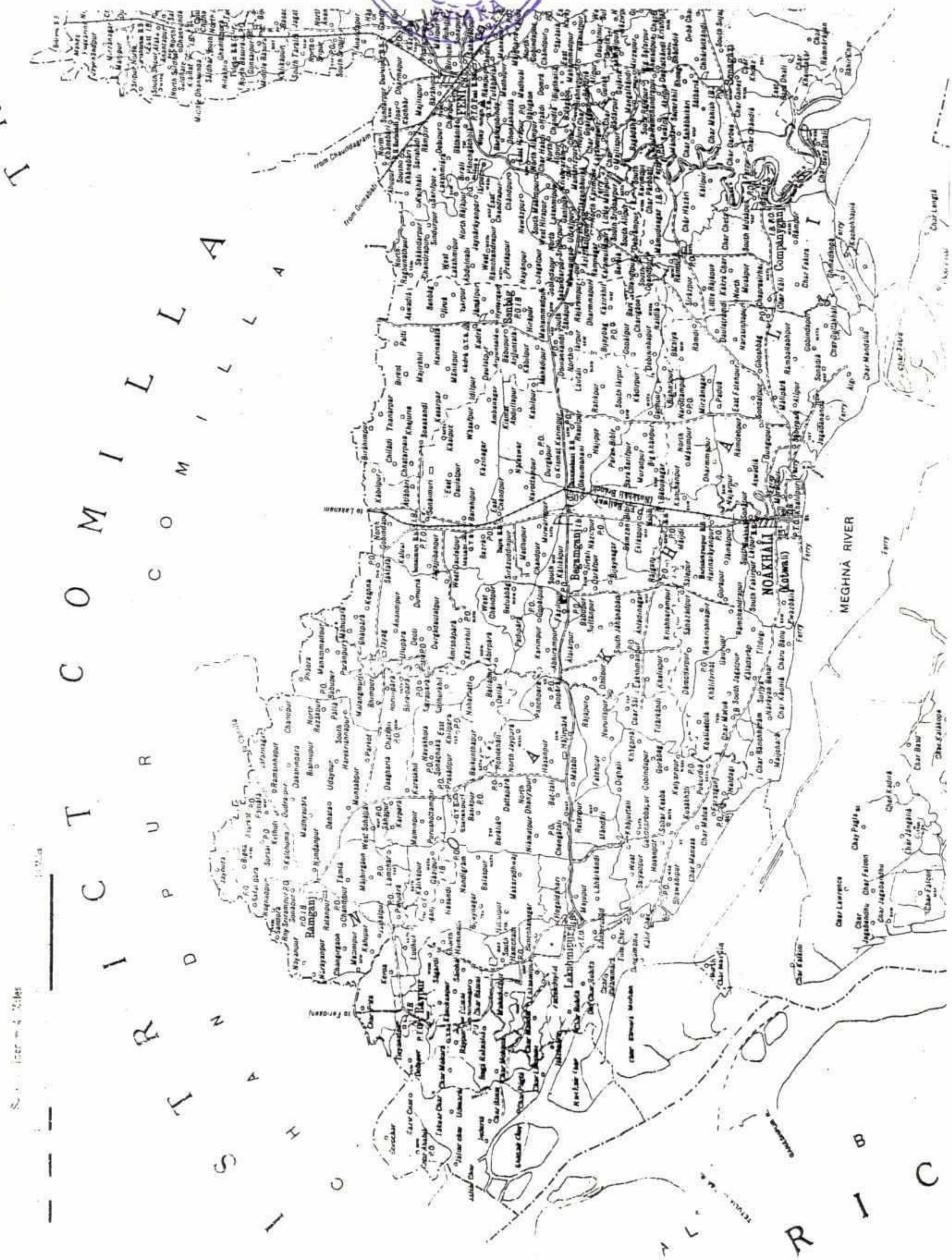
MEGHNA RIVER
CHANDPUR
HAIMCHAR
FARIDGANJ
CHANDPUR
IRRIGATION
PROJECT
RAMGANJ
RAIPUR
South Daka
LAKSHMIPUR
HAJIGANJ
SHAHRASTI
CHITOSHI
KACHUA
CHATKHIL
BATTALI
MANDARI
CHANDRAGANJ
LAKSHAM
NANGALKOT
CHAUDDAGRAM
SONAIMURI
SENBAG
UTTAR SAHAPUR
CHAUMUHANI
BEGUMGANJ
DAGAN
BHUIYAN
COMPANIGANJ
KABIR HAT
KALAMUNSHIR
HAT
UTTAR NAMCHI
NOAKHALI
DASHER HAT
FENI
SONAGAZI
Satkhali K.
Jumi Jumia K.
Bodhuri K.
Kachua K.
Curzon K.
New Dakatia R.
Old Dakatia R.
Little Feni
Kamta K.
Dhamra K.
Mellar K.
Sadar K.
Noadona K.
Barakanchi K.
Panchgur K.
Cazoria K.
Mohamadra K.
Shekh Sufi K.
WAPDA K.
Aliabari K.
Kabir K.
Sonaimuri K.
Noakhali K.
Kala K.
Chuprasi K.
Kamta K.
Gdar K.
Musar K.
Rahmatkhali K.
90°45'
91°00'
91°15'
23°15'
23°00'
22°45'
RAHMATKHALI
REGULATOR
CROSS-DAM Nr 1
CROSS-DAM Nr 2
OLD COASTAL
EMBANKMENT
KAZIRHAT
REGULATOR
N
Legend :
Thana H.Q.
River
District H.Q.
Khal
Other Important Places
Railway
Road
Project Boundary
International Boundary
Embankment
Scale:
0
5
10 km
B:\nnp_new.drw



CHANDPUR IRRIGATION PROJECT
CHANDPUR
HAIMCHAR
FARIDGANJ
RAMGANJ
RAIPUR
LAKSHMIPUR
HAJIGANJ
SHAHRASTI
LAKSHAM
CHAUDDAGRAM
NANGALKOT
CHITOSHI
CHATKHIL
KACHUA
SONAIMURI
FENI
BEMBAG
CHANDRAGANJ
DATTAPARA
MANDARI
CHAUMUHANI
BEGUMGANJ
UTTAR SAHAPUR
DAGAN BHUIYAN
COMPANIGANJ
SONAGAZI
KABIR HAT
NOAKHALI
DASHER HAT
KALAMUNSHIR HAT
UTTAR HAMCHI
MEGHNA RIVER
RAHMATKHALI REGULATOR
KAZIRHAT REGULATOR
OLD COASTAL EMBANKMENT
CROSS DAM Nr 2
CROSS DAM Nr 1
Legend :
Thana H.Q.
District H.Q.
Other Important Places
River
Khal
Railway
Road
Project Boundary
International Boundary
Embankment
N
Scale: 0 5 10 km
B:\mp_new.dw

Figure H.2.15

The Study Area in 1931



Source: District Gazetteer Map, Surveyed 1893-98, 1913-1916, Additions 1931 embankment around the Chandpur project area has effectively cut off the study area drainage system from the Meghna river system except through the controlled Rahmatkhali regulator to the south and the uncontrolled Dakatia river to the north. Even the latter system has been constricted into an area bounded by the road and railway embankment to the north and the Chandpur embankment to the south. However the study area still has significant rain-fed floodplains covering nearly half of the study area in the peak of a 1 in 2 "normal" flood year as shown in Figure H.2.5. This increases still further in a 1 in 5 high "normal" year as shown in Figure H.2.7. There is at present no set of agreed national policy aims and objectives with regard to ecological issues and particularly management and conservation for sustainable resource use, let alone a structure for implementing this. There is a Draft National Conservation Strategy and this is in the process of being reviewed by Central Government as part of NEMAP. There is as yet no unified body of environmental legislation and it is likely to be some time before this is in place, let alone enforced. What is important for the study is how any national environmental policy guidelines are to be adopted at the regional and sub-regional level. Specifically what are to be the priorities for the area and is this reflected in the proposed intervention for the study area? The central issue is likely to be if the seasonal floodland losses caused by a drainage improvement intervention are considered justifiable due to the agricultural benefits that are likely to result. It is a matter of priorities and specifically if the government considers the seasonal floodlands of the Noakhali North area to be of low ecological and economic value within the national context. This should consider the issues of loss of economic use of resources as well as wider concerns as to ecological sustainability and changes in bio-diversity.

The real problem is the lack of hard ecological data, particularly with regard to trends over time and also an understanding of the very complex linkages within the natural ecological system and how these interface with the human use of these resources. Significantly more data collection is needed to do this, spread out over a minimum period of a year to reflect the full seasonal cycle. In addition, longer term trend data is required and this is especially the case with the fish system which is of major economic and nutritional use to the people of the study area.

H.2.2.10 Flora

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

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

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

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

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

H.2.2.11 Fauna

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

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

The main fish habitats are shown in Figure H.2.30 and comprise internal rivers (of which the Dakatia is the most important), large seasonal flood plains and Khals and drains, some of which are perennial. Some 45% of the gross study area goes under standing water in the monsoon season in a 1 in 2 "normal" year, due to local rainfall and drainage constraints, the latter having mainly been caused by construction of the coastal cross dams resulting in land accretion now inhibiting drainage outflow. Ponds are also important habitats, many of which are now stocked and managed for capture fisheries.

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

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

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

H.2.2.12 Seismic Activity

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

H.2.2.13 Other Natural Hazards

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

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

Erosion has historically been a major threat for the present study area, both from the Meghna river in the west and the coast to the south. This has resulted in the need to move major towns in the past. It would appear that the District Headquarters town of Bhulua dating from the 13th Century was lost to the Meghna river around 1820 and the original site of Companyganj (present site just outside the eastern edge of the study area) was lost to the sea in 1911. Conversely the area has recently had considerable accreted land attached to the south and this has rendered many ports and Ghats inoperative. When the new District Headquarters was established at Noakhali in 1821 it was a railhead coastal port, where as now it lies over 30km from the coast. This accretion has recently been considerably hastened as a result of the construction of coastal cross dams and polderisation which have sometimes been made prematurely, causing land to be settled before it has had a chance to accrete to a safe level and making it dependent upon the coastal embankment for protection from tidal waves. It has also caused drainage difficulties, particularly in the study area. A map of the area dated 1919 with amendments in 1931 (some 25 years before the start of coastal cross dam construction) is shown in Figure H.2.15.

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

H.2.3 The Human Environment

H.2.3.1 Introduction

The most notable feature of the human environment is the very high population density and the long length of time that the area has been settled (from 350 BC at least with stable administration from before the 9th Century AD). Formal political adminstration has been well established in the area and the boundaries of the units have been fixed for a considerable time. These are shown in Figure H.2.16 and are based upon the BBS Small Area Atlas data and Police Station Maps which in turn are based upon the 1913-16 survey maps of the area, amended in 1931 and reproduced in the Government Gazetteers.

H.2.3.2 Population Settlement and Land Tenure

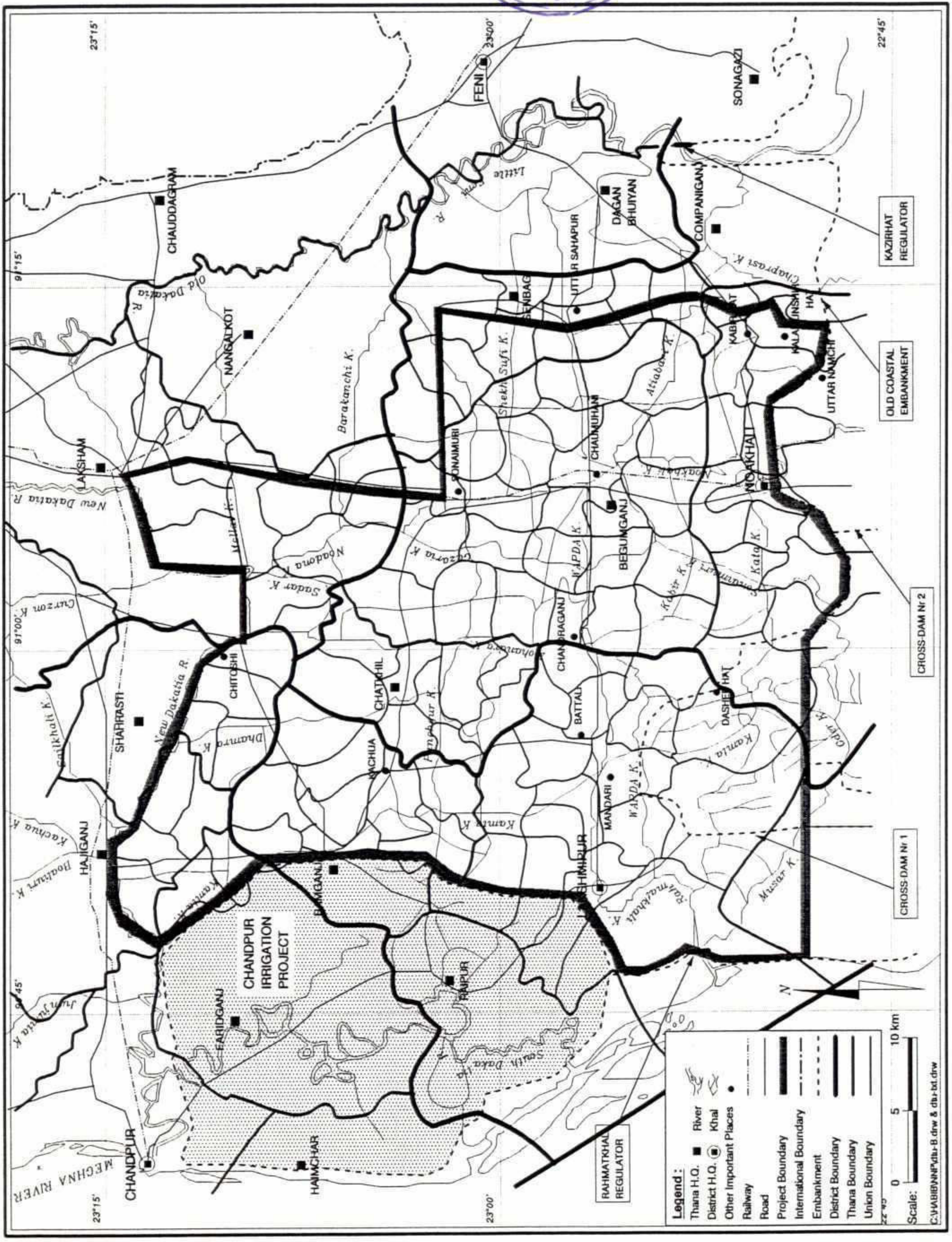
The history of human settlement in the Noakhali North area appears to be very long indeed, however the physical evidence for this is relatively limited. This is partly due to the dynamic nature of the natural environment (large scale river and coastal erosion and accretion along with cyclones and seismic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

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

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

Figure H.2.16

Administrative Boundaries



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

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

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

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

There is significant differentiation in population density across the area, although the only presently available complete data is for 1981 and is shown in Figure H.2.17. In 1981 the density varied from below 750/km2 in the south western newly accreted and settled lands to over 1750 per km2 in the peri-urban areas round Noakhali, Begumganj and the old administration town area around Lakshmipur. The mean density in 1981 would appear to be around 1000-1250 people per Km2. The situation in 1991 for the south east portion of the study area is given in Figure H.2.18 together with the trends for this area between 1981 and 1991 in figure H.2.19. This indicates some decline in localised peri-urban areas, possibly due to local in-migration to the larger towns. Otherwise there appears to be a general increase although this is highest in the urban centres and lowest in central parts of Zone D. However the full data set is required to sensibly interpret the picture, particularly for the south west part of the study area which is very different than the rest.

The 1981 distribution of landless households (defined as having less than 0.02ha of land) is given in Figure H.2.20. In general the rural figure is about 30-40% which is lower than many parts of the country, perhaps an indicator that dispossession due to river bank erosion is not a major problem in the study area. The highest levels are found in the urban areas and are between 50-70%. Similar data for 1991 is available for the south east part of the study area and shown in Figure H.2.21 with the difference between 1981 and 1991 for these areas given in Figure H.2.22. This shows a very fragmented pattern with some 20% of the Unions (mainly the more peripheral rural and smaller urban ones) having decreased landlessness. This may well be the result of

Figure H.2.17

Human Population Density, 1981

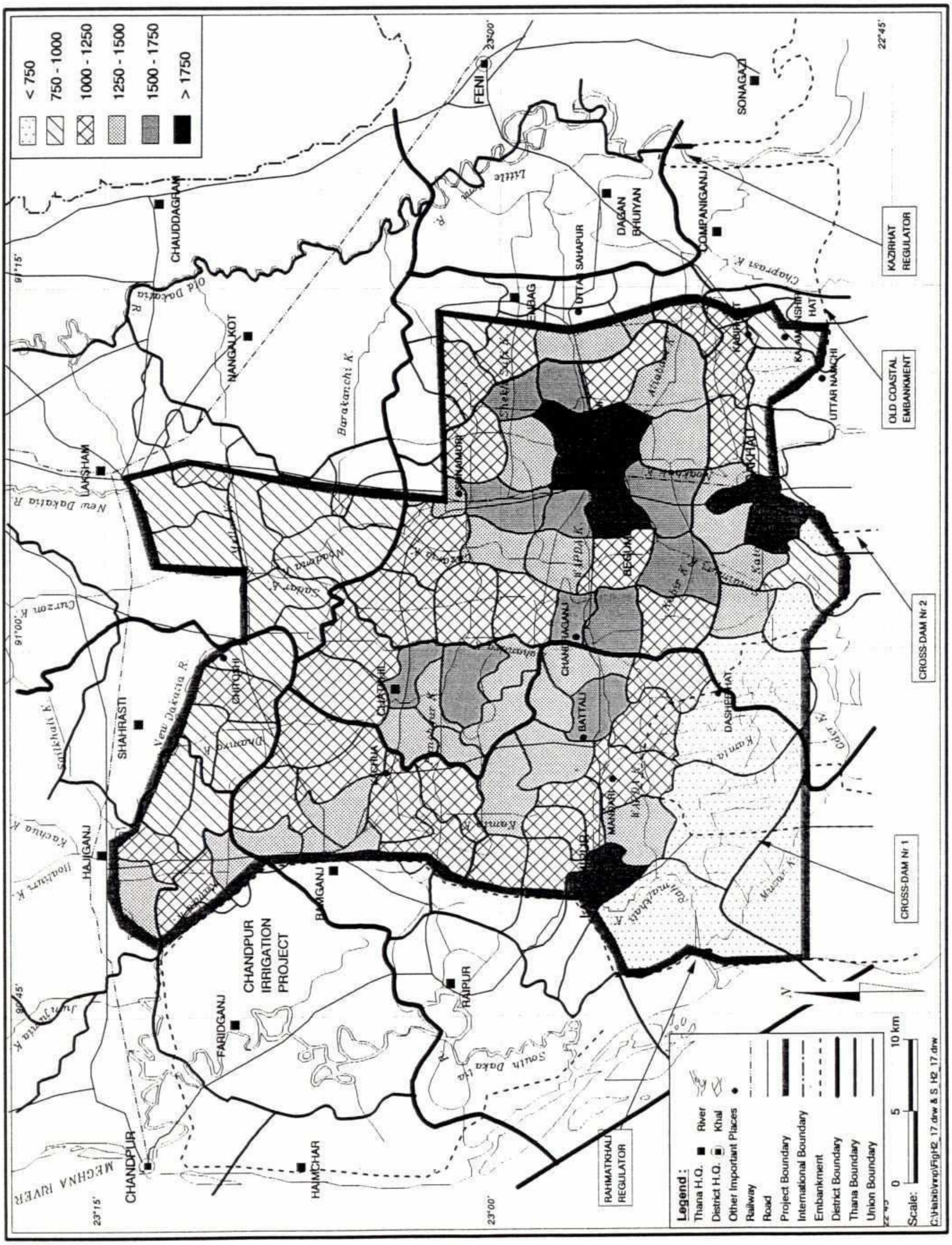


Figure H.2.18

Human Population Density, 1991

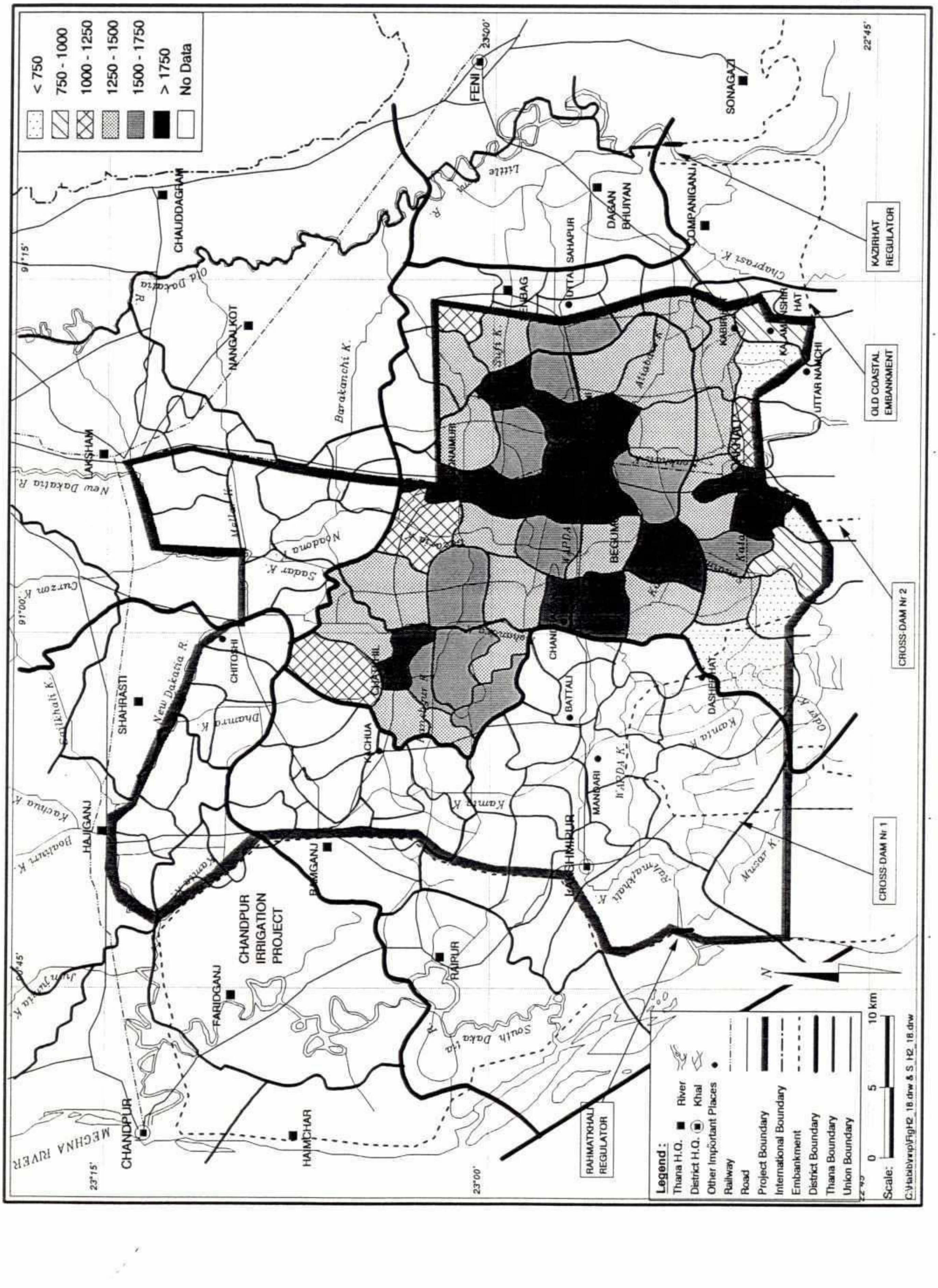


Figure H.2.19

Human Population Density % Change 1981 - 1991

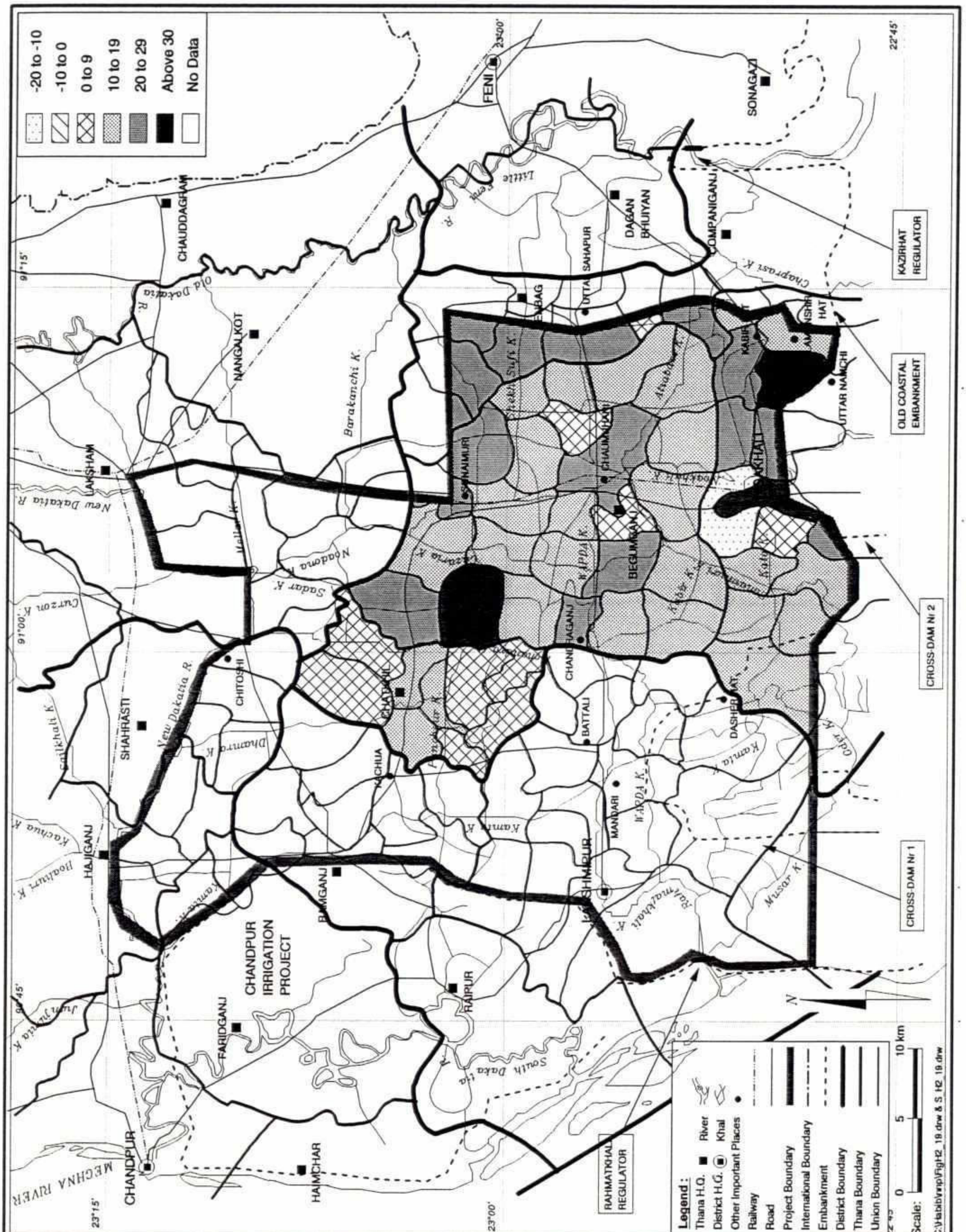


Figure H.2.20

% Landless, 1981

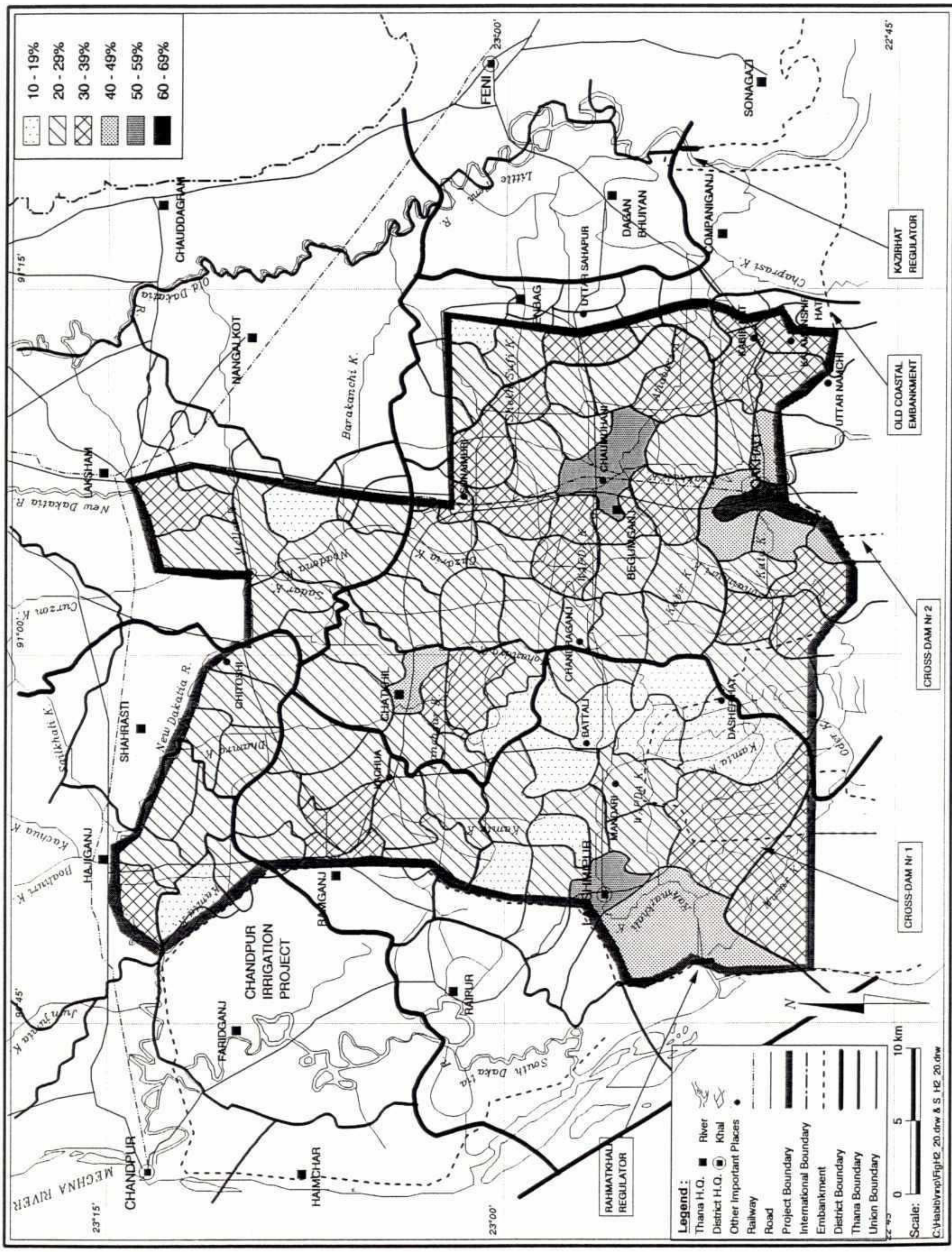


Figure H.2.21

% Landless, 1991

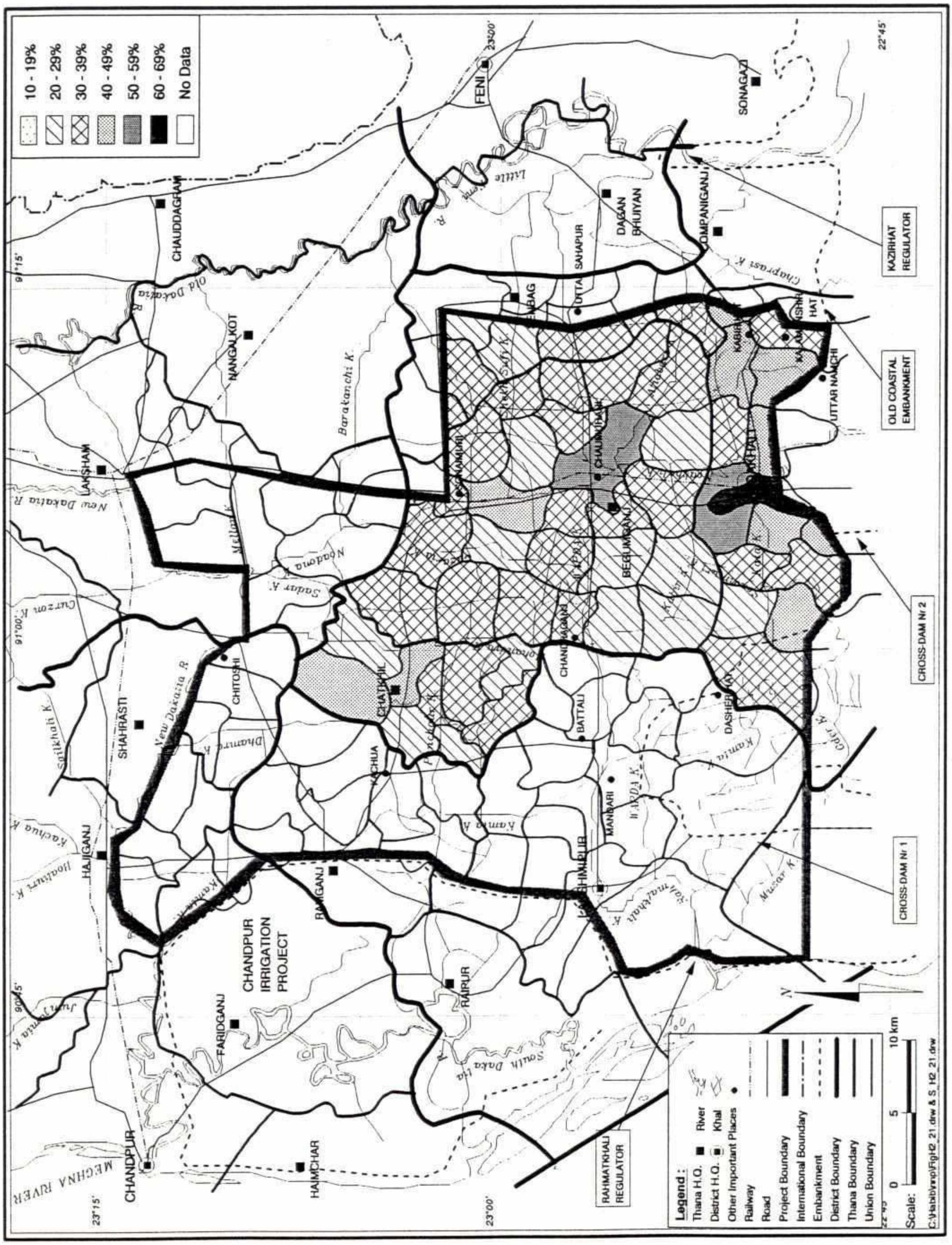
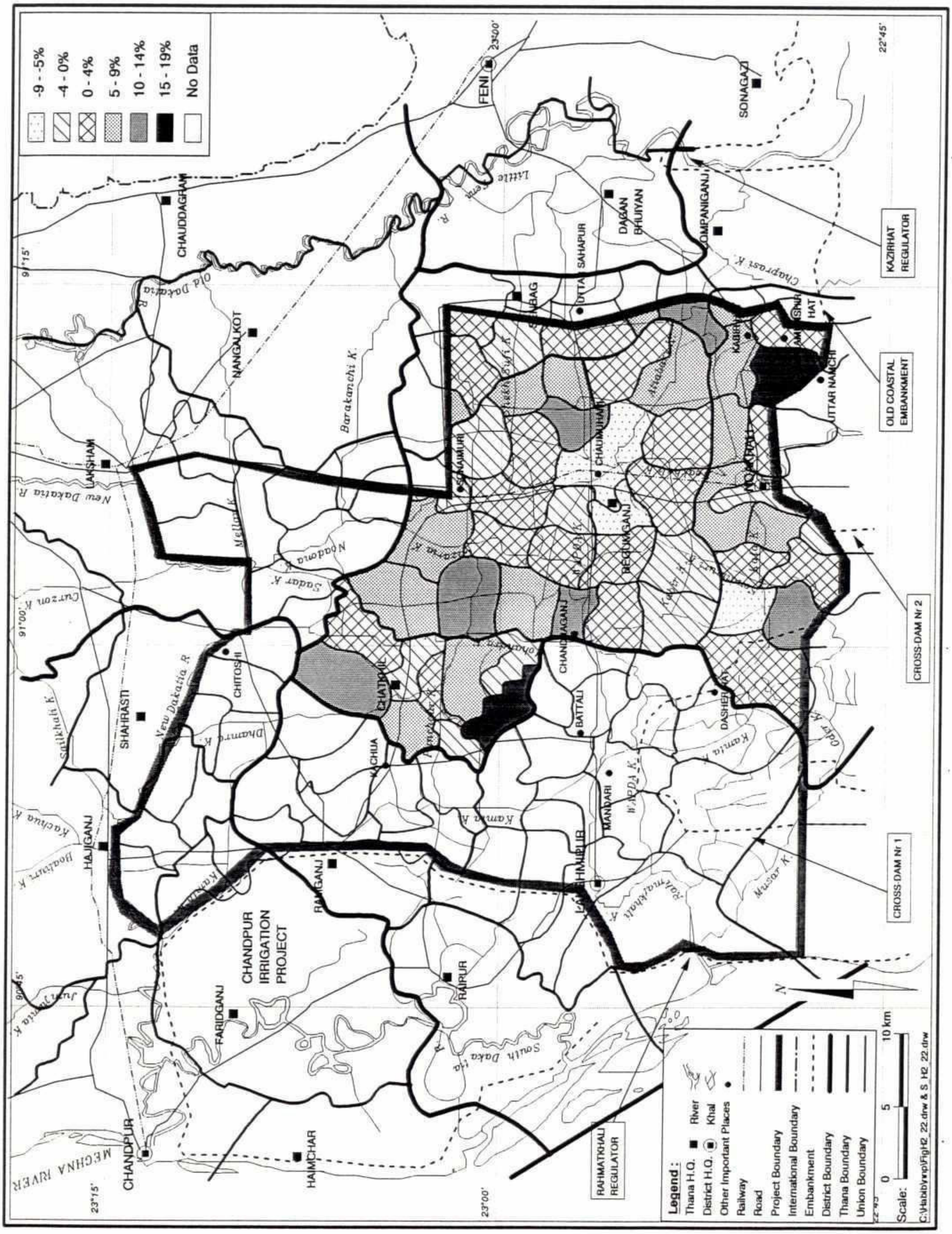


Figure H.2.22

% Change in the Landless Population 1981-1991



out-migration from these areas to the larger urban towns. Overall there would seem to be an increase in landless households of some 5% over the 10 year period, a normal situation for Bangladesh.

H.2.3.3 Household Economic Livelihood

The proportion of households in 1981 with agriculture as their main activity is shown in Figure H.2.23. This shows that the highest levels are in the south western area. This is newly accreted and settled land with poorly developed urban employment sectors. Apart from this the pattern is again very fragmented with general levels of around 50-60%. The lowest levels are along the north south spinal road and rail system routes. The 1991 data for the southeast area is shown in Figure H.2.24 with the difference 1981-1991 for the same area in Figure H.2.25. The 1991 map shows a very different situation than the one in 1981, with a nucleated pattern from a centre of low agricultural employment at Begumganj unevenly spreading outwards. The 1981-1991 change map shows highly variable patterns and without the full 1991 data set it is unwise to read much into this.

Literacy rates for 1981 are given in Figure H.2.26 and are very low in the south western part of the study area being less than 20%. This is possibly due to the fact that the area is relatively newly settled land with fewer facilities than elsewhere. In addition it is likely to have encouraged in-migration of dispossessed people who are probably poorer than the average and less well educated. The highest literacy rates (50-60%) are recorded in the immediate urban area of Noakhali town followed by the north central part of the study area with levels of 40-50%. Similar data for 1991 are available for the south eastern part of the study area and are given in Figure H.2.27 with difference data in Figure H.2.28. They show that there has been a considerable improvement in literacy rates in some areas although the high levels in Noakhali town have declined, presumably as a result of in-migration. However a complete set is required to sensibly interpret this data.

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

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 to map land use in a formalised way in much of Bangladesh due to its complexity in both seasonal and spatial terms. Even attempts to do this using detailed SPOT multi-spectral satellite imagery down to 1:25 000 have failed to produce useable information (see the work of FAP 3) and if anything have confused the situation still further. Instead a conceptual model is required which combines the agro-ecological zones (Figure H.2.11) with flood timing (Figures H.2.5 - H.2.8) and depth to the seasonal cropping calendar (Figure H.2.29) and also how this varies across the different flood zones. This demonstrates the importance of flood timing, extent and depth on the cropping pattern and agricultural production system in the area.

Figure H.2.23

% Households with Farming as Primary Occupation, 1981

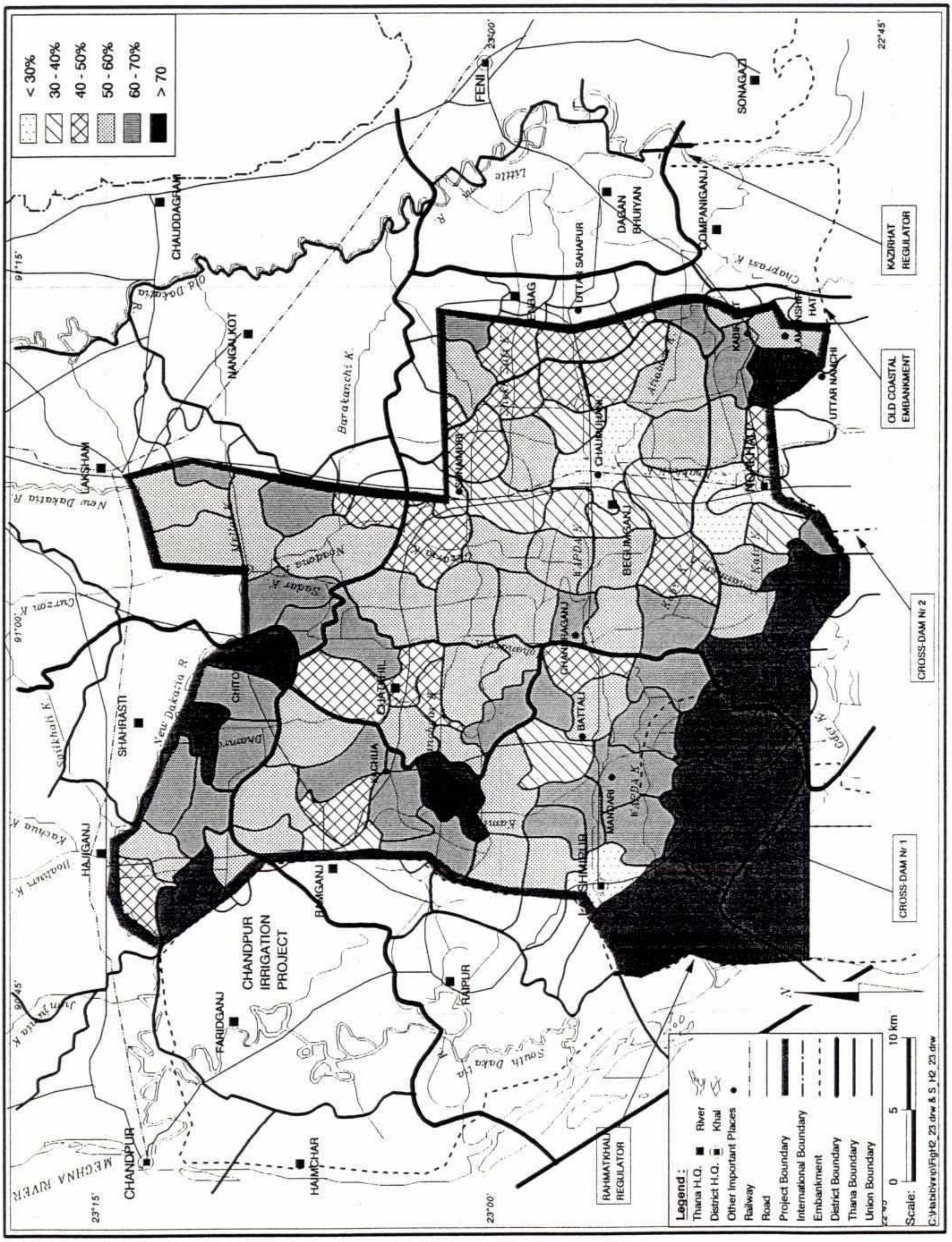


Figure H.2.24

% Households with Farming as Primary Occupation, 1991

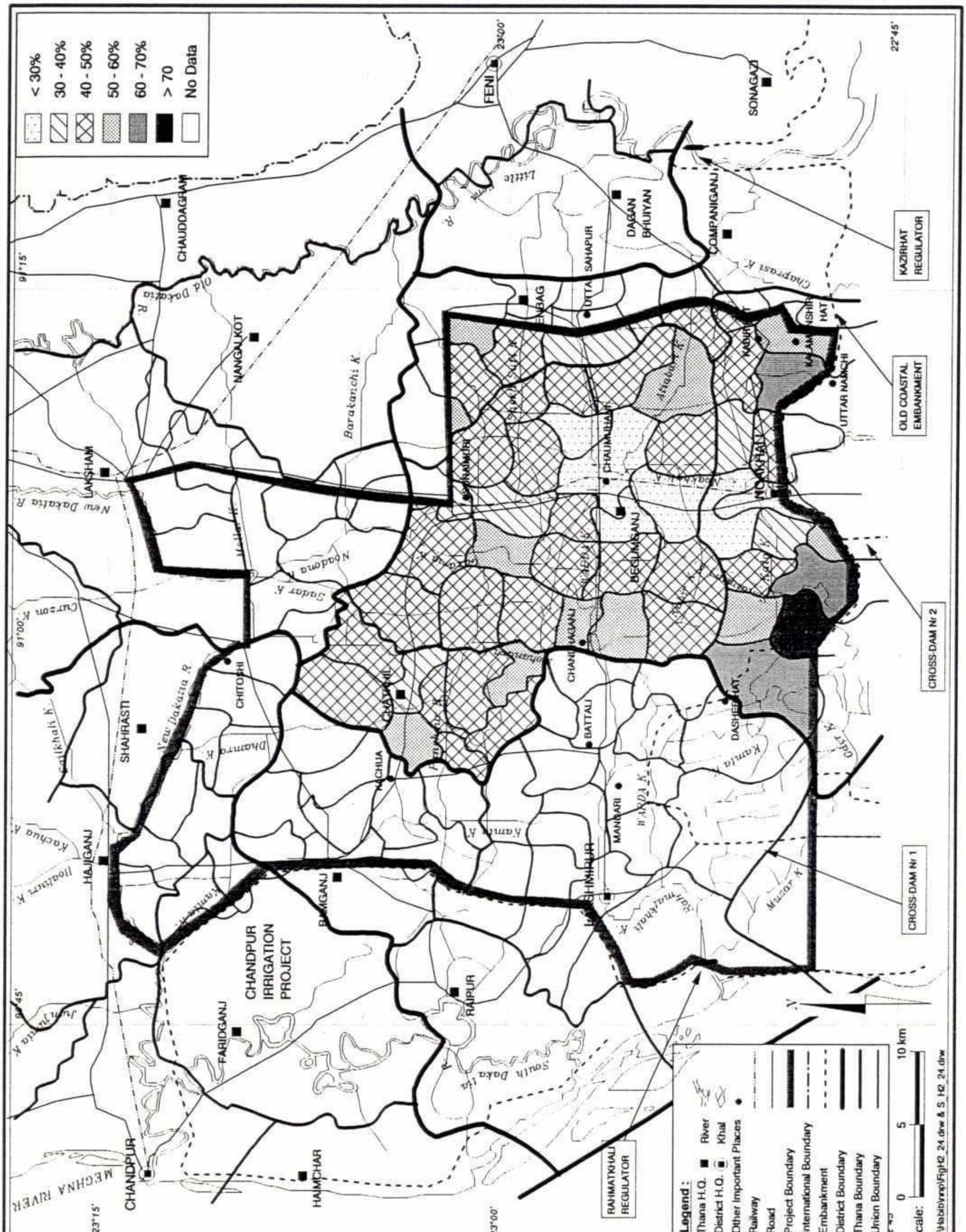


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Figure H.2.25

% Change in Farming as Primary Occupation 1981-1991

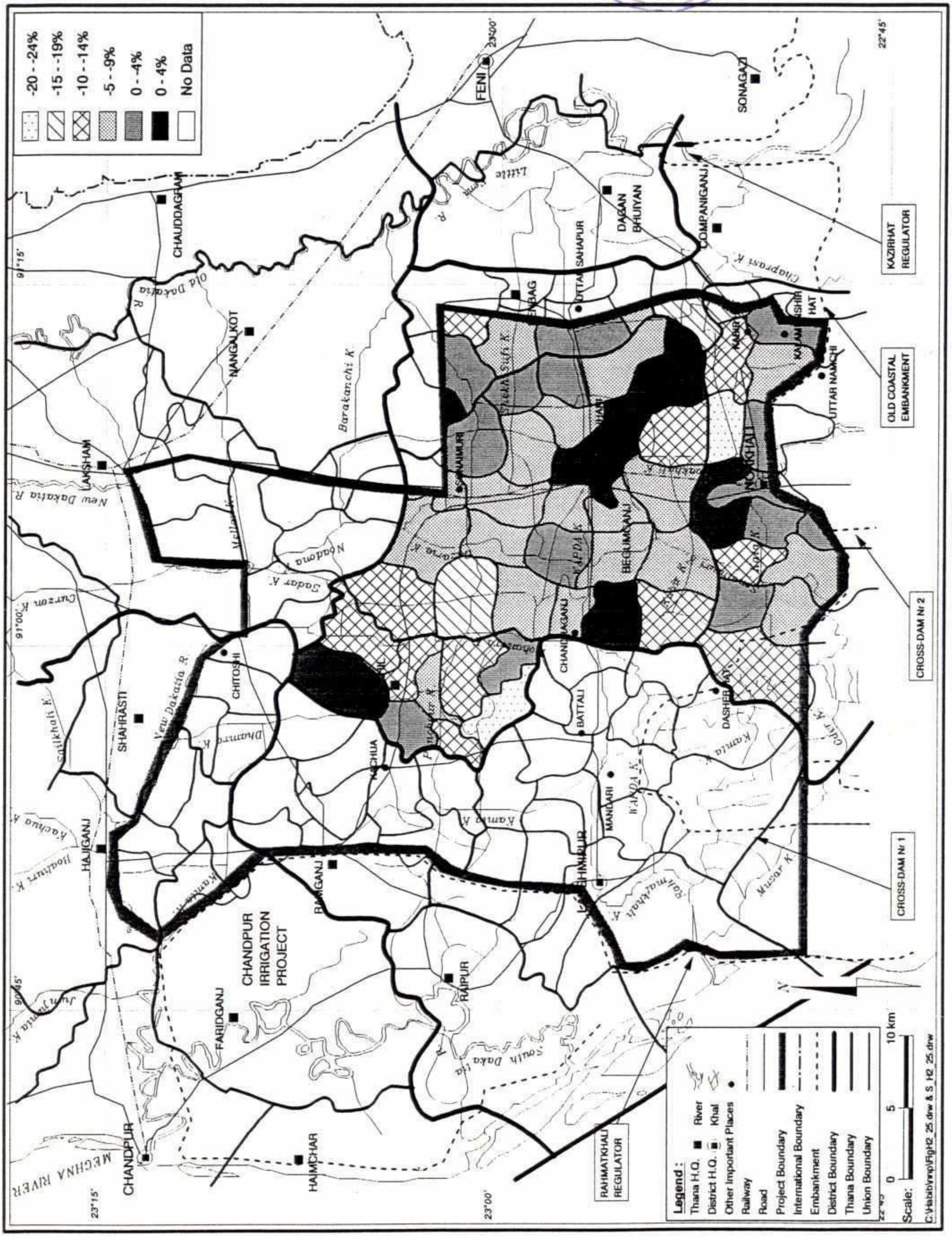

Figure H.2.26

Literacy Rate, 1981

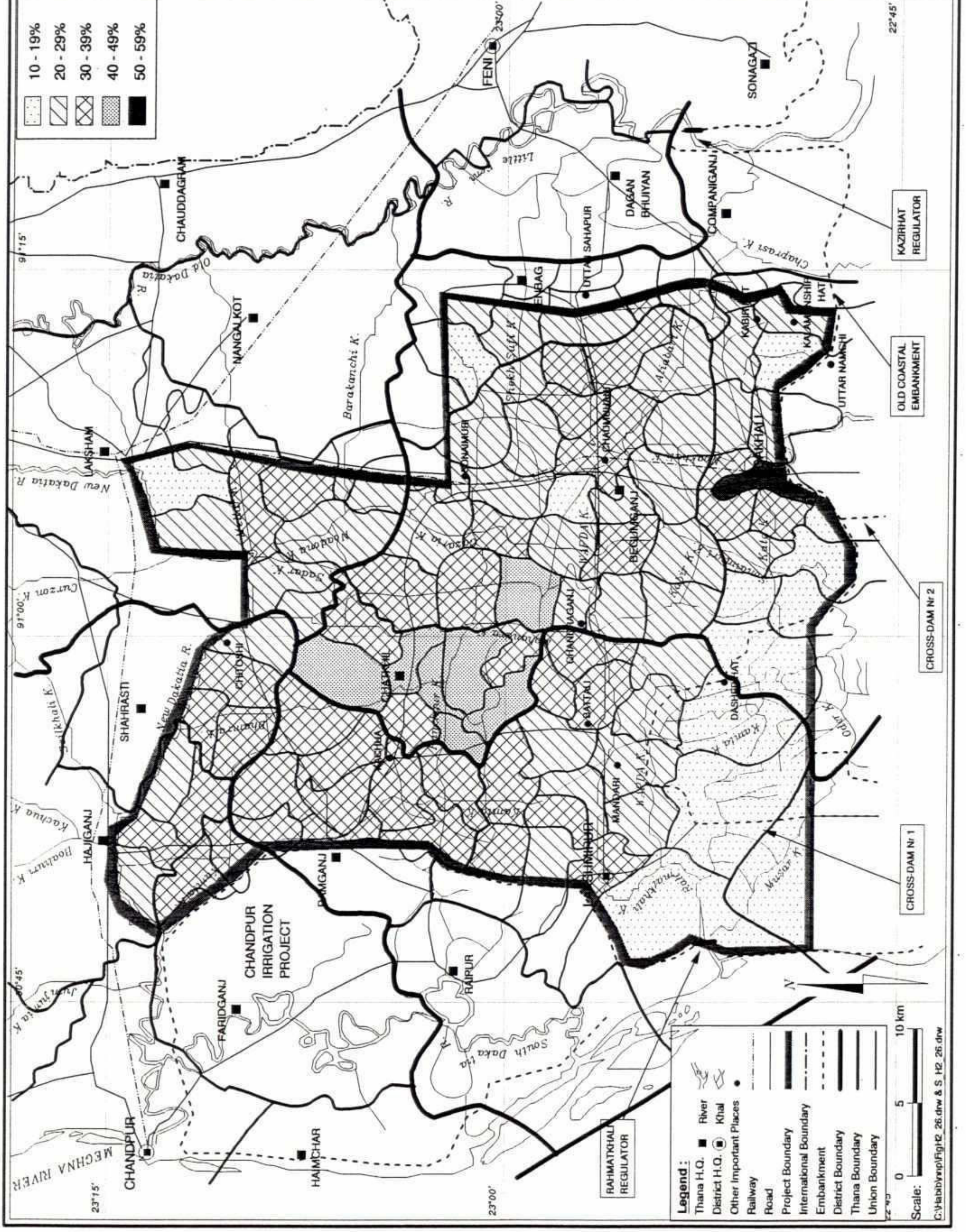

Figure H.2.27

Literacy Rate, 1991

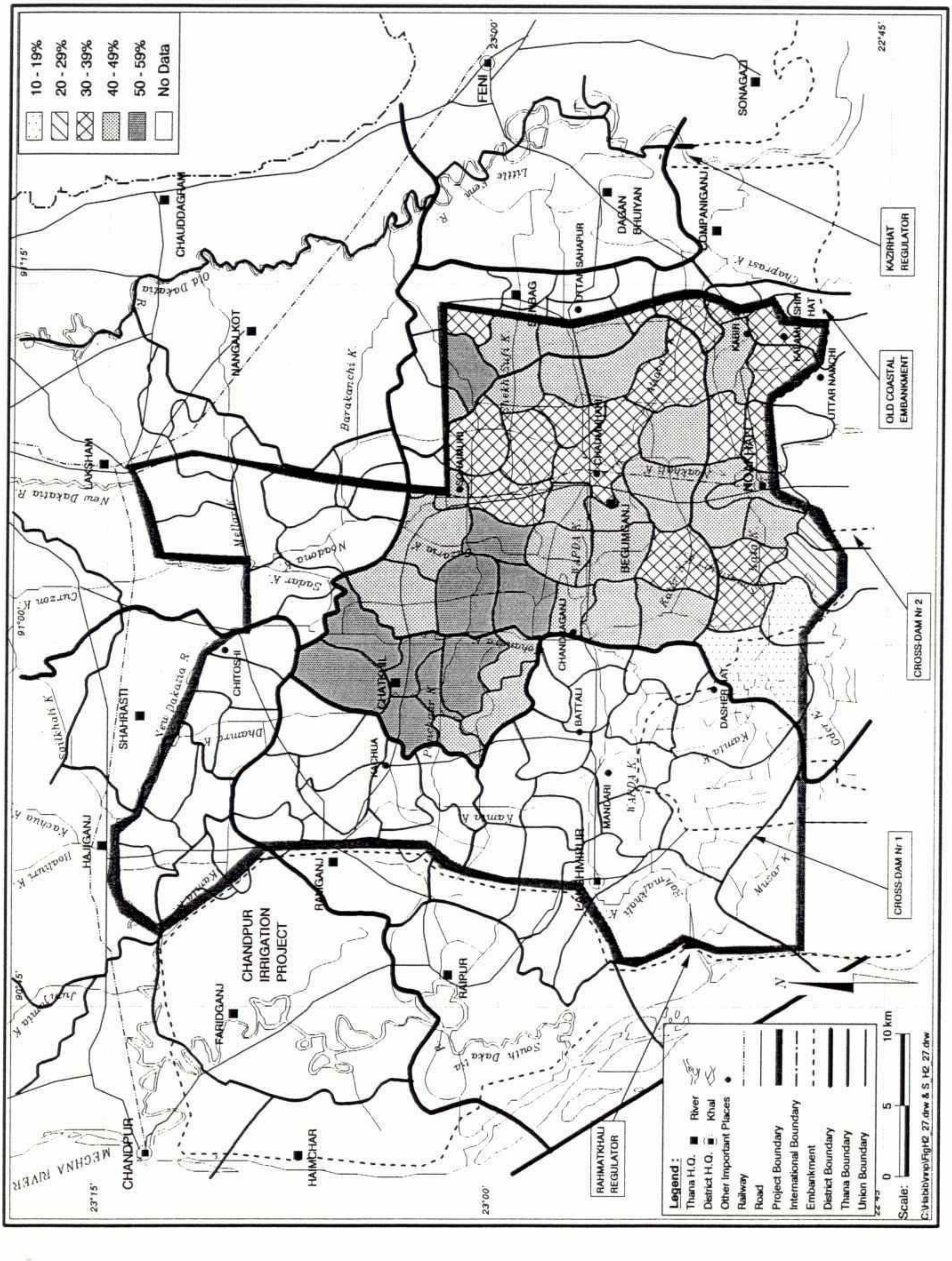

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Figure H.2.28

% Change in Literacy Rate Between 1981-91

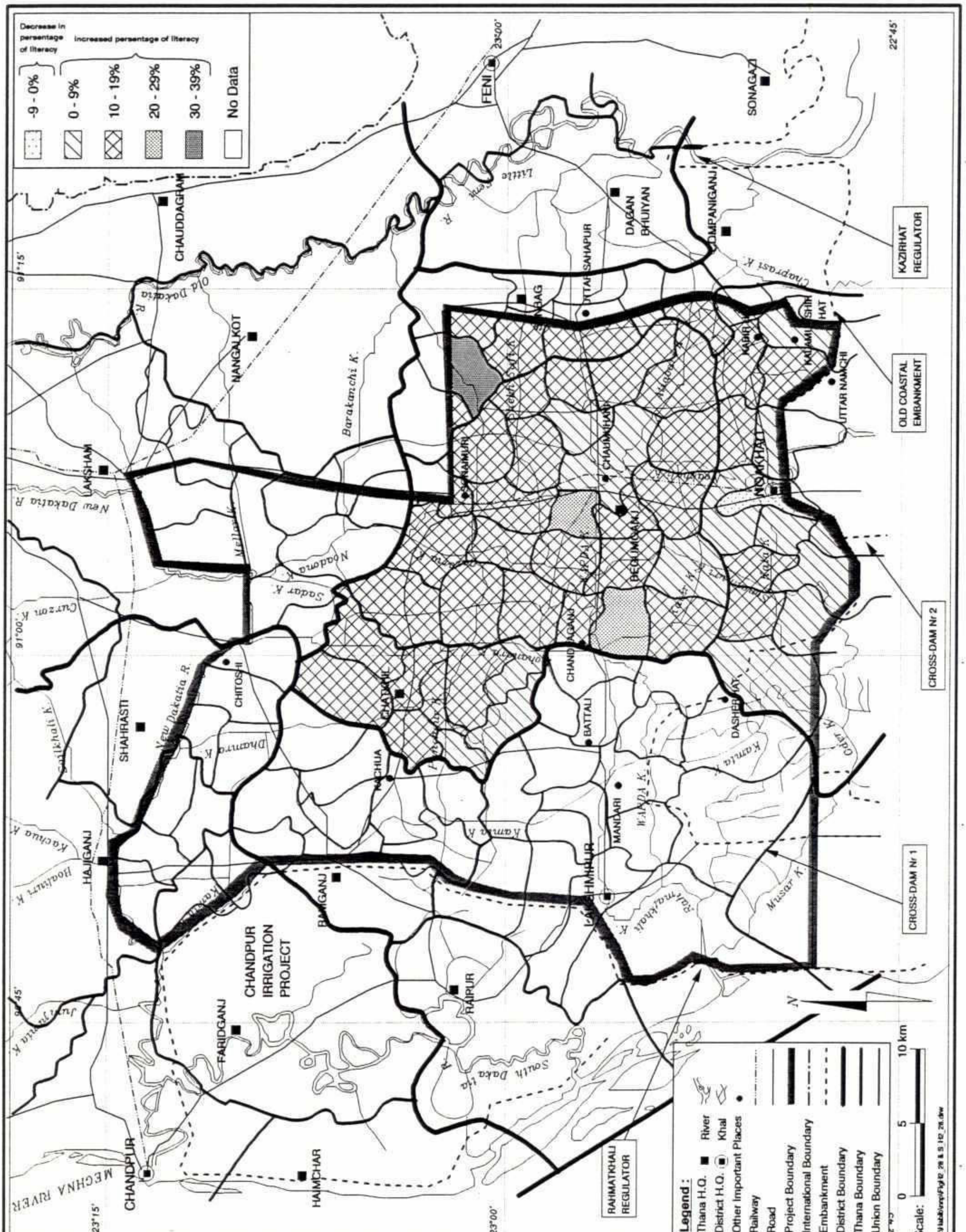


Figure H.2.29a
Simplified Cropping Calendar

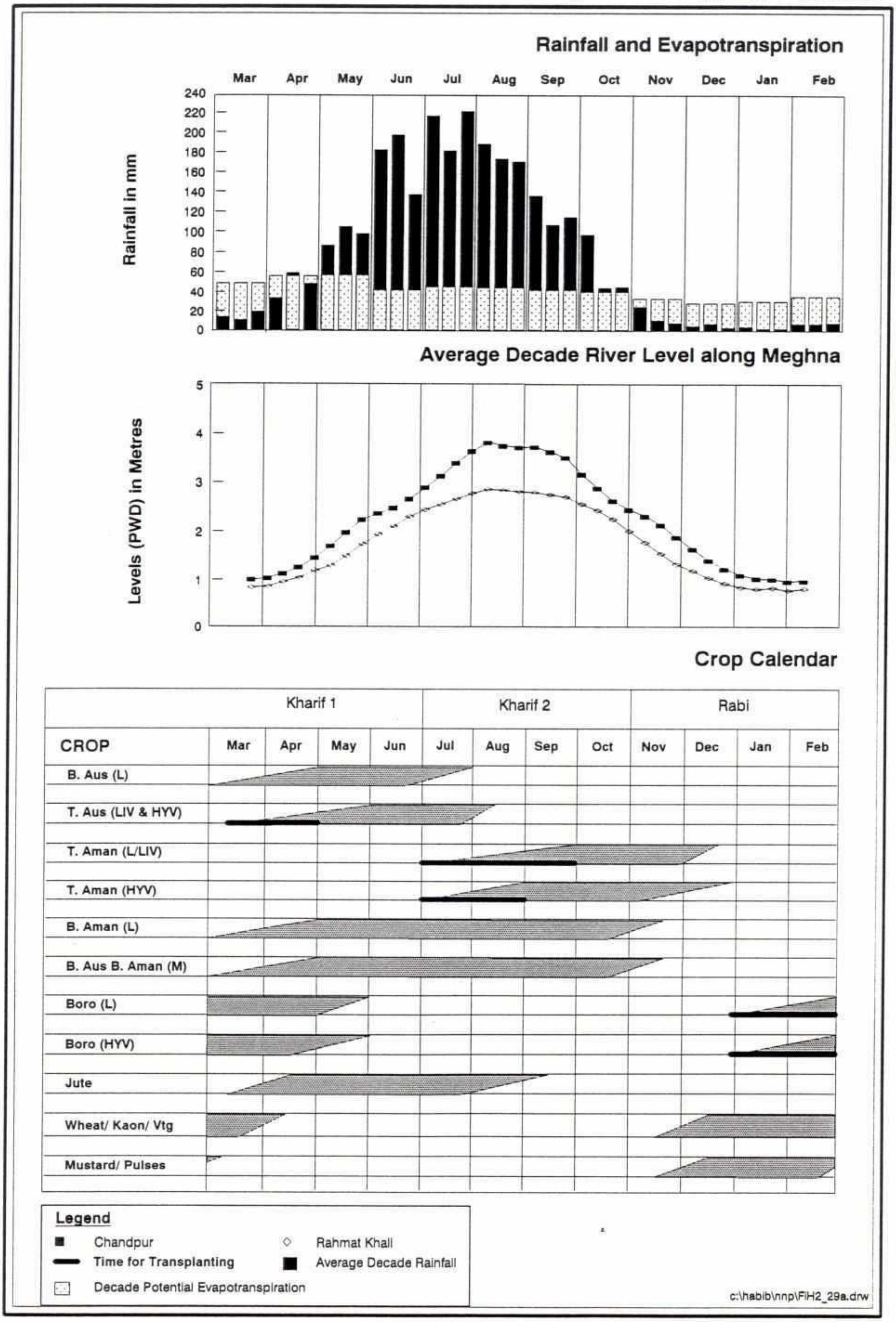
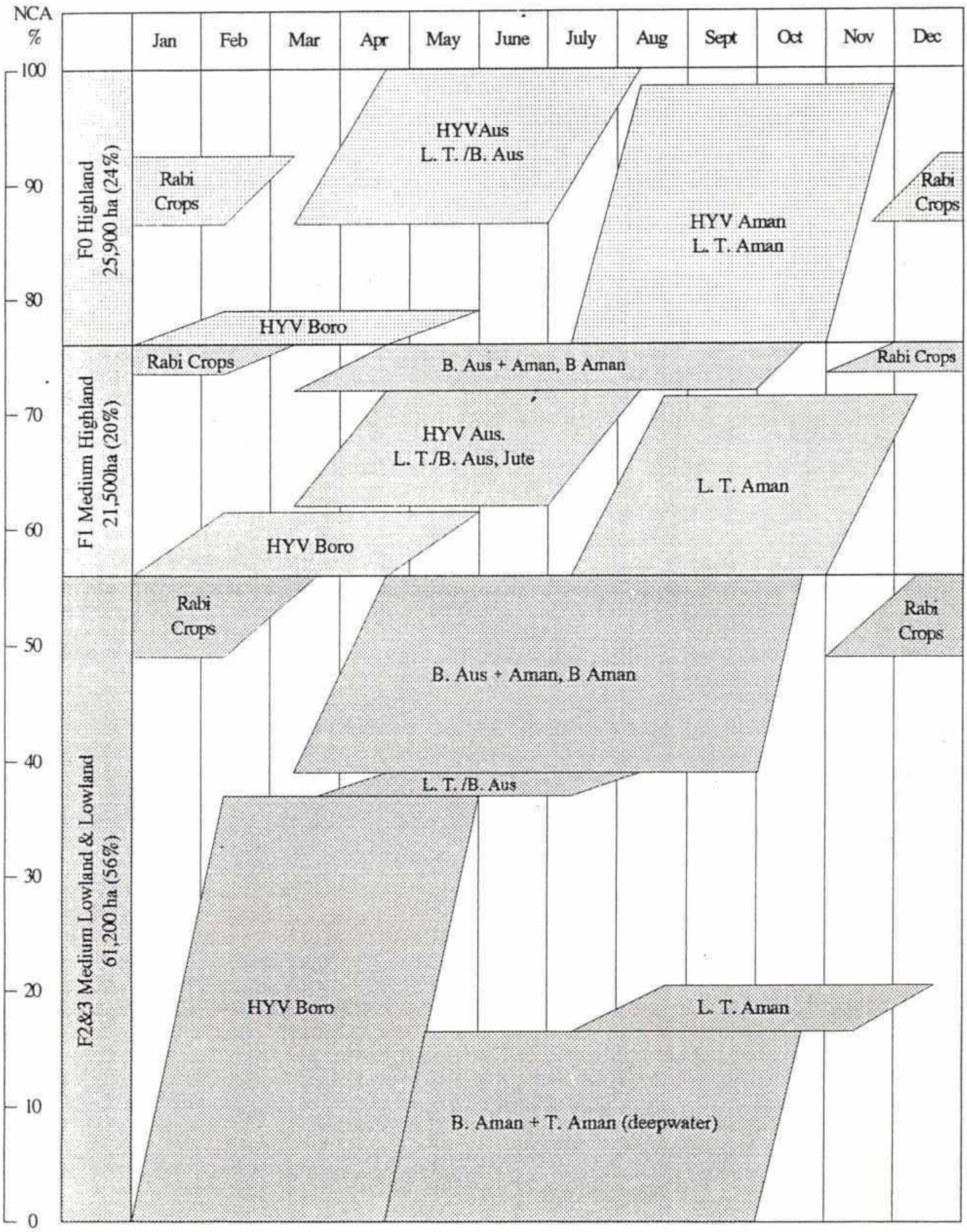


Figure H.2.29b
Cropping Calendar By Flood Zone



H.2.3.6 Fisheries

The level of fishing activity in the study area is very varied indeed and the fishing systems are shown in Figure H.2.30 and household dependency on these in Table H.2.4. Approximately 15% of households (60 700 households) depend on fishing to some degree. The degree of household dependence upon fishing for both economic livelihood (full time and part-time fishing households) and for directly consumed animal protein (occasional fishing households) shows that some 4% of households are primarily dependent upon full time fishing, with the figure in zones A and D being nearly 7%. The number of part time fishing households (i.e. doing it as their second economic activity for cash sale) is overall very low at 1%, again with the highest figures in Zones A and D. The proportion of occasional fishing households is around 10% and looks to be concentrated in the flood plain areas in Zones C, followed by A and B with the lowest figure in Zone D. It is not known how many of the fishing dependent households are involved in culture fisheries as opposed to capture fisheries. In all the area presently produces an estimated 23 600tonnes of fish, 65% of which are from ponds, the rest being capture fisheries, by far the majority of which come from seasonal flood plain fisheries. Overall the most production is estimated to come from Zone D followed by Zones B, C and A. The relative importance of capture fisheries by zone is also the same, concluding that the pond production diffusion spatial pattern maybe similar to that of floodplain fisheries production. There is insufficient data to ascertain the degree to which fishing dependent households rely upon capture and culture fisheries.

TABLE H.2.4

Household Dependency on Fisheries

	Number of Fishing Households								
	Number of Households	Full - Time	%	Part - Time	%	Occasional	%	Total	%
Zone A	50.755	3.294	6.5	633	1.2	6.030	11.9	9.957	19.6
Zone B	114.383	927	0.8	393	0.34	12.081	10.6	13.401	11.7
Zone C	87.462	2.070	2.4	471	0.54	12.335	14.1	14.876	17
Zone D	145.841	10.061	6.9	2.392	1.6	10.011	6.8	22.464	15.4
Total	398.441	16.352	4.1	3.889	0.98	40.457	10.2	60.698	15.2

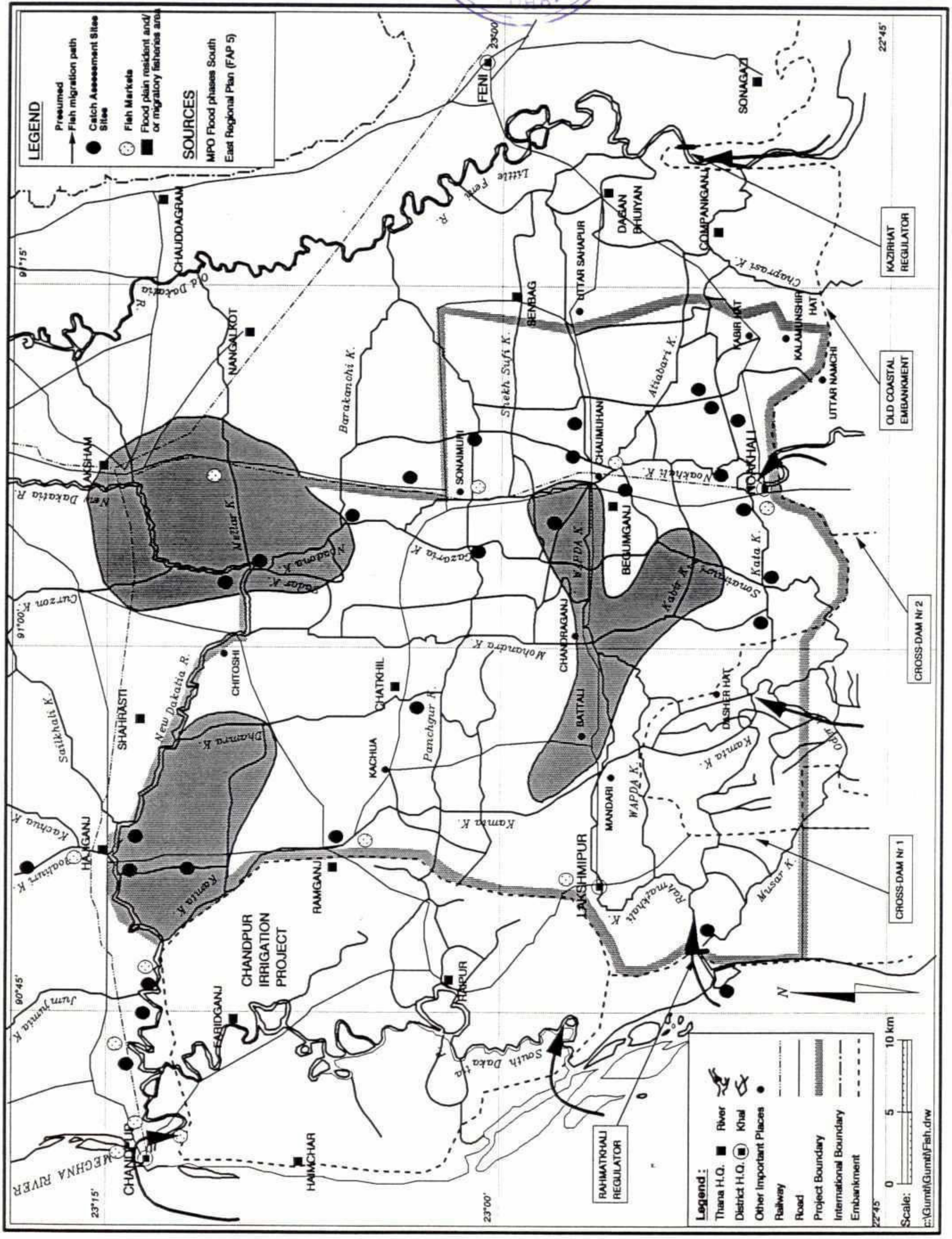
Source: 1991 estimates of population and BBS 1991 Census for Number of Households.
Noakhali North Thana Fisheries Office Survey for Number of Fishermen

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.2.14. 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.

Figure : H 2.30

Fish Systems and Sampling Sites



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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 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. The urban informal sectors are apparent alongside the main railway and road lines north-south through the centre of the study area and also in the small to medium sized towns.

H.2.3.10 Industry

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

70

Figure H.2.31

% Households with no Potable Water Supply, 1981

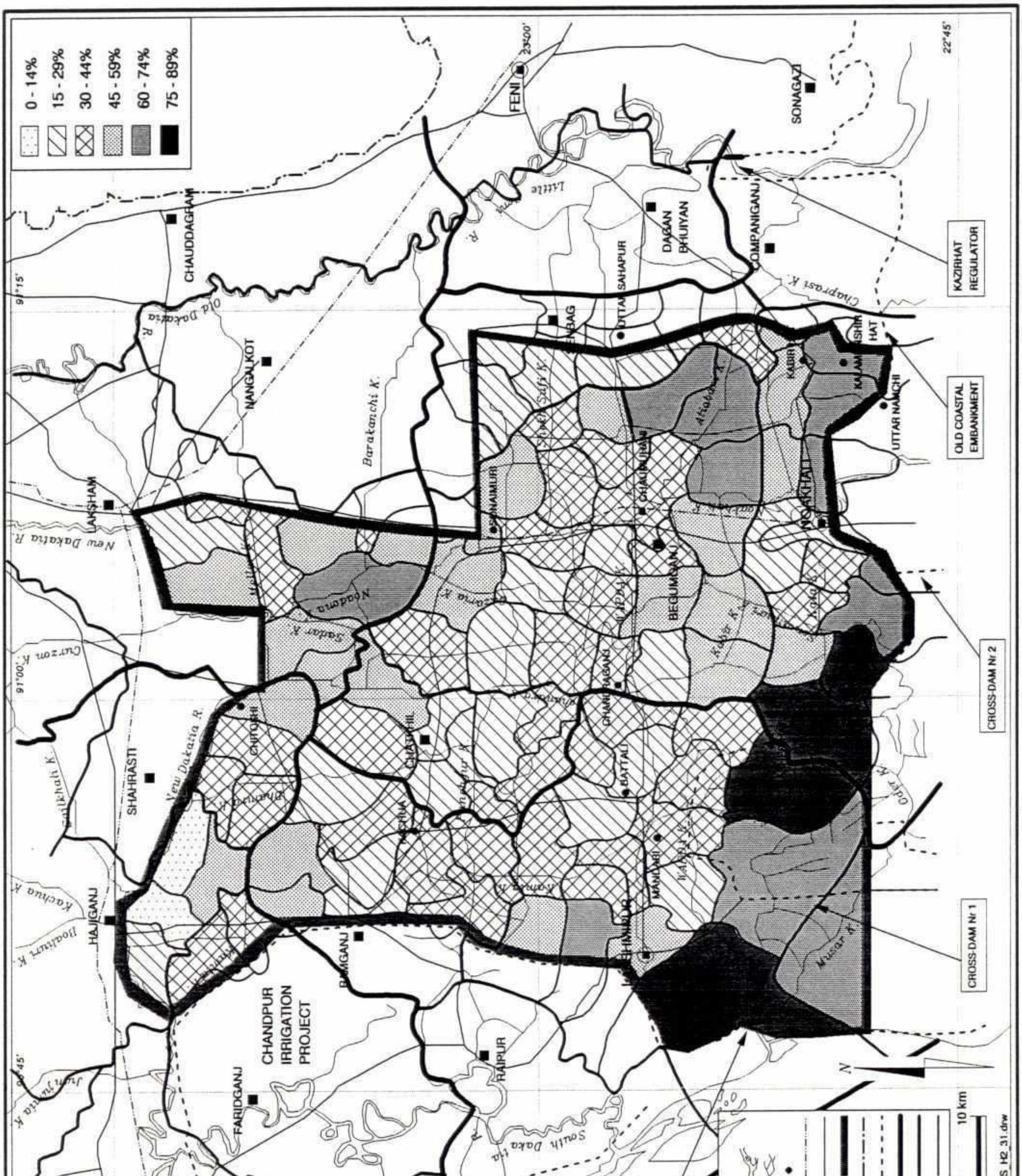


Figure H.2.32

% Households with no Potable Water Supply, 1991

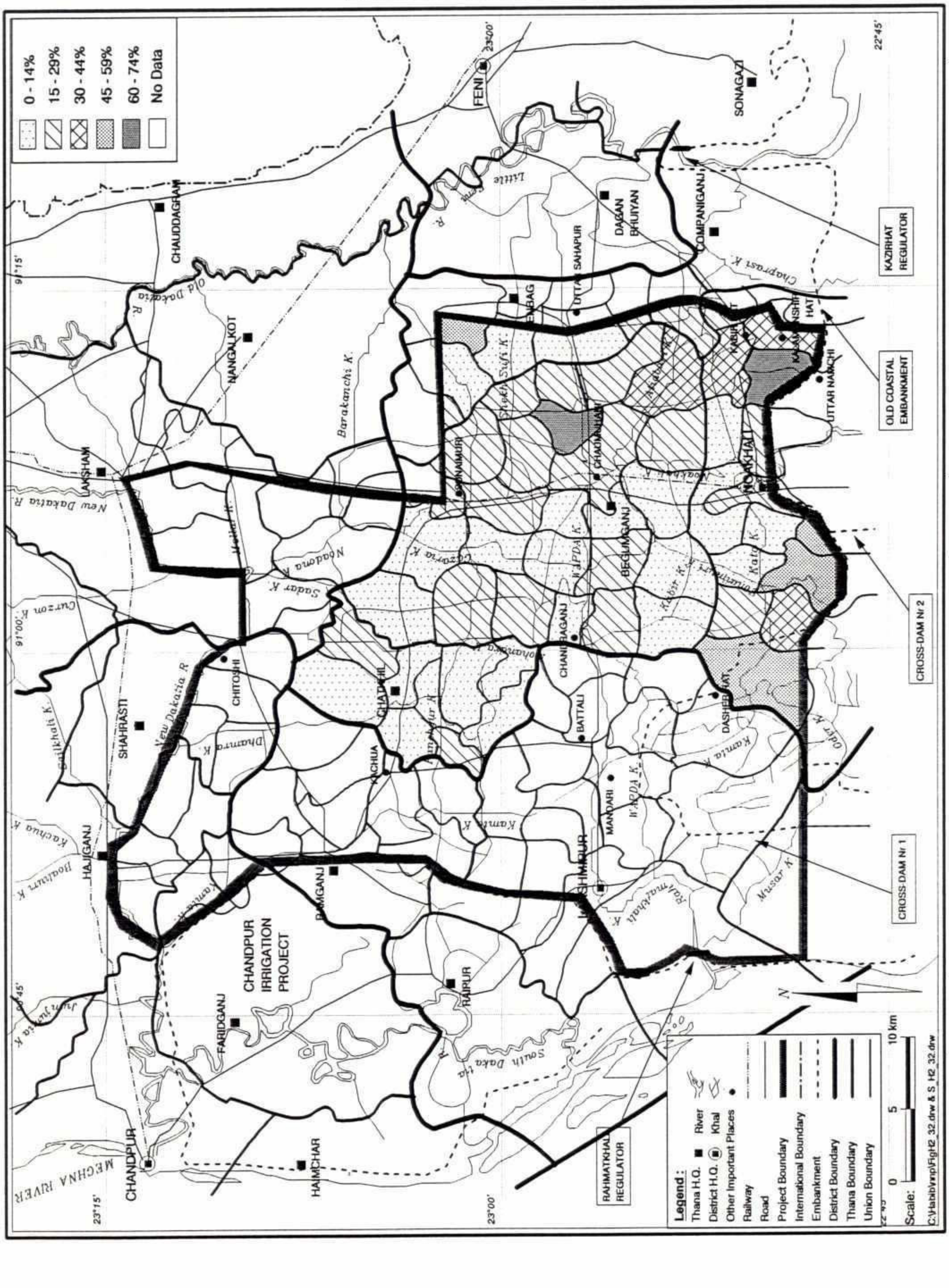
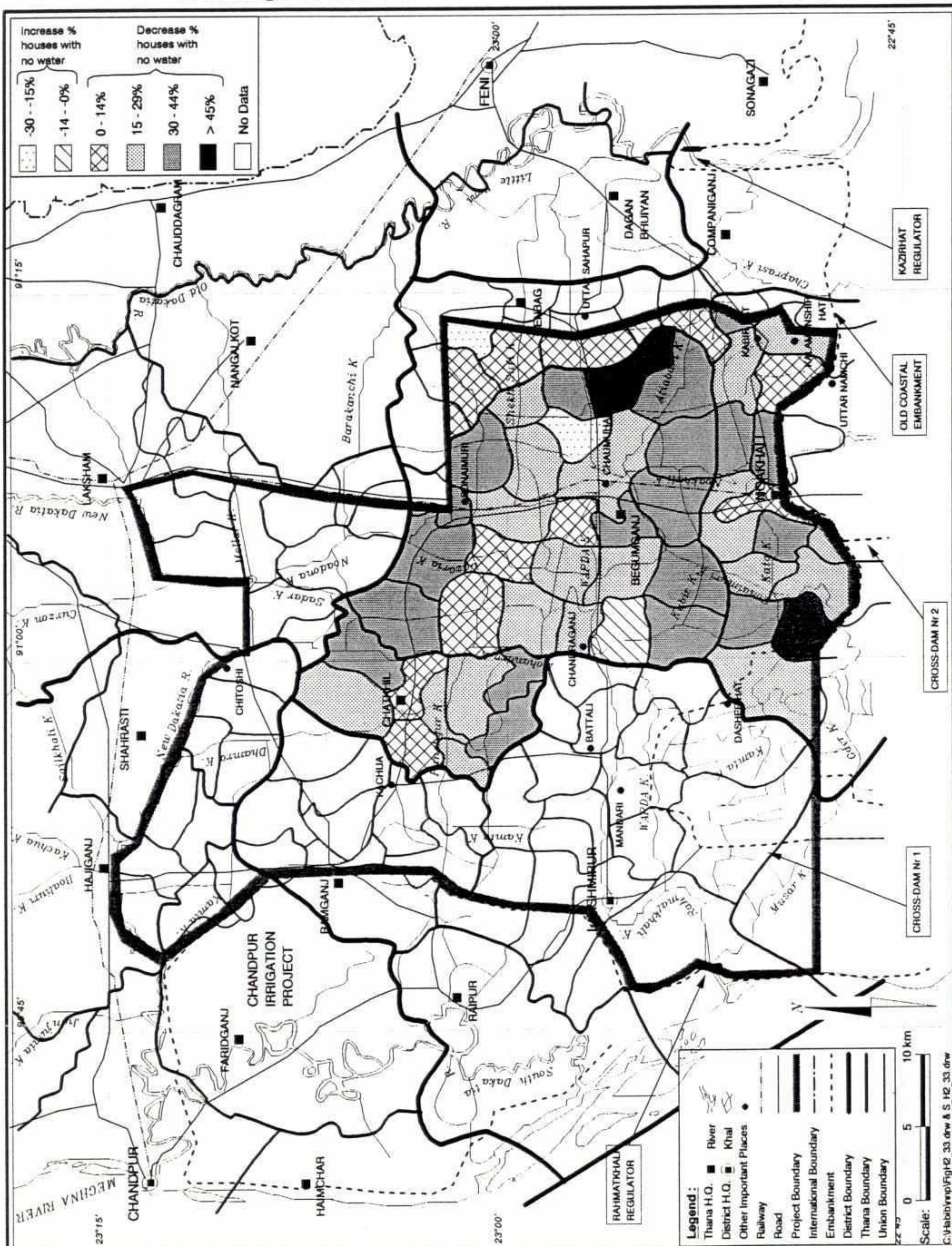


Figure H.2.33

% Change in Households with no Potable Water Supply, 1981-91



sampled sites were so high that they were unmeasurable. The health surveys have also confirmed that diarrhoeal disease is the biggest health hazard in the area and a significant cause of mortality. The quality of groundwater has been assessed in Section 2.1.5 of the Main Report and in detail in 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. The findings of the study were that overall the area has slightly lower disease rates than the national average, however these are still significant and vary greatly within the study area with some pockets of high incidence. There are problems with waterborne disease related to poor water supply provision, sanitation and lack of health education. Diarrhoeal disease outbreaks, including cholera, occur particularly after the monsoon period and are a cause of death, especially amongst children. Diarrhoeal disease is particularly a problem in Zone D (6% of the population are seriously effected) and malaria in zones A and B. The level of skin disease is generally high throughout the year in all zones effecting 17% of the total study area population. Night blindness was very variable, with serious and escalating problems at Ramaganj in Zone D and a one-off high recorded incidence in March 1992 at Laksmipur in Zone A. The incidence figures for diarrhoeal diseases, malaria, skin disease and night blindness by zone are shown in Figures H.2.34 - H.2.37 respectively.

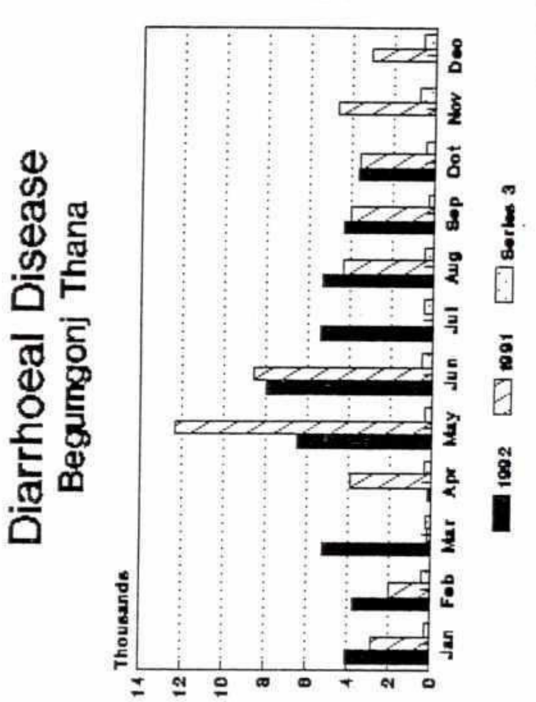
The findings of the nutritional survey indicated that fish is extremely important throughout the study area, providing by far the greatest proportion of protein in diets and being much more significant than pulses and meat. The main source of fish was purchased from markets but consumption from own ponds was significant in Zone B. However the nutrition field studies were carried out in the dry season and consumption was only recorded from Khals and not floodplain sources. This is probably a serious omission from the overall picture of nutritional sources. Virtually all Dhal consumed in the area was purchased rather than grown. The possible loss of free-good or affordable fisheries resources as a result of any intervention is therefore likely to be a significant issue. Whilst the overall nutritional levels were little different than the national average (which are well below WHO minimum standards), significant differences were found to exist across the study area. Incidences of malnutrition and vitamin deficiency were much higher in Zone D than elsewhere in the study area and there were specific problems with children under the age of five in Zone A. More details of the health and nutrition situation in the study area are given in Appendix H.IV.

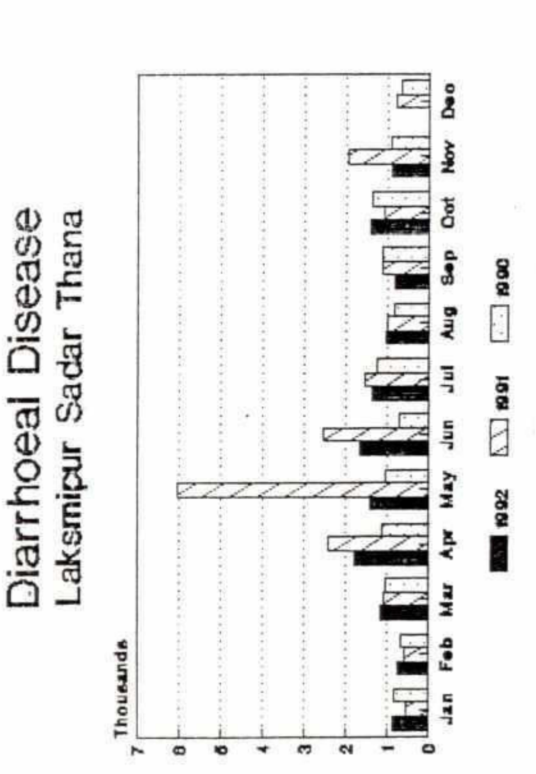
H.2.3.13 Access and Transport Infrastructure

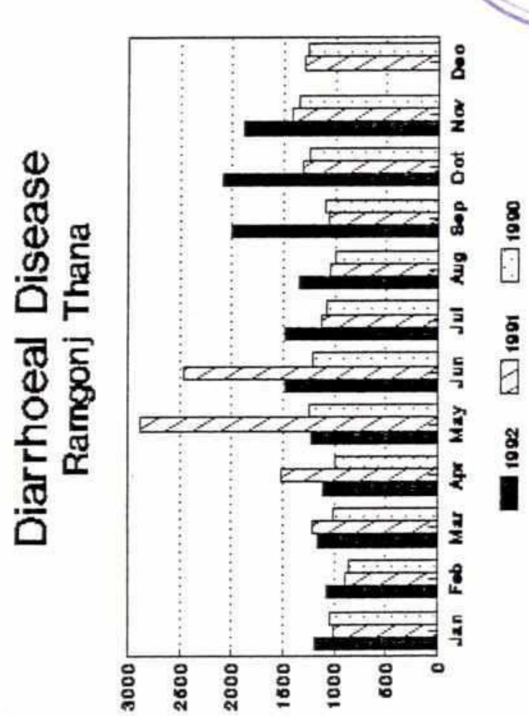
Transport access through the centre of the area is good with a tarmac road system and the railway line. However it would have been improved considerably for the peripheral areas (particularly the western edges of zone A and D) if the major embankments had been constructed for dual purpose use as flood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

Figure H.2.34

Prevalence of Diarrhoea







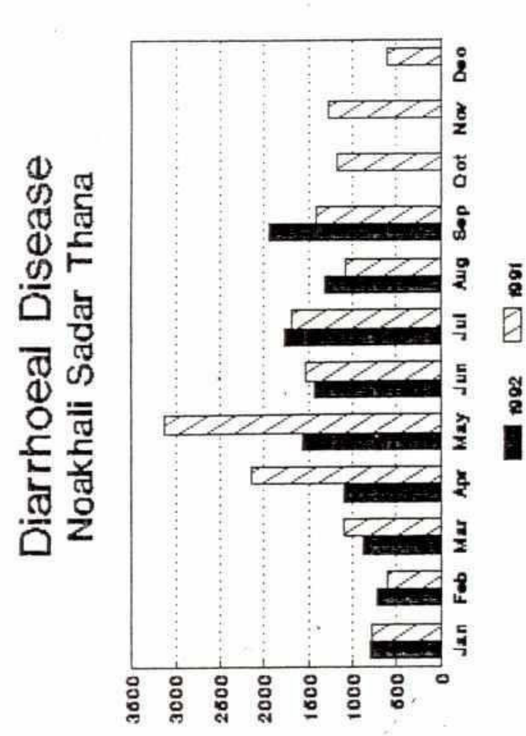


Figure H.2.35

Prevalence of Malaria

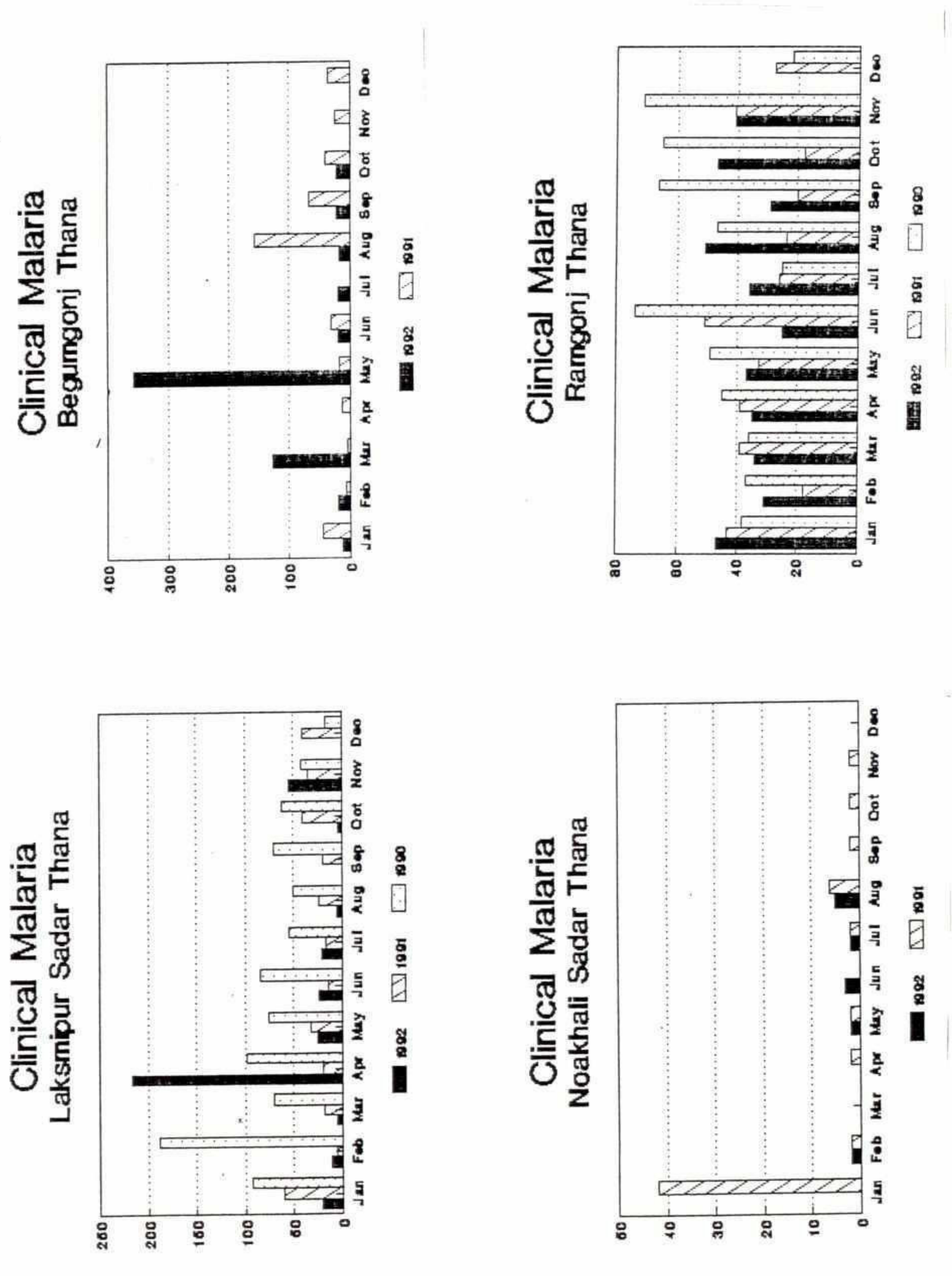
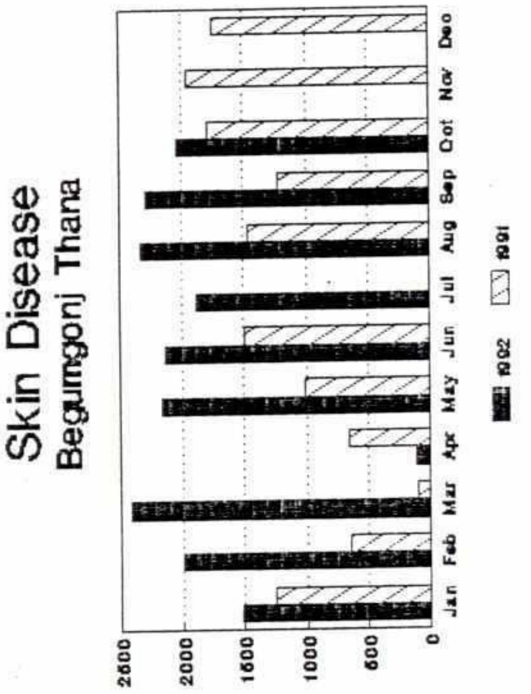
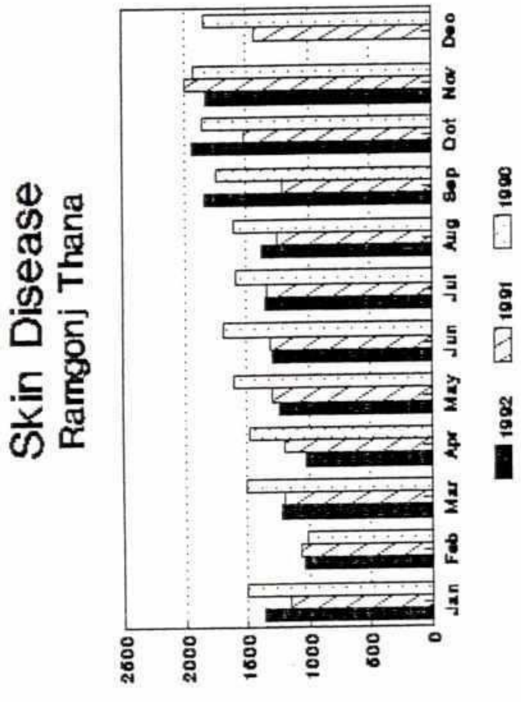
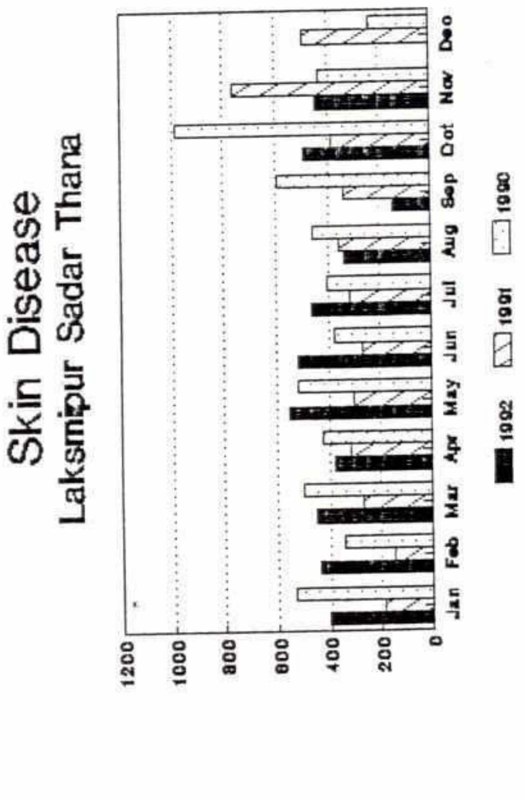


Figure H.2.36
Prevalence of Skin Diseases







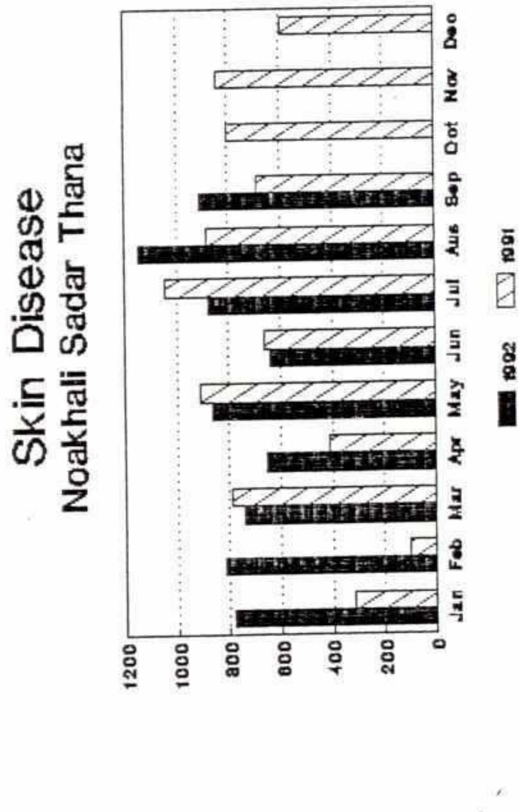
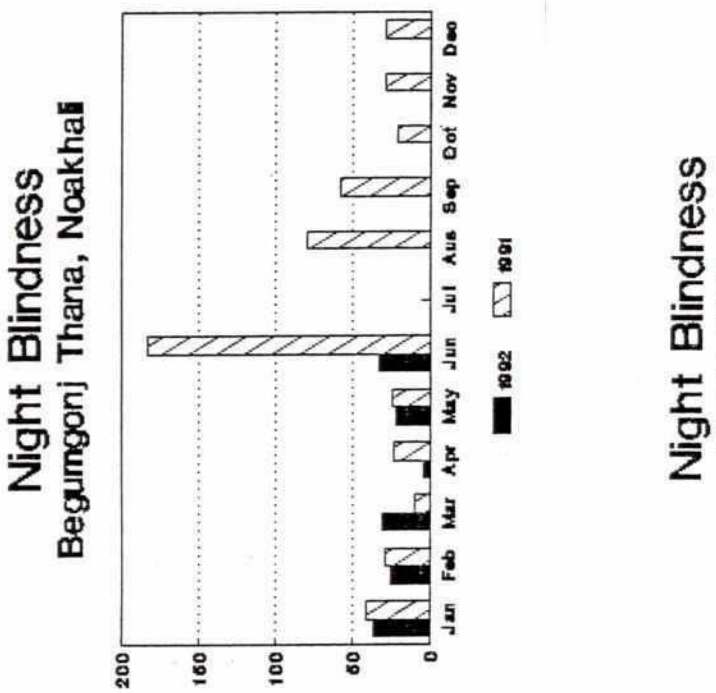
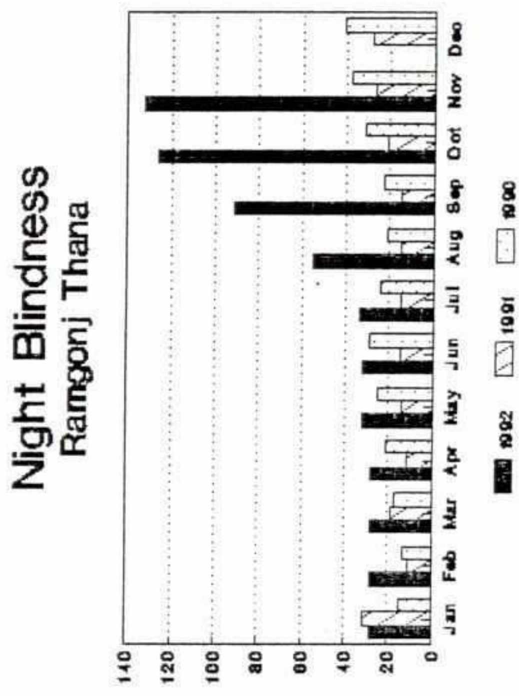
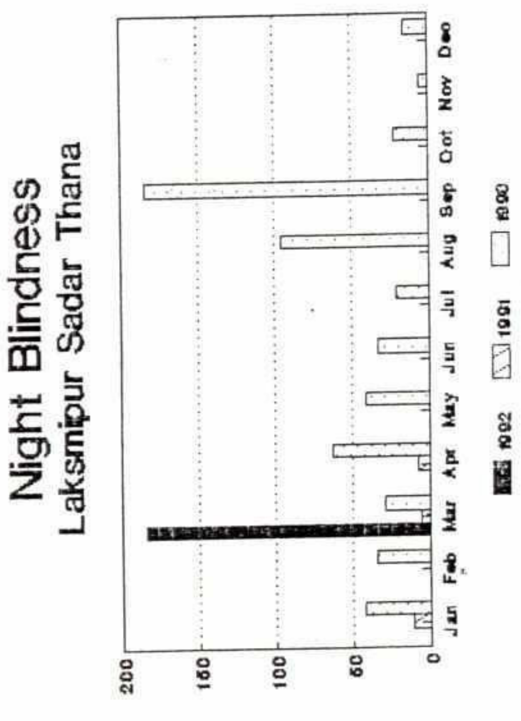


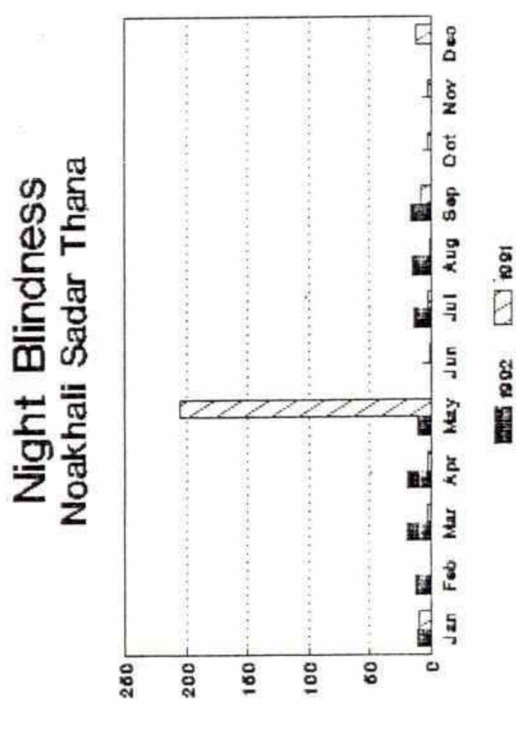
Figure H.2.37

Prevalence of Night Blindness









H.2.3.14 Archaeology and Cultural Sites

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

- Mira Shahetis Dargah (Islamic Holy Shrine) from the 11th Century at Kanchanpur in Ramganj Thana.
- An architecturally important 15th century mosque at Bajra in Begumganj Thana which is a major pilgrimage centre.
- Dargah of Bhuiya Anis Mohammad at Mohammadpur in Senbag Thana.
- A very ruined but ancient village with a temple at Amishapara in Begumganj Thana.
- The Asram of high saint Ram at Choumahani in Begumganj town.
- Dalak Bazar in Lakshmipur Thana is an old Zamindar headquarters with several fine buildings including temples, tanks and Khoasagar Dighi. It was important as a trading place for indigo during the British colonial period.
- Lakshmipur town was an important British colonial trading port and cloth production centre.
- Companyganj just to the east of the study area was an East India Company trading port originally on the coast.

H.2.3.15 Landscape and Recreation

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

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

H.2.4 External Factors and the Regional Context

H.2.4.1 Upstream Constraints

The main upstream constraints to development in the study area are likely to be any measures proposed by FAP 6, the North East Regional Study and any developments on the river systems in India. The FAP 6 proposals are understood to include doubling the area of land enclosed by submersible embankments. This could have significant downstream effects in passing on early main Meghna river floods. However the present flood modelling work of FAP 25 has not taken this possibility into account as yet. In terms of developments in India, it would appear that there are proposals to dam upstream rivers and store water for irrigation use. This would seem to perhaps be a marginal benefit in attenuating some peak flows, however without more knowledge and hydraulic modelling of these it is impossible to comment more. The FAP 25 modelling would seem to indicate that the most significant modelled intervention is likely to be the construction of a right embankment of the Padma river. This would result in a slight increase in peak water levels but it is almost negligible and would appear unlikely to be a serious constraint to any proposed intervention to the study area.

H.2.4.2 Adjacent Floodplains and Chars

The adjacent areas to the delineated study area include the flood plain areas to the east and the north. The flood modelling has taken these into account both for the present situation and the with project situation. These have been included in the analysis as far as is possible, however there will need to be more detailed analysis in any Detailed Design Phase of likely agricultural benefits in these areas as opposed to the floodplain fisheries losses. At present it is assumed that the benefit/dis-benefit ratios are similar to the main part of the study area.

The analysis of the FAP 25 data indicates that if anything main river peak flood levels are likely to fall in the Upper Meghna (i.e. upstream of the Padma confluence) and rise very slightly downstream of it if the main rivers were all to be embanked. This is likely to have only a very marginal effect on the unprotected land and char lands. These areas are presently under study by FAP 16 as part of their special studies programme.
main river area, chars

H.2.4.3 Downstream Constraints

The main constraint to freeing drainage congestion in the study area are the high water levels in the main Meghna river during the monsoon. The aim of the proposed intervention is to overcome this as far as is possible by using the Rahmatkhali regulator as a tidal pump for drainage in the wet season and irrigation supply in the dry season. This actually reduces the influence of this constraint as far as possible and maximises it in an optimal way by excavating Khals.

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H.3. DEVELOPMENT PROPOSALS AND IMPACT ASSESSMENT METHODOLOGY

H.3.1 Development Options and Strategies

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

As stated in Section H.1.1, the aim of the environmental component of the study is to review the previously selected Noakhali North Drainage intervention proposal to see if, overall, it is considered to be sound from an integrated environmental perspective. This process should allow the principal negative impacts to be identified and their differing social and spatial variation to be studied. Provided it is considered sound overall, then recommendations are to be made as to how any negative impacts could be avoided or mitigated for, within the framework of an integrated Environmental Management Plan.

H.3.2 The Proposed Intervention

The intervention proposed for the Noakhali North area is to widen, deepen and grade the bed of 200km of the main drains and Khals upstream of the Rahmatkhali Regulator. In addition the regulator itself is to be enlarged from 14 to 24 gates, increasing its peak capacity from 300cumecs to 540cumecs, and its operation improved. The overall aim is to remove the constraints to drainage within the present system to allow faster out-flow in the monsoon season and also inflow of water in the dry season (using tidal back-up flow and two way flap gates) for surface irrigation supply. The intervention is illustrated in Figure H.3.2. The locations and quantities for Khal excavation have been optimised using the hydraulic modelling so that the drainage outflow has no bottlenecks and also allows the maximum possible dry season inflow based upon tidally induced back-up flow.

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

The basis for data collection and analysis of the impacts are the Planning Zones shown in Figure H.3.1. These zonal boundaries were drawn up early in the study using the MPO Flood Zones (Figure H.2.4) and the 1988 FAO Agro-ecological Zones (Figure H.2.11), before the results of the MIKE 11 hydraulic modelling for the area were available. Once the model results for the present situation were plotted in map form, it became apparent that the boundaries between Zones A, B and C did not fit the flooding pattern as had been intended. This has resulted in the spatial impact analysis being of less use than it could have been, as Zones B and C are very mixed and do not show the benefits and dis-benefits to flood plain reduction nor the benefits of dry season surface irrigation as clearly as they could.

Figure H.3.1

Planning Zones

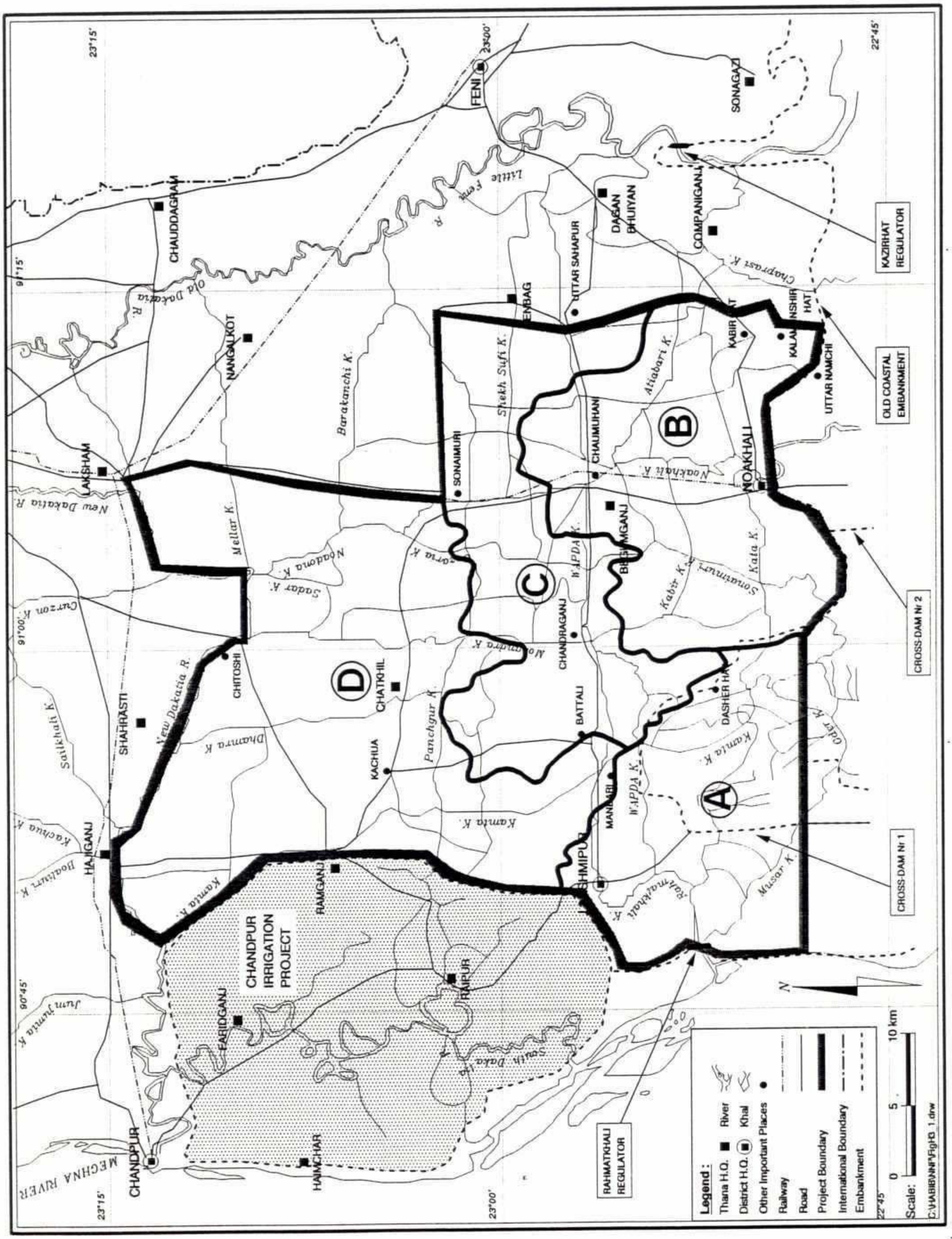
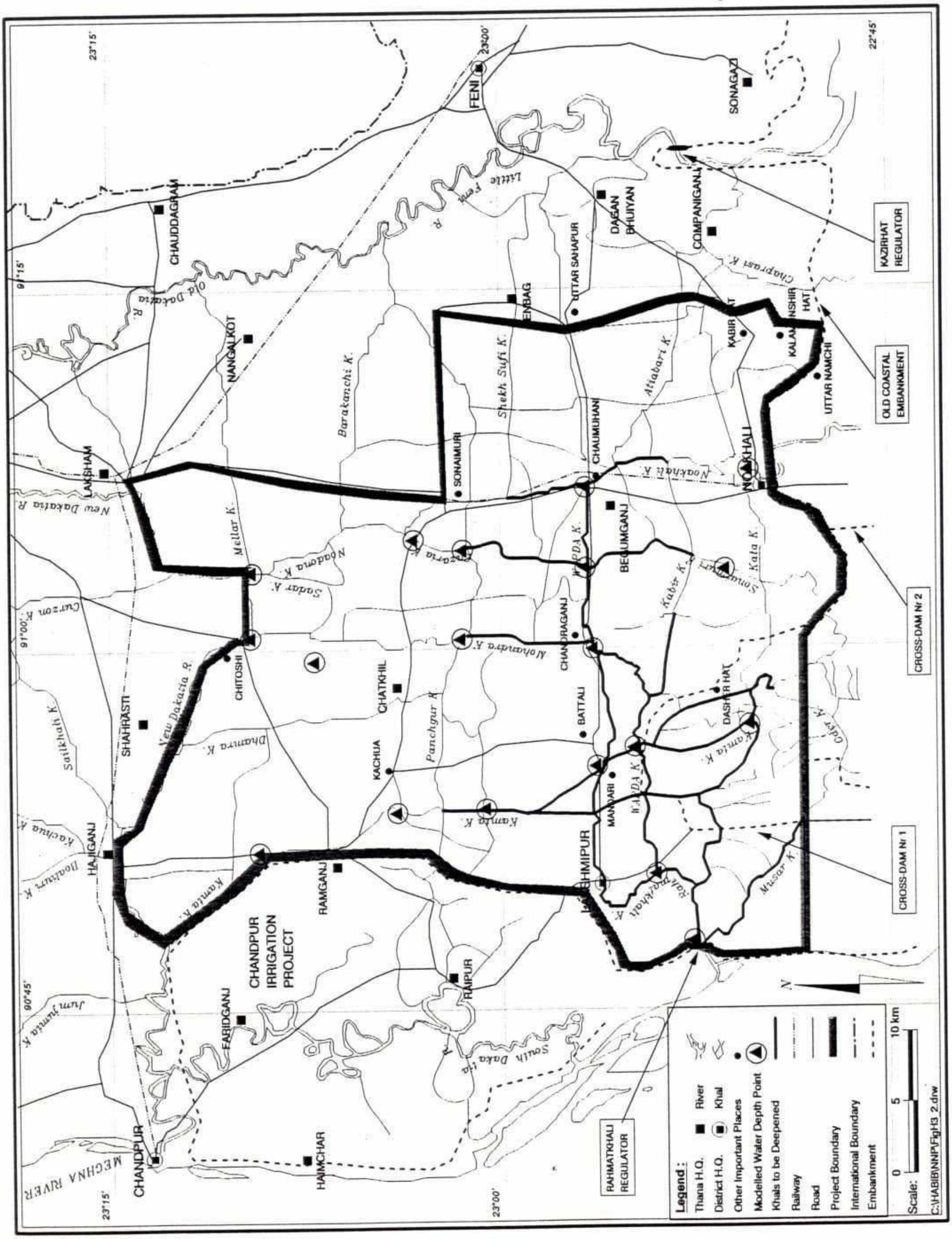


Figure H.3.2

Proposed Intervention



The identified impact zones are shown in Figure H.3.17 and comprise the deepened and widened Khals, the predicted dry season surface water irrigation area, the area of peak "normal" floodplain which will remain unflooded due to the intervention and the peak area of floodplain which will remain after the intervention. However the floodplain which remains will be inundated for a shorter time. It can also be seen that there are adjacent areas to the study which presently flood but will not do so after the intervention or will flood for a shorter period.

The "with intervention" results of the hydraulic modelling for both a rising and falling flood in a 1 in 2 "normal" and 1 in 5 high "normal" flood are shown in Figures H.3.3 - H.3.6. The differences in floodplain extent in the with and without intervention for a 1 in 2 "normal" flood are shown by decad in Figures H.3.7 - H.3.15 and interpreted in Section H.3.4 below.

H.3.3 Identification of Major Environmental Issues

The major likely environmental issues in the study area were identified during the reconnaissance stage of the study and listed in the Inception Report of November 1992 which was included in the FAP 5 Second Interim Report. These issues are shown in the environmental rating matrix given as Figure H.3.16 and are listed down the left hand side. They are ordered logically by the natural and then the human environment, followed by external constraints and possible impacts to and of the intervention. The environmental issues considered to be priorities are indicated in two columns, the first from a detached technical viewpoint and the second from the local peoples perceptions as indicated in the public participation work.

In terms of the proposed intervention, the major impact issues stem directly from the implications of changes in flooding regimes. Specifically the reduction in flood plain area and changes in timing, duration and depth of these. In addition the deepening of Khals has the effect of draining the non deepened Khals quicker than previously, resulting in slightly shallower mean water depths and longer periods when they will be dry. This may therefore marginally reduce the dry season availability of surface water still further in these areas.

The encouragement given to surface water irrigation by providing all year water in the Khals is likely to result in greater intensification of agriculture and all year cropping in some areas. It is predicted that the mean agricultural cropping intensity will increase from 166% to 183%, however this is likely to be very variable across the zones, the predicted increase in rice production being as high as 67% in Zone A as opposed to 7% in Zone D with B and C around 25%. It has been predicted that agricultural labour demand will be increased by 4.3million person days per annum. These estimations are calculated using the FAP Guidelines methodology with the stipulated crop prices.

H.3.4 Hydraulic Modelling of the Intervention

As stated above the intervention has been subject to hydraulic modelling, both for a 1 in 2 "normal" year and a 1 in 5 high "normal" year. The outputs from this work are shown for rising and falling floods in Figures H.3.3 - H.3.6. In addition these outputs have been compared to the without intervention situation and the differences mapped by decad are shown in Figures H.3.7 -H.3.15. In addition the areas of flood plain for each decad were tabulated for each zone for the with and without intervention situation. This work indicated that overall the mean reduction of flood plain area in a 1 in 2 "normal" flood year was 81% in Zone B, 62% in

Figure H.3.3
Extent of Rising Flood with Intervention, 1 in 2 Year

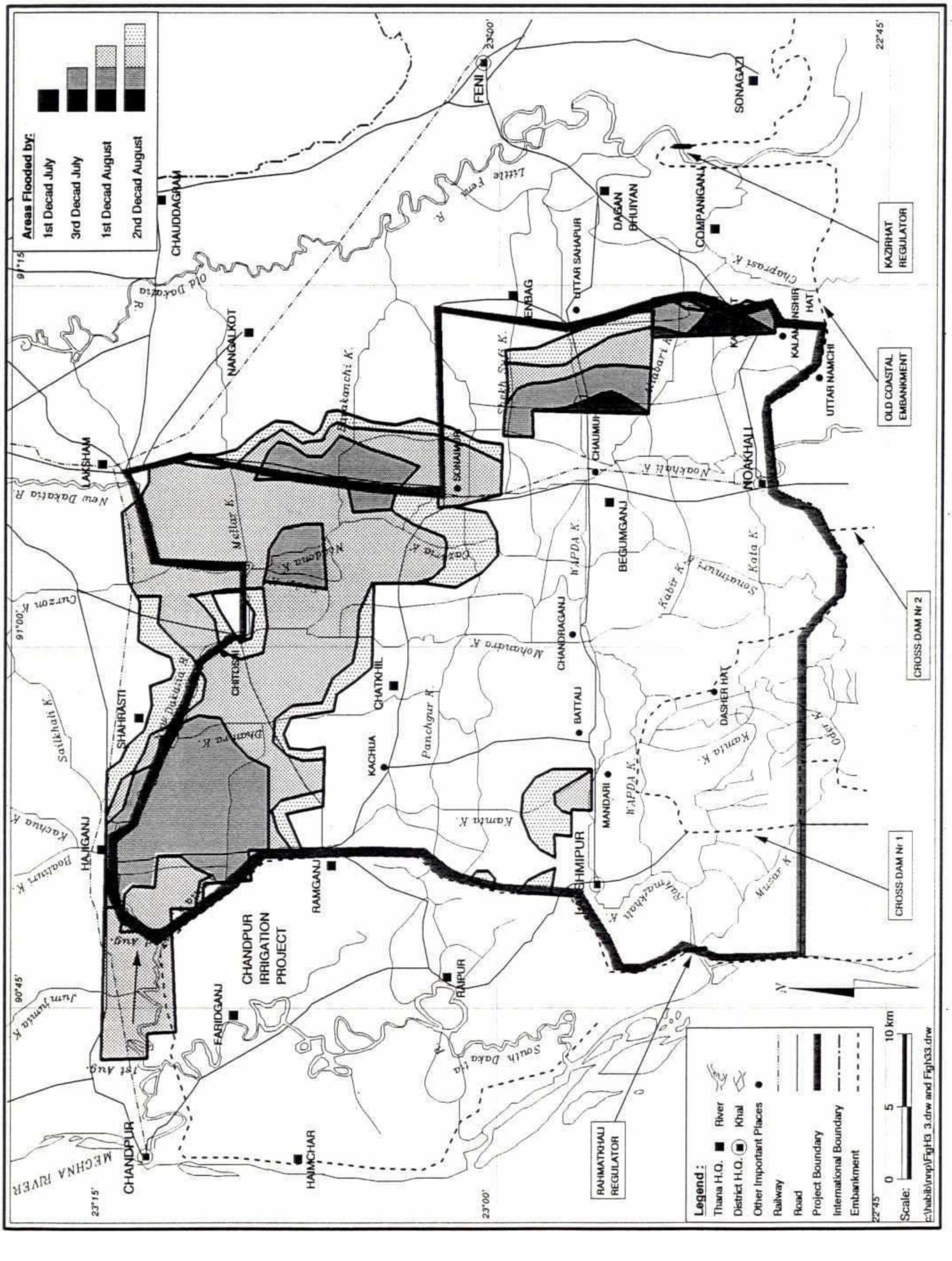


Figure H.3.4

Extent of Falling Flood with Intervention, 1 in 2 Year

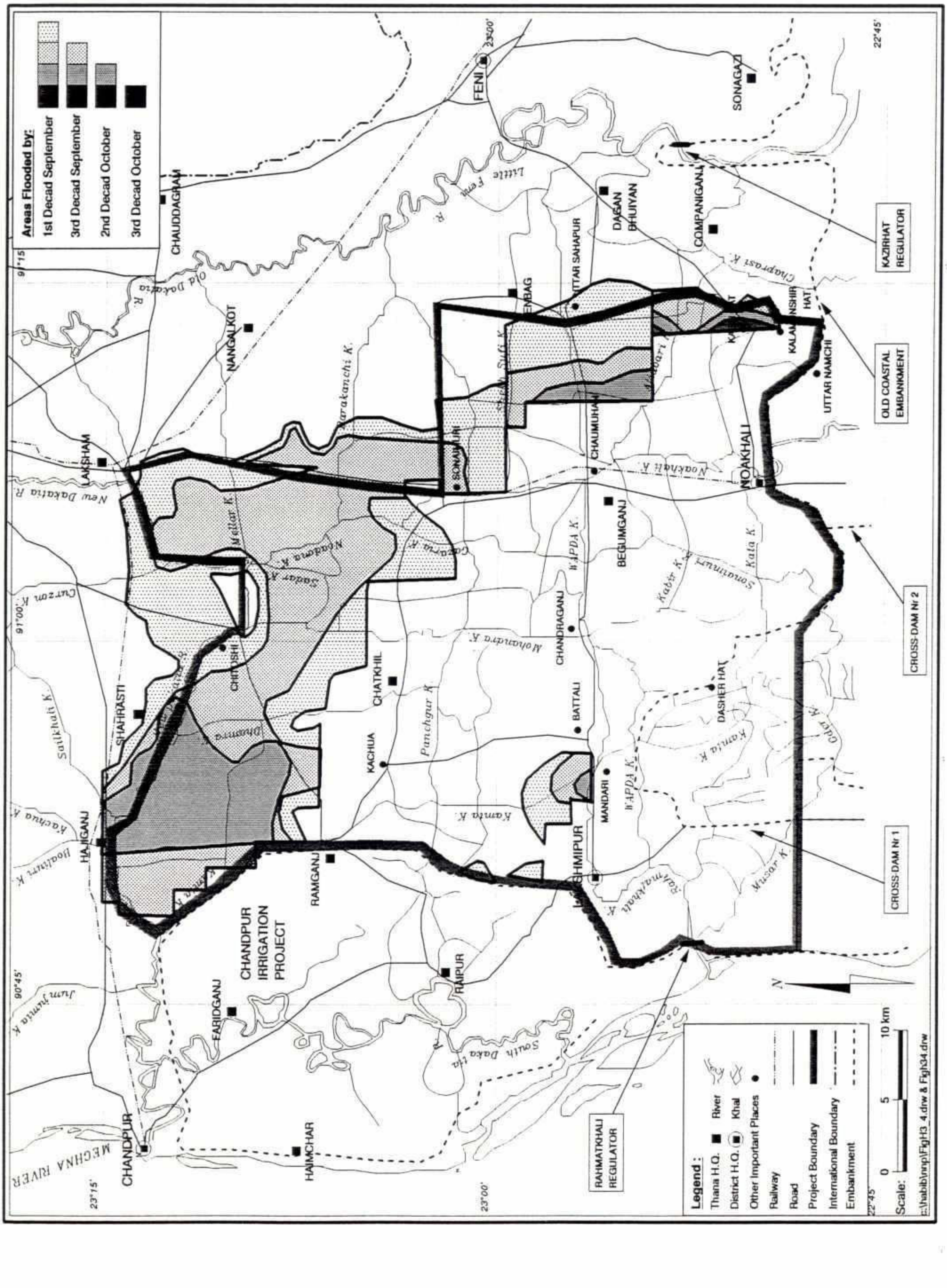


Figure H.3.5
Extent of Rising Flood with Intervention, 1 in 5 Year

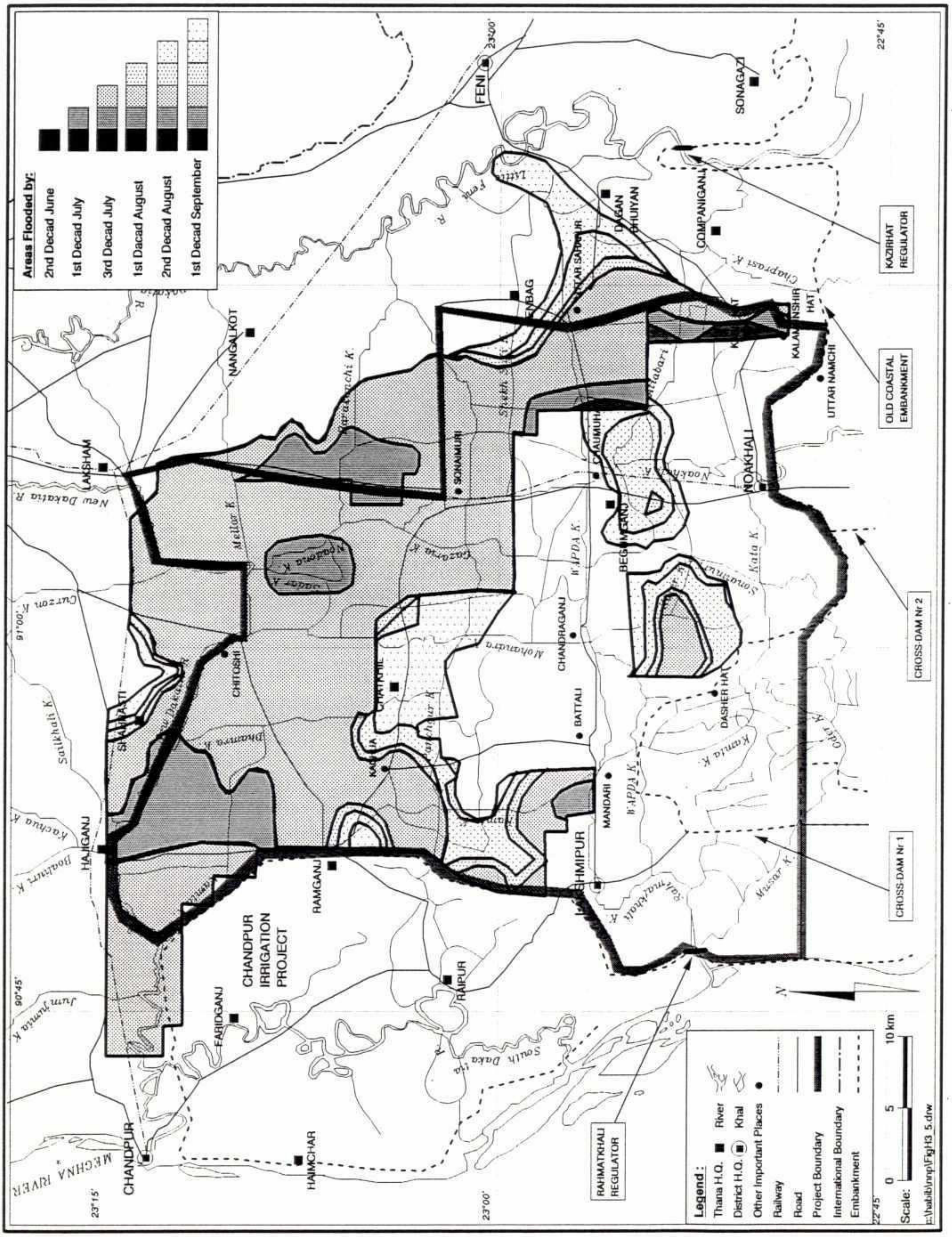


Figure H.3.6

Extent of Falling Flood with Intervention, 1 in 5 Year

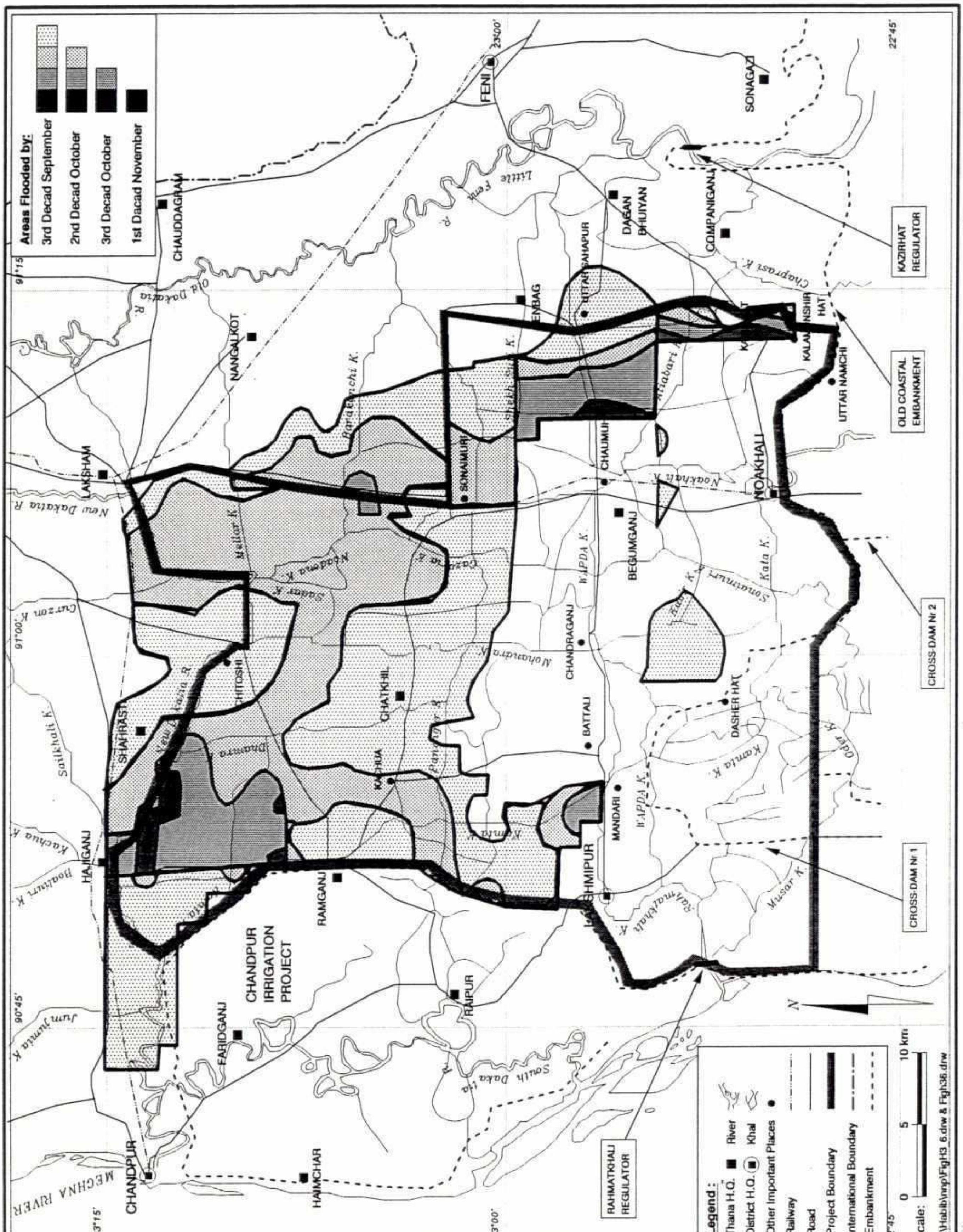


Figure H.3.7

Differential Flood Modelling by Decad (1st Decad in July)

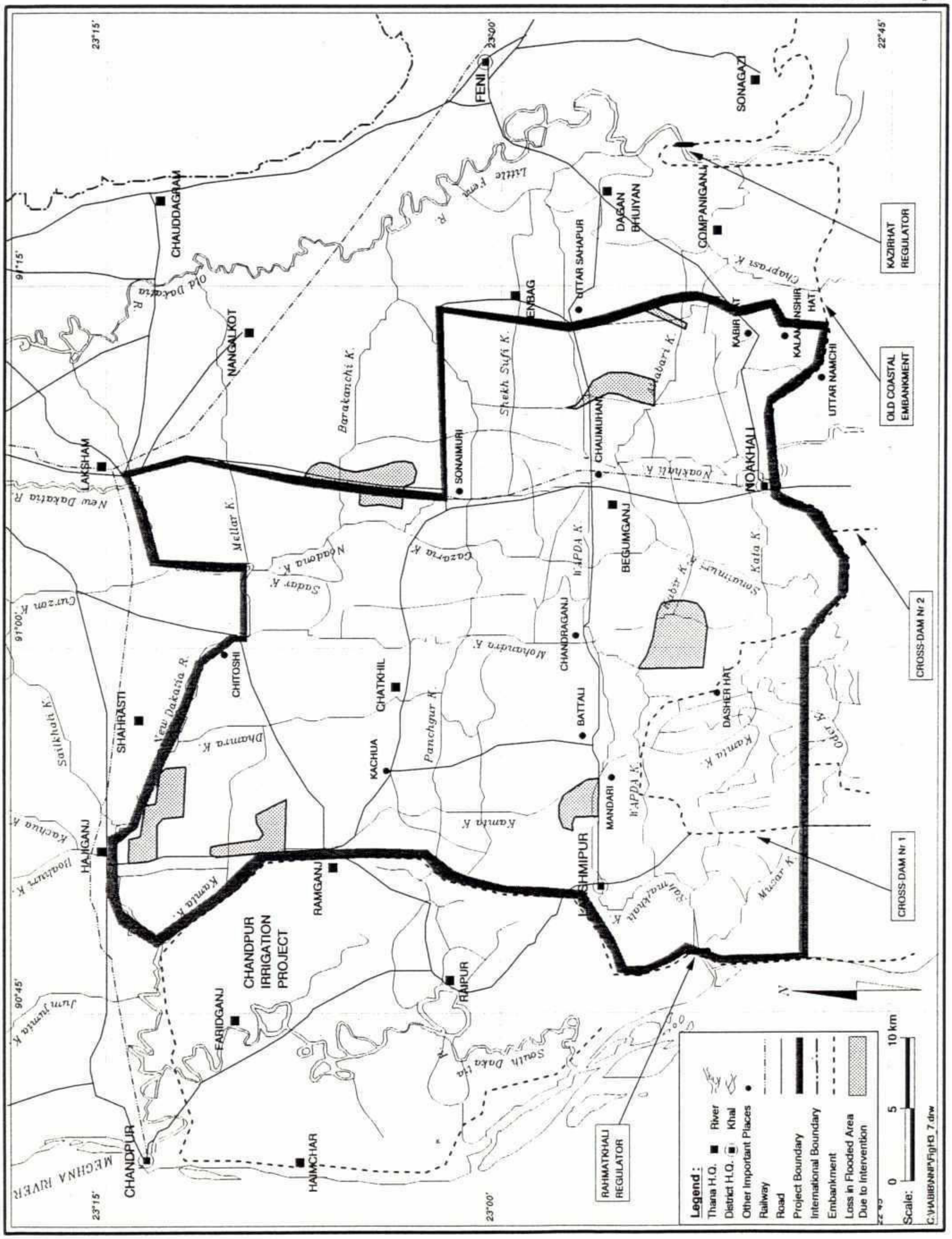


Figure H.3.8

Differential Flood Modelling by Decad

(3rd Decad in July)

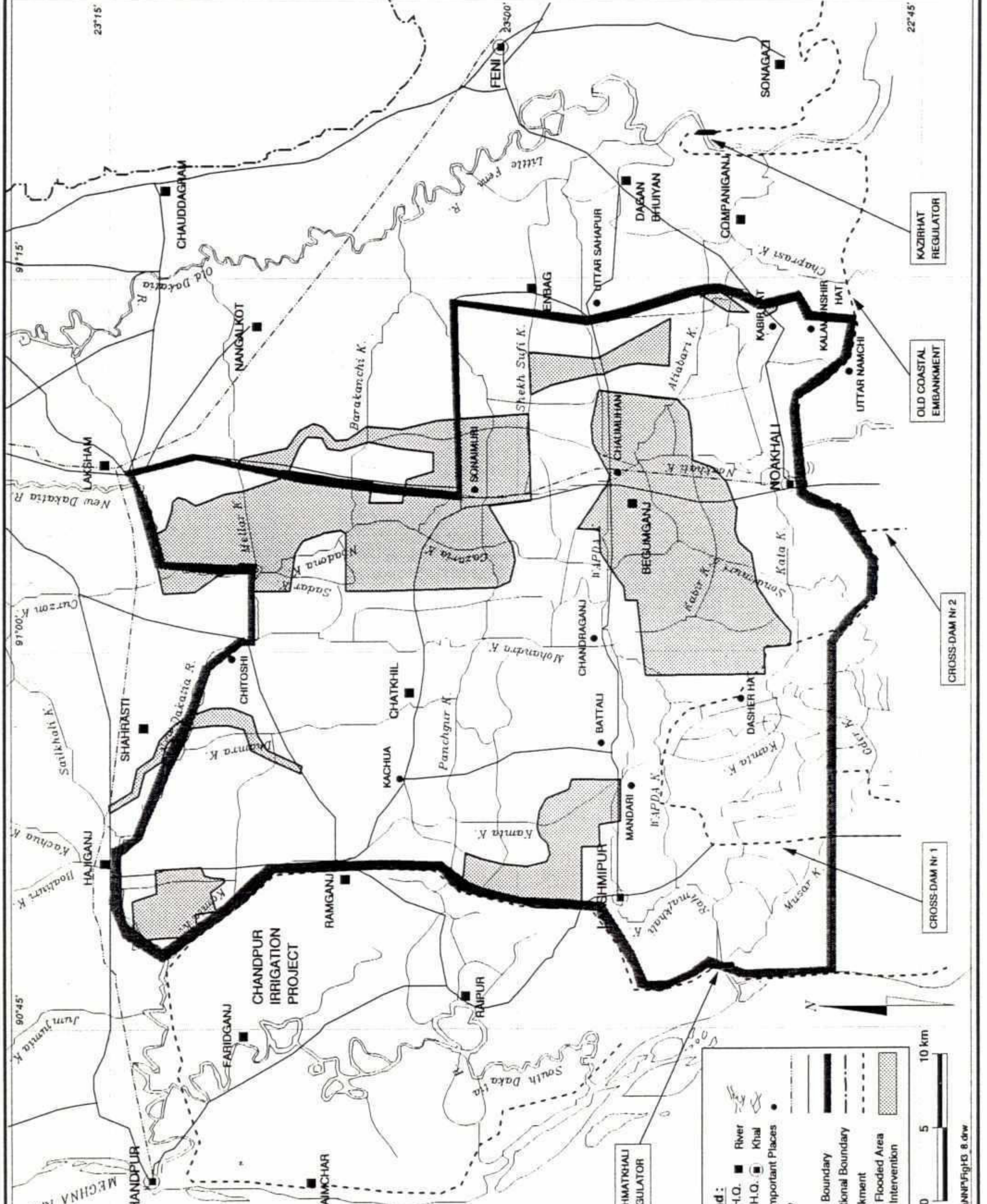


Figure H.3.9
Differential Flood Modelling by Decad
(1st Decad in August)

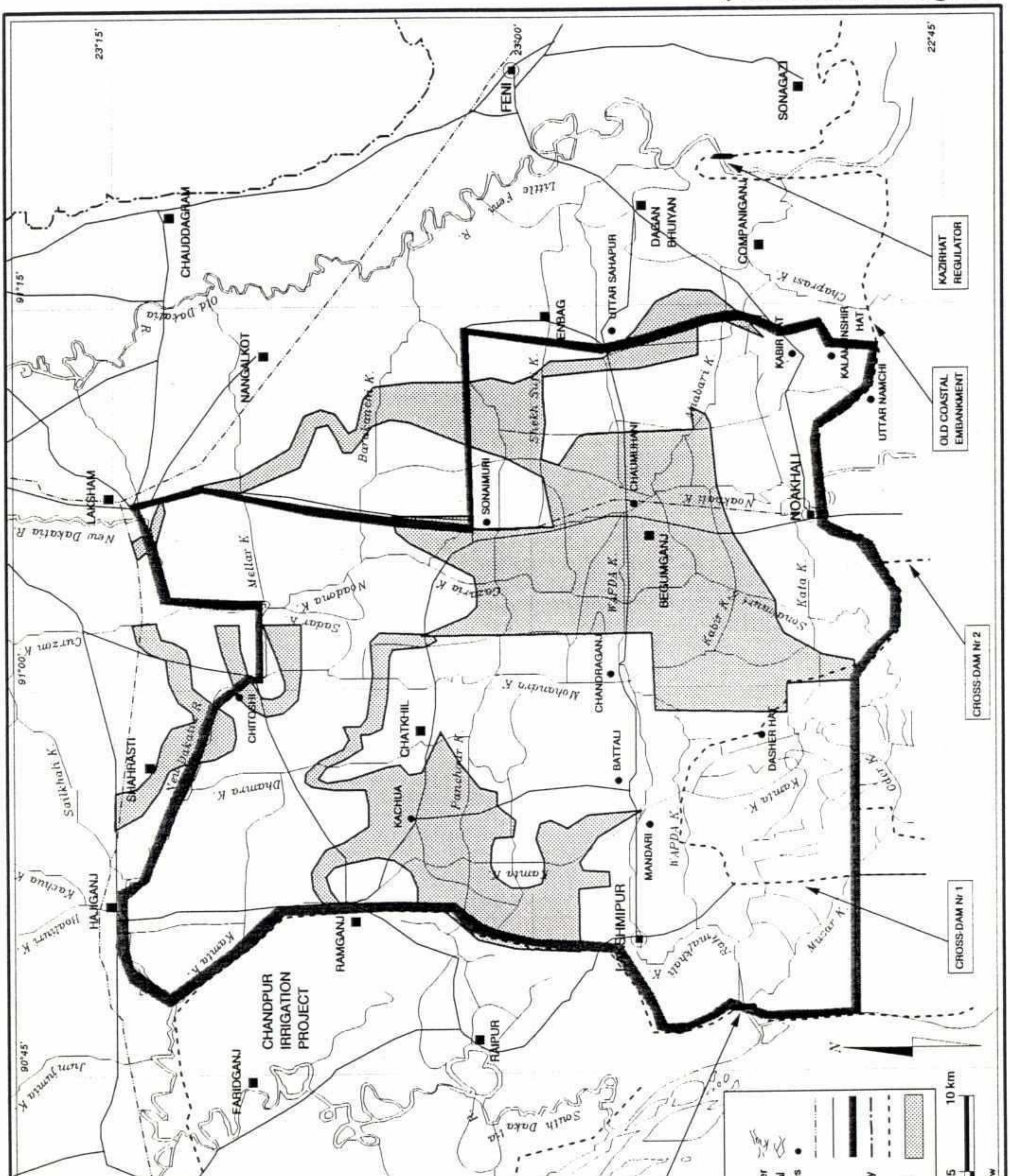


Figure H.3.10
Differential Flood Modelling by Decad (2nd Decad in August)

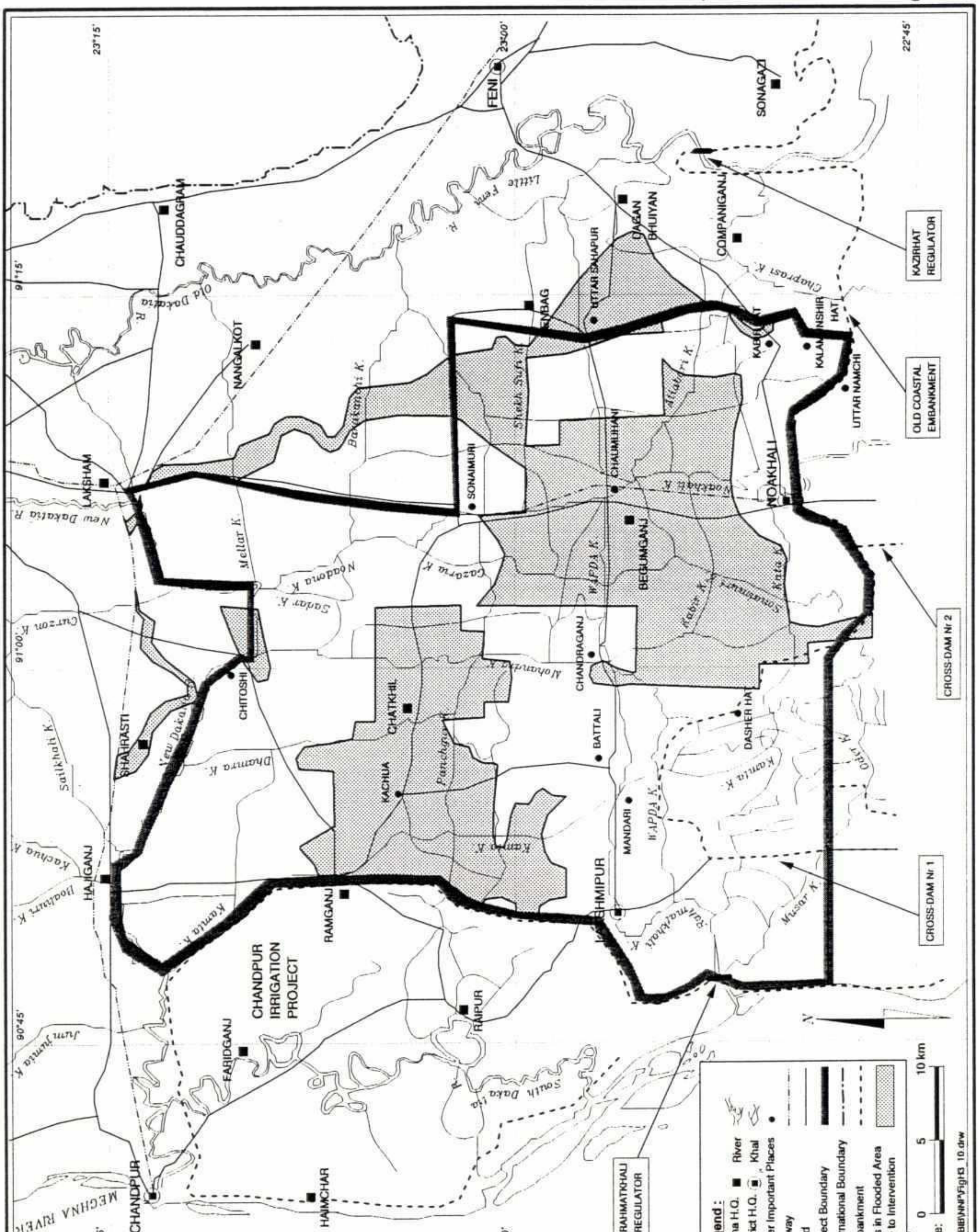


Figure H.3.11

Differential Flood Modelling by Decad (1st Decad in September)

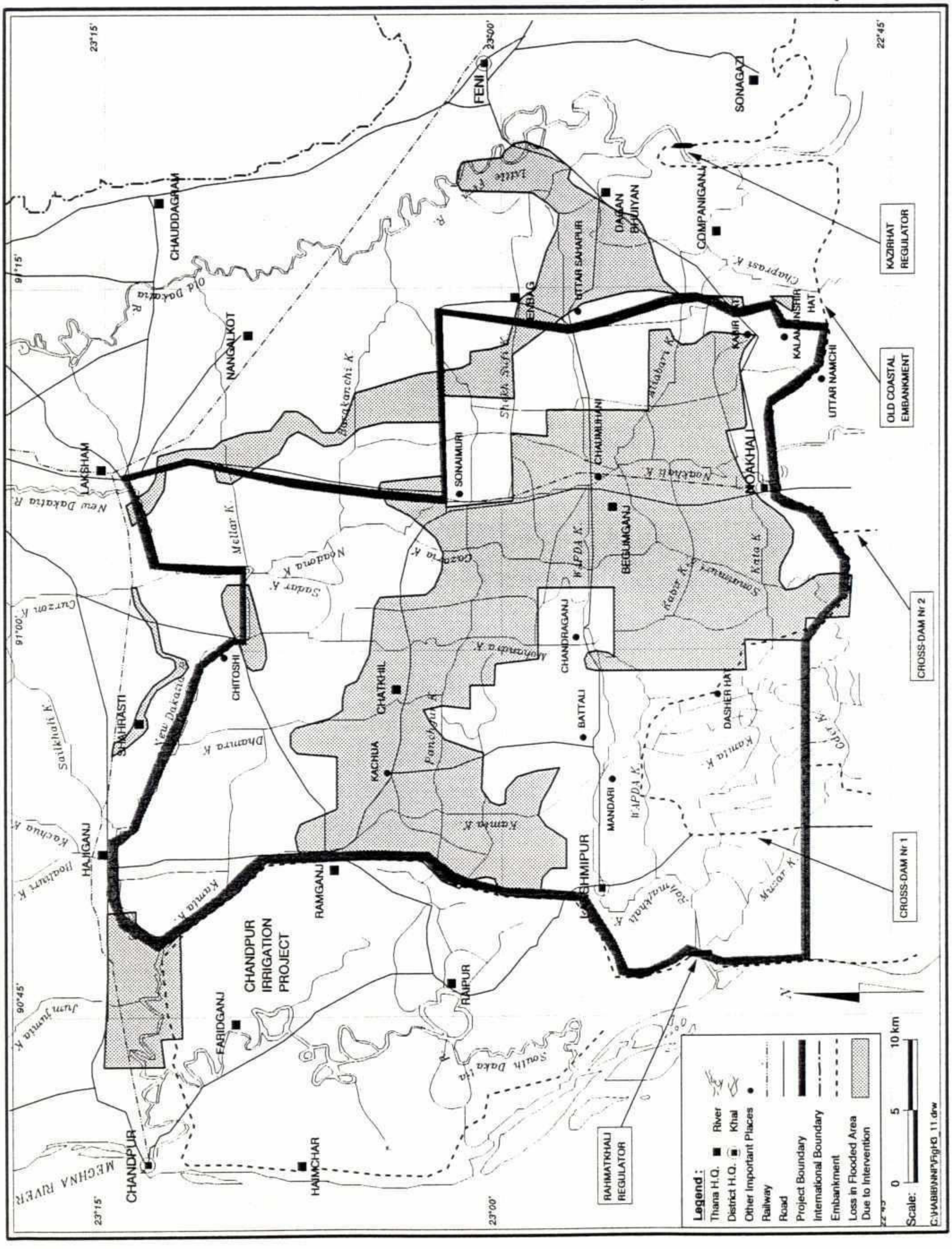


Figure H.3.12

Differential Flood Modelling by Decad (3rd Decad in September)

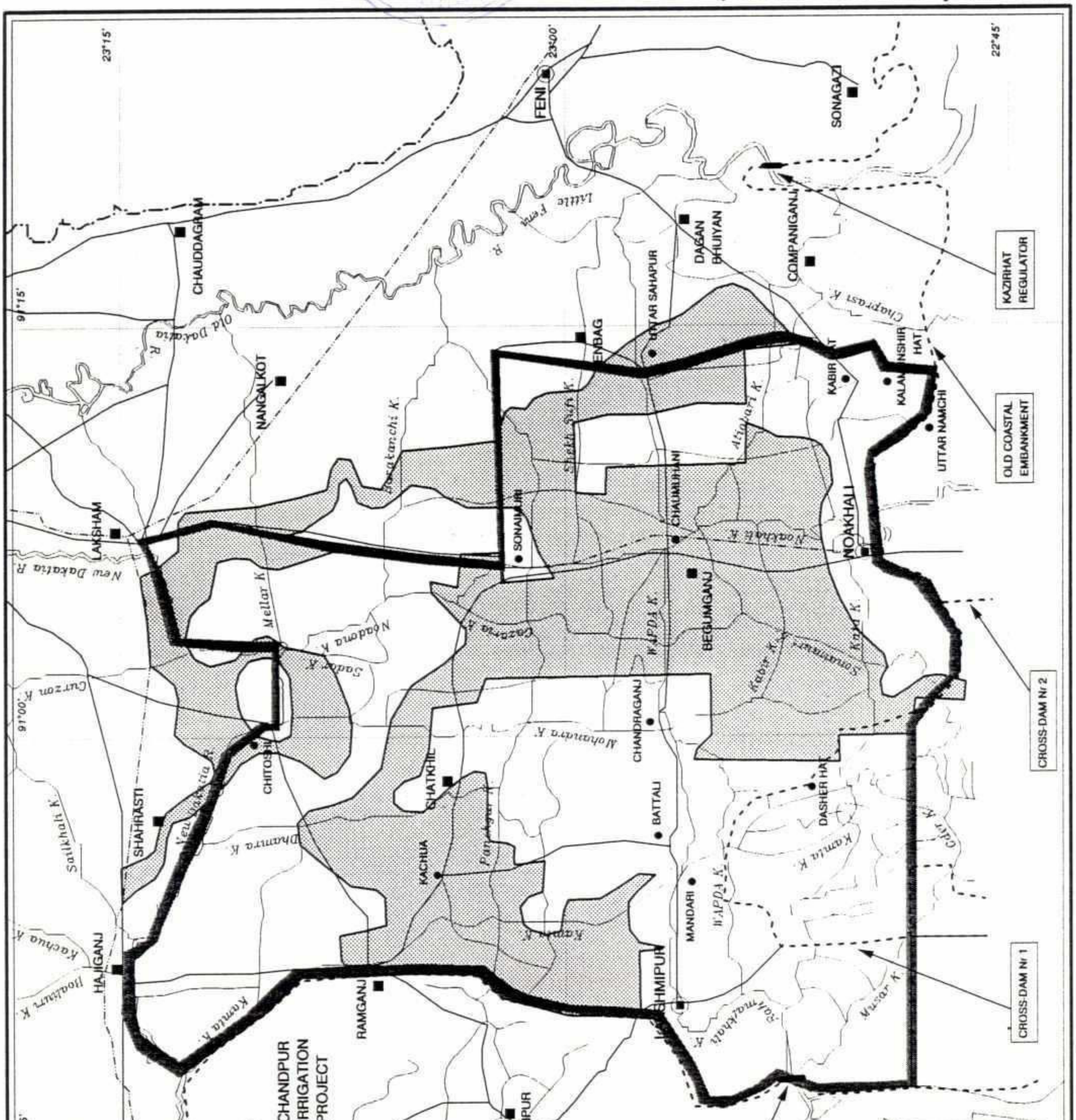


Figure H.3.13
Differential Flood Modelling by Decad (2nd Decad in October)

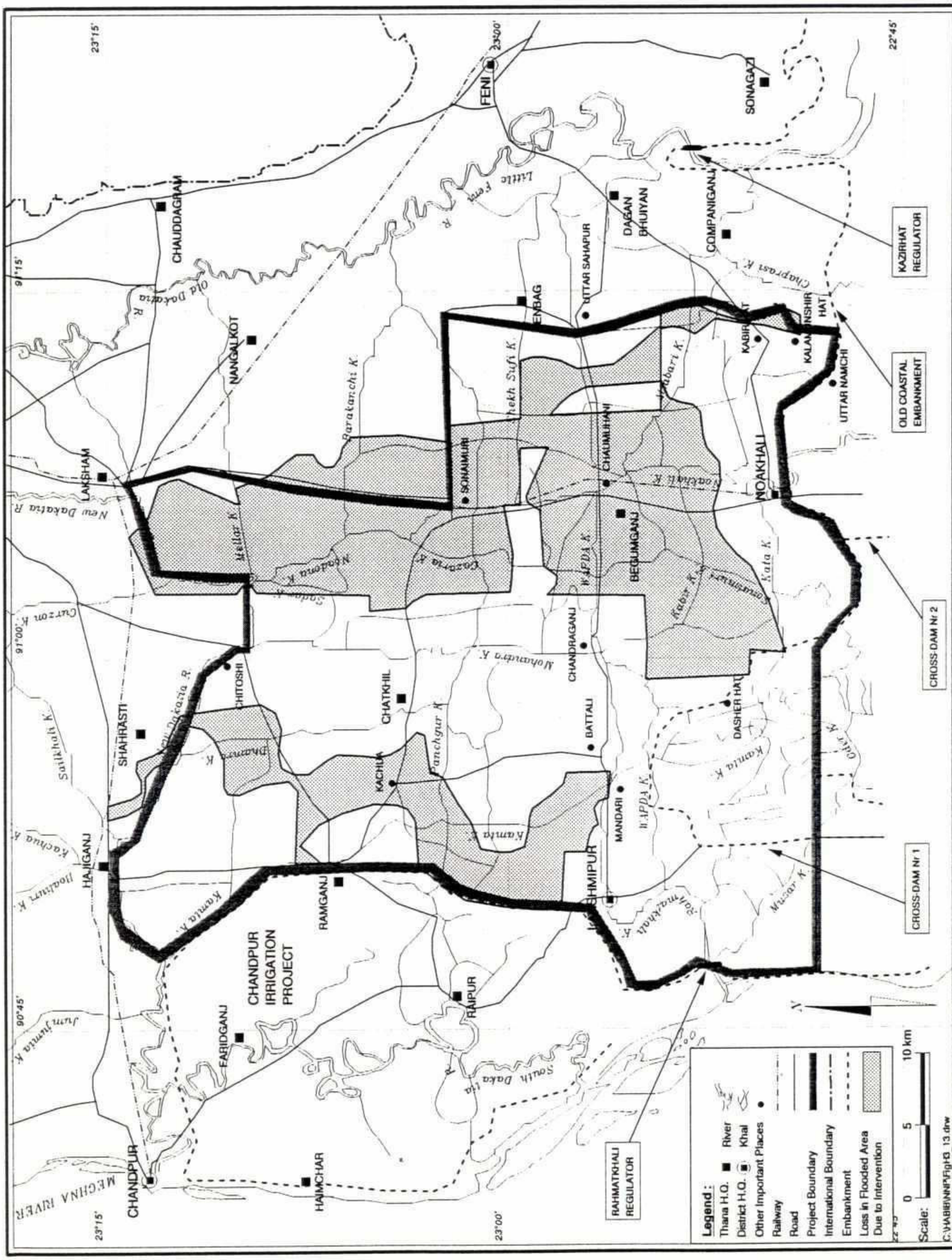


Figure H.3.14

Differential Flood Modelling by Decad (3rd Decad in October)

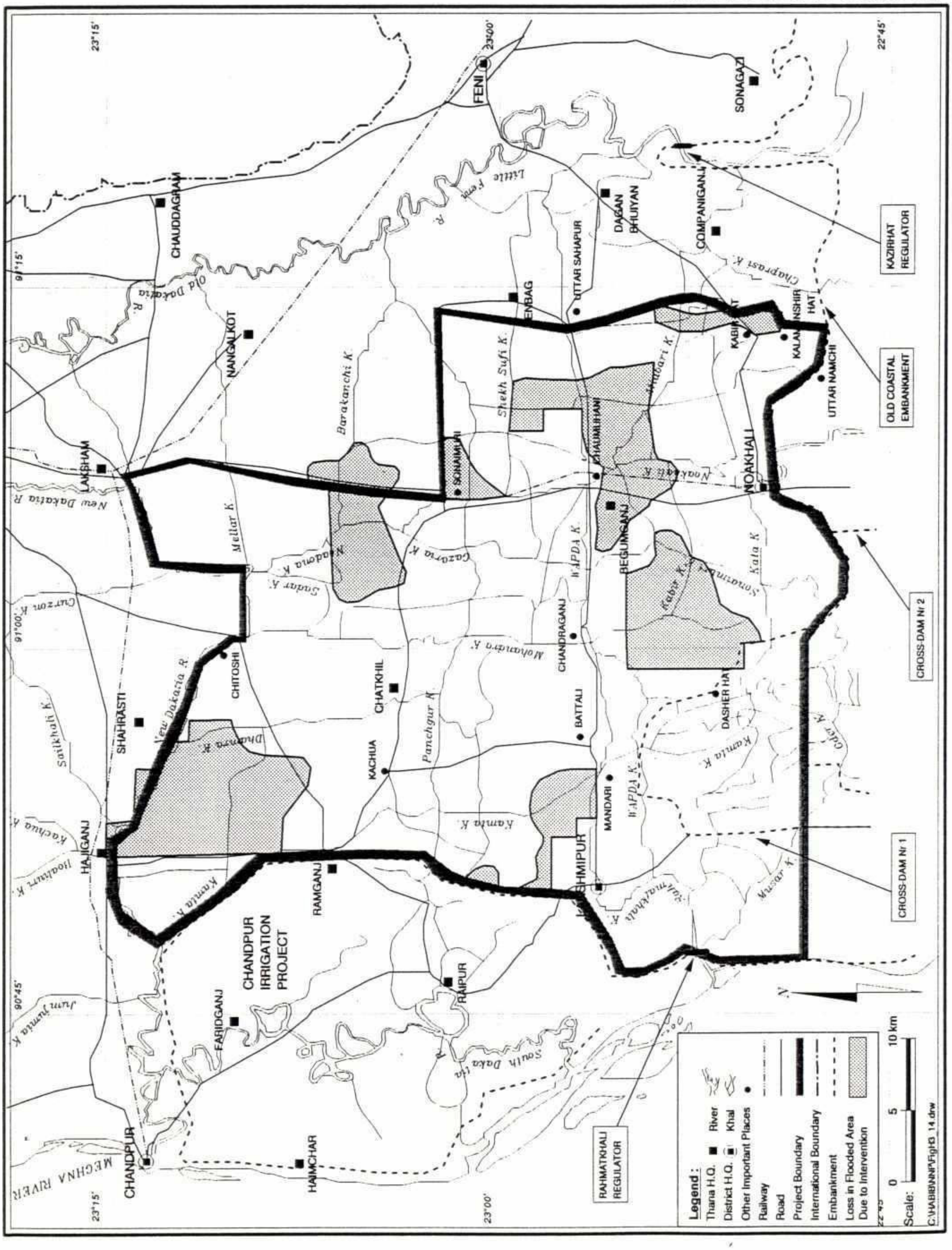


Figure H.3.15
Differential Flood Modelling by Decad
(1st Decad in November)

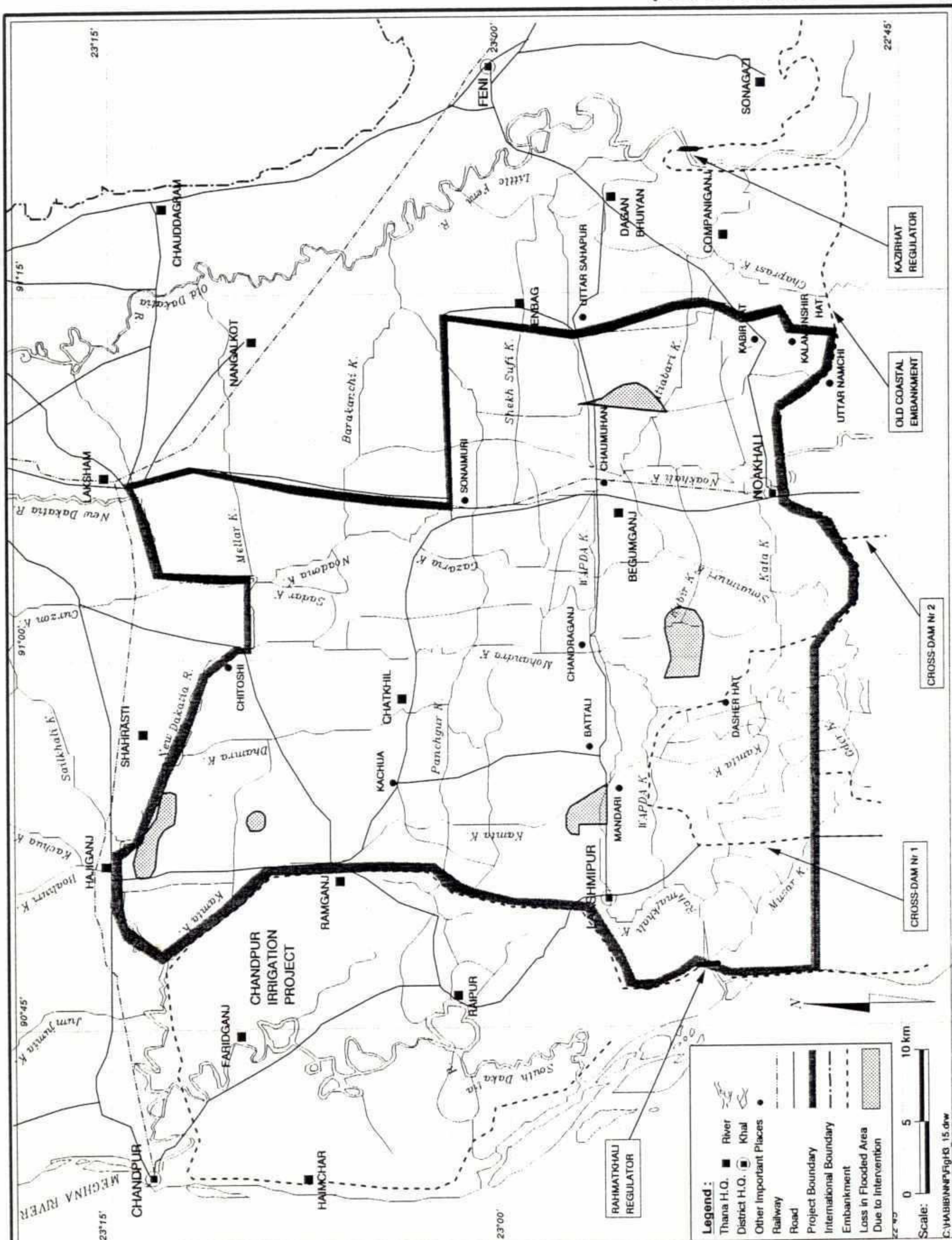


Figure H.3.16

Environmental Rating Matrix of Proposed Intervention by Zone

ISSUES	P	LP	NOW	WO	ZA	ZB	ZC	ZD	EX	MP	MC
THE STUDY AREA NATURAL ENVIRONMENT											
Hydrology											
Surface											
Flood Damage Land & Crops		*	0	-1	0	+2	+1	+2	+1		
Drainage Problems	*	*	0	-2	0	+4	+3	+2	+1		
Surface Water Availability	*	*	0	-2	+3	+2	+2	-1	-1		
Dry Season Irrigation	*	*	0	-2	+3	+2	+2	-1	-1		
Groundwater Availability	*	*	0	-1	-1	-1	-1	-1	-1		
Domestic Water Supply	*	*	0	-1	-1	-1	-1	-1	-1		
Erosion - Internal			0	0	0	0	0	0	0		
Meghna	*		0	-2	-2	0	0	0	0		
Sedimentation											
Internal Khals and Drains			0	-2	+3	+3	+3	+1	+1		
Land Accretion			0	+1	0	0	0	0	0		
Within Project Area											
Clogging/Smothering			0	-1	+3	+2	+2	+1	+1		
Soil Fertility			0	0	0	0	0	0	0		
Navigation			0	-1	+2	+1	+1	-1	-1		
Water Quality											
Domestic Water Quality			0	0	-1	-1	-1	0	0		
Agriculture Water Quality			0	0	+1	+1	+1	0	0		
Land Resources											
Soil											
Quality/Chemistry			0	-1	-2	-2	-2	-1	-1		
Waterlogging			0	-2	+2	+2	+2	+1	+1		
Erosion			0	0	0	0	0	0	0		
Ecology											
Flora			0	-1	-2	-2	-2	-1	-1		
Fauna			0	-1	-2	-2	-2	-1	-1		
Fish	*		0	0	+1	-4	-3	-2	-2	VD	
Seismic Activity (#)											

THE STUDY AREA HUMAN ENVIRONMENT	P	LP	NOW	WO	ZA	ZB	ZC	ZD	EX	MP	MC
Economic Livelihoods											
Risk			0	0	+2	+3	+2	+1	+1		
Settlement			0	0	0	+1	+1	+1	+1		
Land Tenure											
Scarcity			0	-1	-2	-2	-2	-1	-1		
Agricultural Land Values			0	+1	+2	+4	+3	+2	+2		
Common Resource Rights											
Fish			0	0	0	-4	-3	-2	-2	VD	?
Fuelwood			0	-1	-3	-2	-2	-2	-1	PO	
Grazing			0	-1	-3	-2	-2	-2	-1	PO	
Fodder			0	-1	+1	+1	+1	0	0		
Agricultural Output			0	+1	+4	+3	+3	+2	+2		
Fishing ("Professional")			0	+1	0	-1	-1	-1	-2		
Forestry and Fuelwood			0	-1	-3	-2	-2	-2	-1	PO	
Livestock			0	-1	-1	-1	-1	-1	-1		
Wage Paid Employment	*	*	0	-1	+2	+4	+4	+1	+1		
Industry			0	+1	+3	+2	+2	+1	+1		
Drinking Water Availability	*	*	0	-1	-2	-1	-1	-2	-1		
Human Health	*										
Waterborne Diseases	*										
Diarrhoea	*	*	0	-2	-2	-2	-2	-3	-2	PO	
Cholera	*		0	-2	-2	-2	-2	-3	-2	PO	
Insect Borne Diseases											
Malaria			0	-2	-2	-2	-2	-1	-1		
Kala-azar			0	0	0	0	0	0	0		
Drinking Water Quality	*	*	0	-1	-1	-2	-2	-1	-1		
Sanitation			0	-1	-2	-2	0	-1	-1		
Nutrition	*		0	-1	-2	-1	-1	-2	-1		
Mental Health			0	-1	?	?	?	?	?		
Access and Transport Infrastructure											
Waterborne											
Dakatia River			0	0	0	0	0	-1	-1		
Internal Rivers and Khals		*	0	-2	+1	0	0	-1	-1		
Within Flood Plains			0	0	0	-2	-1	-2	-2		
Railway			0	0	0	+1	+1	+1	0		
Road			0	+1	+2	+2	+2	+2	+1		
Archaeology and Cultural Sites			0	0	-1	-1	0	0	0		

EXTERNAL FACTORS	P	LP	NOW	WO	ZA	ZB	ZC	ZD	EX	MP	MC
-DOWNSTREAM CONSTRAINTS											
Meghna River Water Levels	*		0	?	+1	+4	+3	+2	+2		
-DOWNSTREAM IMPACTS											
Knock-on Flooding			0	0	0	0	0	0	0		
-UPSTREAM CONSTRAINTS											
Increased Flooding			0	?	0	0	0	0	0		
-UPSTREAM IMPACTS											
Peak Back-Up Flooding			0	0	0	0	0	0	0		
DIRECT CONSTRUCTION IMPACTS											
Permanent Land Acquisition	*		0	0	-3	-1	-2	-1	0	PO	
Forced Resettlement	*		0	0	-3	-1	-2	-1	0	PO	
Temporary Land Acquisition			0	0	-3	-1	-2	-1	0	PO	

LEGEND

RANKING OF IMPACT

-5 Severe Irreversible Negative Impact
-4 Major Negative Impact
-3 Significant Negative Impact
-2 Moderate Negative Impact
-1 Slight Negative Impact
0 Present Baseline Situation and No Change
+1 Slight Positive Impact
+2 Moderate Positive Impact
+3 Significant Positive Impact
+4 Major Positive Impact
+5 Highly Significant Positive Impact

VD = Mitigation Very Difficult
PO = Mitigation Possible
CO = Mitigation Costly
PC = Mitigation Prohibitively Costly
N = Mitigation Not Possible

ABBREVIATIONS/HEADINGS

P = Expert Priority Issues
LP = Local Priorities
NOW = Present Situation
WO = Without Project Situation
ZA = Zone A
ZB = Zone B
ZC = Zone C
ZD = Zone D
EX = External Area
MP = Mitigation Possible
MC = Mitigation Costly?
(#) = A Constraint not an Impact
* = Major Issues
F = In Times of Flood
LF = In Low Flows
PF = In Peak Floods
? = Insufficient Data to Assess

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

Zone C, 34% in Zone D and 40% in the external areas with Zone A remaining unflooded in the with intervention situation. This gives a mean loss of 48% of floodplain area in the with intervention situation.

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

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

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

The outputs of the hydraulic model were also used to study the effects on Khal and drain water depths, bearing in mind before and after intervention bed levels and water levels. Sample points in the drainage system were taken (the locations are shown in Figure H.3.2) and the mean yearly water depths calculated for a with and without intervention situation for a "normal" year. This indicated that, as planned, the deepened Khals have significantly more water in them (up to +2.6m in one case, but the average was +1.25m). However outside this there are non-deepened Khals which are drained quicker and earlier as a result of the intervention, leaving them for longer periods with less or no water. Whilst the mean annual figure was not great at -0.25m, there are localised places where this could be of concern, especially in the southern part of Zone B where the figure was -0.45m. However it may be that in the longer term the channels may regrade themselves and the effects will be less marked.

H.3.5 Impact Assessment Matrix

The aim of the Impact Assessment Matrix is to identify likely major impacts of the proposed intervention, especially negative impacts, as this then allows closer consideration of these problematic issues. This is considered a useful tool as it allows scarce resources to be concentrated on the issues that matter and not be wasted on peripheral aspects or worse still deprive needy dis-beneficiaries of attention. The matrix differentiates impacts by planning zone, including the adjacent external areas. The impact matrix should be considered in relation to the Impact Zoning Map, Figure H.3.17.

The comparative impact assessment matrix for the proposed intervention is given in Figure H.3.16. The issues are listed down the left side and systematically cover the natural and then the human environment. External issues are then covered, both upstream and downstream of the study area, and in terms of constraints to the intervention and impacts caused by it. It should however be noted that the immediately adjacent area is covered separately in more detail as a Zone (EX) in itself. The last section covers major broad direct construction impacts. Those issues that are considered, from a technical standpoint, to be priority ones in terms of policy objectives are indicated in the first column (P), where as those which are of concern to local people are indicated in the second column (LP). The present situation (NOW) has been set at a steady state zero to allow a comparative assessment to be carried out. However this hides the fact that for some issues the present situation is already in dis-equilibrium. The WO column is an indication of the likely general situation over the study area if the intervention were not implemented. Whilst this gives a guide as to the likely future trends, it is notoriously difficult to predict these, especially for the natural environment. It also hides important zonal differences which can not be addressed due to a lack of data, particularly on fisheries trends and the BBS 1991 census work. Analysis of zonal differences is also not helped by the fact that the Zonal boundaries are misaligned for some aspects of impact assessment work. The following five columns are each of the zones, including the immediate external areas (EX). The last two columns indicate the mitigation possibilities for the most serious negative impacts, and if mitigation is possible, how costly it is likely to be. The definition of the ratings is given on the last page of the matrix and covers a scale from -5 to +5 with 0 being the present situation. It should be remembered that the ratings are the actual situation in comparison to that of the NOW column. To give differentials of the situation in six years after the construction period has finished, the WO column rating should be borne in mind when viewing the zonal rating. The period used for assessment of the likely impacts is six years from the completion of construction, as it is considered unrealistic and unreliable to predict further forward than this, especially for issues concerning the natural environment. No statistical weights or totals are used in these matrices as this is considered unjustifiable and would be deceptive giving the work spurious credibility. There is simply not the data available to do this, especially for such a complex and diverse area and with the time and resources given to do the work. The matrix aims to highlight the major issues so that more detailed follow-up work can be targeted on these. The more severe impacts with a rating of -3 and higher are discussed individually in Sections H.4.3 - H.4.5 and those lesser issues with a rating of -2 are dealt with in broad terms in the following Sections.

Figure H 3.17

Impact Zoning Map

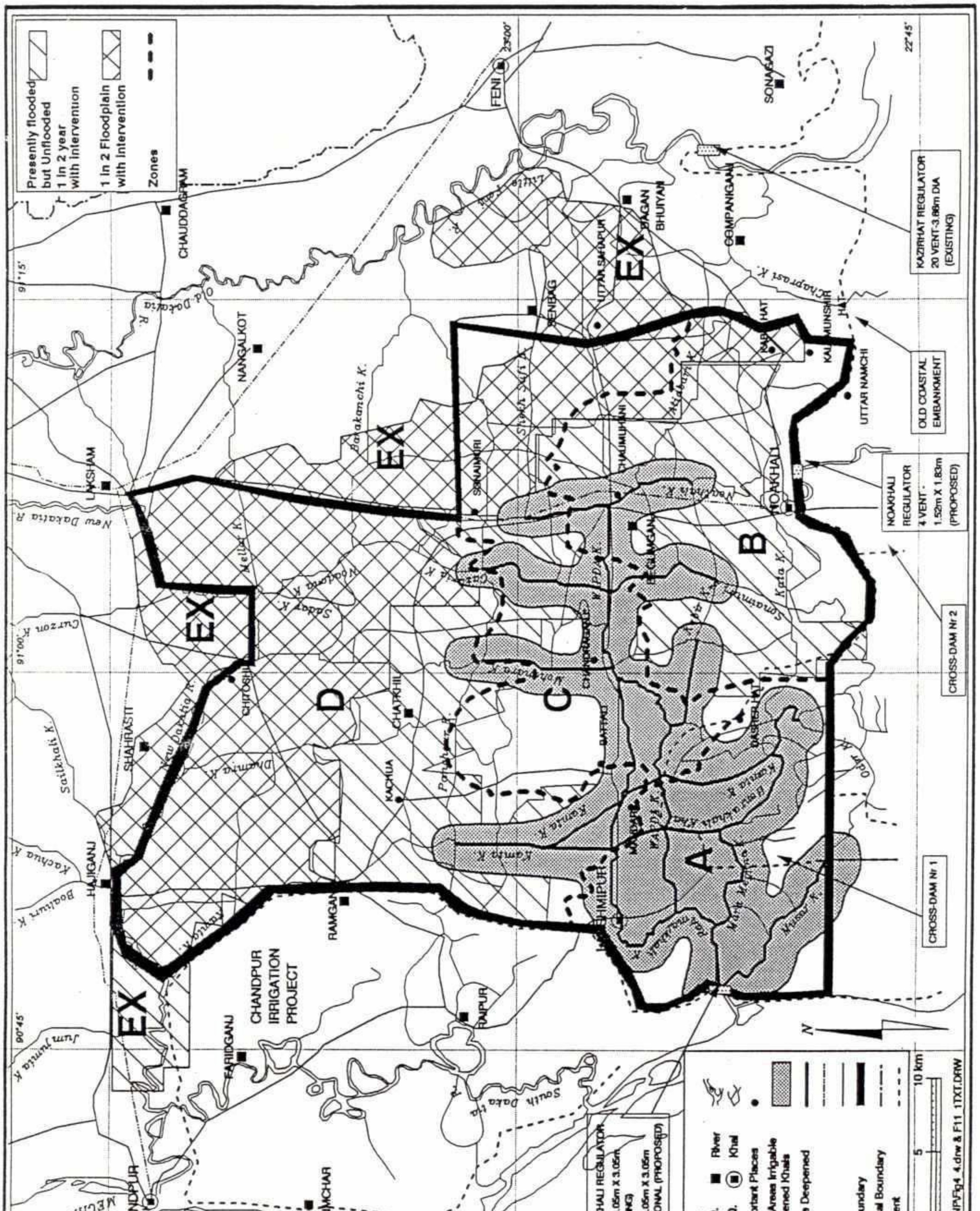


Figure H 3.17 Impact Zoning Map

H.4 PRINCIPAL NEGATIVE IMPACTS OF THE PROPOSED INTERVENTION

H.4.1 Introduction

As stated in the proposed approach and methodology to the study (FAP 5 Second Interim Report, Section 9, November 1992), the resources and time period made available to the environmental component of the study are inadequate to address the likely impacts of the proposed intervention according to both the FPCO Environmental Guidelines and the World Bank Operational Directive 4.01. Consequently it was decided to concentrate the available resources on the most serious negative impacts, with the aim of identifying these and where possible undertaking sufficient work to quantify and value the most serious issues. Considerable additional work with a field data collection period of a minimum of 12 months will be required to bring the environmental component up to the level of a fully integrated assessment with full quantification, mitigation arrangements and an Environmental Management Plan. An outline for this is given in Sections H.5.2, H.6.3 and in Appendix H.III. The main negative impacts are those with a rating of -3 or more on the matrix. There are only four of these:

- Losses to Floodland Fisheries
- Socio-economic and Livelihood Impacts - mainly due to professional fisheries losses and the requirements for land acquisition and resettlement.
- Fuelwood and Grazing Decline
- Changes in Waterborne Diseases

The last two impacts are issues that are likely to emerge irrespective of the intervention but are accelerated by it.

H.4.2 Changes in Flood Risk and Timing

The results of the hydraulic modelling for a with and without project situation in a "normal" and high "normal" flood have been interpreted using the differential flood mapping in Section H.3.4 above. The conclusion from this is that the reduction in area of flood plain due to the intervention is quite considerable although this varies greatly from zone to zone. The peak extent falls by some 36% in the study area and 30% in the external area in a "normal" year. However the mean annual reduction over a full "normal" year is much greater at 48% in the study area and 40% outside it. This is due to the rising flood being delayed and the falling flood starting earlier. Whilst this demonstrates the effectiveness of the intervention in terms of reducing flood damage and allowing monsoon season agriculture and earlier planting in many areas, it is a dis-benefit to the flood plain fish habitats. This has implication for the ecology of the area as well as fisheries production and hence the availability of animal protein as a food source. In addition, the promotion of irrigated dry-season farming is likely to result in the intensification of the agricultural system with a move towards longer periods of rice monoculture. There will also be some parts of the study area outside the Khal deepening and irrigation area that will no longer have seasonal flooding. These areas will have slightly longer periods with no water in their Khals and will not have access to dry season surface irrigation water provided by the intervention. They will be reliant totally on rainfall with limited residual moisture from infiltration and none from standing flood water. These changed hydraulic parameters underpin the thinking behind the assessment of the likely environmental implications of the intervention.

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H.4.3 Losses to Floodplain Fisheries

The most serious negative impact of the proposed intervention would appear to be on floodplain fisheries. The detailed work on fisheries assessment is given in Annex F of this report and the estimated production changes for the intervention by fishing system and zone are given in Table H.4.1. These changes are shown as percentage differences relative to a predicted without project situation for a time at 6 years after completion of construction. This has used assumed national fish production changes of -1.5% per annum for all systems except ponds where +4.5% has been used. These rates have been obtained from FRSS data in collaboration with FAP 17 (the FAP Fisheries Special Study) and are also the same rates of change used by FAP 3.1 and the 1993 Gumti Phase II Feasibility Studies. However there must be great concern as to how valid these national figures are for a specific study area. For Noakhali North it may be that the pond increase is perhaps high as pond production in the area has already been significantly increased.

The main effects of the intervention are the reduction in floodplain area available for fish habitats and the increase in all year water availability in the deepened Khals and drains which should allow increased dry season fisheries retreat areas. It has been predicted that, with the intervention, fisheries production will be less than the without project situation by 3645tonnes (13% of the total) in the study area and 737tonnes less in the external areas. However this varies greatly by zone, with the most effected being Zone B at -18% followed by Zone D at -13%, C at -11% and a very small increase in Zone A. It has not been possible to quantify the present production in the external areas and hence change estimates can only be given for the floodplain areas with no indication as to how important these are to the overall level of fish production.

The main effect is in flood plain fisheries production, which is predicted to be 50% less in the study area and 31% less in the external area when compared to a no intervention situation. However this is very variable by zone, with no loss in Zone A (in fact a small gain due to more water in Khals), an 81% floodplain catch loss in Zone B, a 62% floodplain loss in Zone C and a 34% loss in D. The floodplain catch loss in Zone B may however be offset to some extent by high levels of pond production (over 3 times the floodplain production) which according to the nutritional study are being used for direct consumption by many small scale operators/owners. The same may be true to some extent in Zone C, although the nutritional study has not shown this to be the case but the sample sizes were very small. In Zone C there are 28% gains to Khal fisheries but these are only a very small proportion of the total fish catch and do not act as a significant mitigation measure. In Zone D there is a 34% loss to flood plain and 32% loss to Khal fisheries and this constitutes an overall loss of 13% to all fisheries production.

The procedures for valuation of the fisheries resources are given in Annex F and have been incorporated into the financial analysis of the intervention, both in terms of lost value of production and loss of wages/income to fishing households. The cash valuation of the catch is based on market prices and it must be remembered that the fisheries work covers only the fish caught by full time and part time fishermen and excludes occasional fishermen who are far more numerous in all zones except D where they are similar to the numbers of full-time fishing households. Overall there are about twice as many occasional fishing households than full or part time ones, the occasional fishing households catching fish for self consumption.

TABLE H.4.1

Change in Fish Production Estimates in the Noakhali North Study Area Due to the Proposed Intervention Without Mitigation and Management

		NOW	% Total Catch	WO Year 6	% Total Catch	WI Year 6	% Total Catch	Difference in Year 6 WI and WO %
Zone A	River	0	0.00	0	0.00	0	0.00	0.00
	Khals	27	0.11	25	0.09	33	0.14	35.78
	Floodplain	0	0.00	0	0.00	0	0.00	0.00
	Ponds	1 324	5.61	1 724	6.27	1 724	7.23	0.00
	Subtotal	1 351	5.73	1 749	6.36	1 757	7.37	0.50
Zone B	Rivers	0	0.00	0	0.00	0	0.00	0.00
	Khals	29	0.12	26	0.10	26	0.11	−0.59
	Floodplain	1 841	7.81	1 681	6.11	319	1.34	−81.00
	Ponds	4 387	18.60	5 712	20.77	5 712	23.94	0.00
	Subtotal	6 257	26.53	7 420	26.98	6 058	25.39	−18.36
Zone C	Rivers	0	0.00	0	0.00	0	0.00	0.00
	Khals	25	0.11	23	0.08	29	0.12	27.60
	Floodplain	1 441	6.11	1 316	4.79	500	2.10	−62.00
	Ponds	4 446	18.85	5 789	21.05	5 789	24.27	0.00
	Subtotal	5 912	25.07	7 128	25.92	6 318	26.49	−11.36
Zone D	Rivers	105	0.45	96	0.35	96	0.40	0.00
	Khals	53	0.22	48	0.18	33	0.14	−32.02
	Floodplain	4 723	20.03	4 314	15.69	2 847	11.93	−34.00
	Ponds	5 181	21.97	6 746	24.53	6 746	28.28	0.00
	Subtotal	10 062	42.67	11 203	40.74	9 721	40.75	−13.23
Total	Rivers	105	0.45	96	0.35	96	0.40	0.00
	Khals	134	0.57	122	0.45	122	0.51	−0.43
	Floodplain	8 005	33.95	7 311	26.59	3 666	15.37	−49.85
	Ponds	15 338	65.04	19 970	72.62	19 970	83.72	0.00
Sub−Total (1)		23 582		27 499		23 854		−13.25
	Floodplain Areas External to Project Area							
Dakatia River	Floodplain	862		787		680		−13.70
Eastern Side	Floodplain	1 725		1 575		945		−40.00
Sub−Total (2)		2 587		2 362		1 625		−31.20
Grand Total		**26 169**		**29 861**		**25 479**		**−14.67**

According to the apportioned 1991 census data, some 10% of all households in the study area carry out occasional fishing. The nutritional study has indicated that the fish consumption levels in the study are very high (over 45% had eaten fish in their last meal and 82% in the last three days), especially in comparison to Dhal (18% and 45%) and meat (4% and 10%). In the dry season period of a very dry year when the nutritional surveys were undertaken the source of fish was the market for 80% of households, own ponds were 15% (although 40% in Zone B) and self caught in Khals was 3%. This later figure seems to roughly fit the 4% of households who are recorded as being professional fishermen but can only be reconciled with the 10% of occasional fishing households by assuming most occasional fishing is a wet season occupation in flood plain areas. It also highlights the possibility, particularly in Zone B, of many fish dependent households being involved in pond fisheries.

The overall conclusion is that an in-depth study of fishing household socio-economics is required, targeted on issues and locations that are likely to arise as a result of the proposed intervention. This also needs to include a catch assessment survey over a full yearly cycle in a "normal" flood year and include the adjacent areas external to the study boundary. Even without this data it seems possible to surmise that the most serious problem is likely to be the floodplain loss in Zone B, followed by Zone C, the eastern external area, Zone D and finally the Dakatia floodplain. The severity of this loss is likely to be greatest to occasional fishing households in Zone B (estimated to be a maximum of 9 800 households), and in Zone C (7 650 households). There may be some full time fishing household losses in Zones B and C but the numbers are low and likely to be no more than 2 000. In Zone D the proportion and number of full time fishing dependent households is far higher than in other zones, however the degree to which they depend on the present flood plain is unknown. It is estimated that some 3 400 occasional fishing household will be effected in Zone D and perhaps a up to a similar number of professional fishing households. The situation in the external areas is even less certain as the numbers of fishing households are unknown and there are no catch assessment data split by fishing system.

In all some 20 000 occasional fishing households are estimated to be directly effected in Zones B, C and D, by that order of priority. The main outcome is likely to be declining levels of nutrition in these households. In addition an unknown number of fish dependent households will be negatively effected in the external areas and around 3 500 full and part time fishing households could be at socio-economic livelihood risk in Zone D. There are also likely to be losses to full time fishing households in Zones B and C, but these are likely to be small, in the order of 1 000 - 2 000 at the maximum.

H.4.4 Socio-Economic and Livelihood Impacts

A Social Impact Assessment (SIA) has been carried out as part of the socio-economic studies and is written up in Section 4 of Annex G and summarised in Chapter 5 of the Main Report. The overall aim of the SIA is to ensure that no one group of people is dis-benefitted as a result of the intervention and benefits are spread in an equitable and non-divisive manner. In addition any constraints to achieving benefits were also considered so that the aims of the intervention are more likely to be realised. Investigations for the SIA were carried out as part of the public participation programme using group discussion techniques and raised a wide range of issues. The work identified likely disadvantaged groups and considered mitigation programmes to overcome these, including appropriate institutional structures for achieving these. Additional specific issues were raised by the SIA team that were of concern to them and had not been raised by local people. This is an important aspect of creating awareness of the specific localised issues that are likely to occur due to the highly site specific nature of the proposed intervention.

The two major causes of loss to socio-economic livelihood as a result of the intervention are likely to be amongst full time fishing households and those who lose land and fixed assets as a result of the need to acquire land for permanent works. The latter is likely to be a highly localised issue but in the case of a few households could be severe.

It has been estimated that as many as 3500 professional fishing households could be seriously effected in Zone D and up to a further 2000 in Zones B and C. In addition there are an unknown number in the adjacent external areas. A specifically targeted programme of replacement livelihood provision would need to be set up for these households. The development of a suitably owned and managed pond aquaculture programme would seem to be a strong possibility, especially as there appear to be such activities already happening in Zone B. In addition it could be the case that the extra labour required as a result of construction and development of irrigated agriculture would provide a suitable replacement livelihood. However the most serious problem lies in Zone D which is outside the intervention and irrigation area.

It has been calculated that the intervention programme will require 76ha of land to be acquired for permanent works although this could in theory be offset to some extent by 19ha gained from straightening the khals. A detailed cadastral mapping survey with full field verification and certification is required of the chosen deepened Khals so that accurate numbers can be given of the number of households effected and to what degree. This will require a socio-economic component that looks at each effected households asset portfolio and an assessment made as to the degree to which their livelihood is jeopardised. This will allow a suitable resettlement and compensation strategy to be developed which allows the greatest flexibility for the affected households. Overall such land and fixed asset acquisition must be done in a fair, equitable and timely manner or the construction programme could be seriously jeopardised. Recent difficult experiences on the Coastal Embankment Rehabilitation Project illustrate what can happen if these issues are not tackled in a timely and rational manner. The FAP 15 study review of land acquisition, resettlement and compensation issues raised serious questions as to the adequacy of the present implementation of these procedures. It is imperative that these issues are addressed and that there is close liaison with the effected people in avoiding and solving any potential disputes over land acquisition and compensation. It should be the case that all assets are full compensated for and resettlement satisfactorily completed before any works can commence on it. In addition there is a World Bank requirement for an agreed resettlement and compensation plan following the Operational Directive 4.30 to be agreed prior to funding. For the present study, estimates of compensation costs have been included in financial analysis of the intervention, based upon field reconnaissance and land values found in the area.

In addition land is required for storage/disposal of excavated soil. If this were to be for large permanent spoil tips it would require 457ha of permanent land acquisition. However if the spoil were to be thinly spread this would effect 3633ha but only temporarily during the construction period and for a period after spreading for any infertility to be redressed. These two alternatives have been costed (see Tables J.5.1 and J.5.2) and although the temporary acquisition option is slightly more expensive (overall the soil disposal costs are estimated to be some 5% of the total construction cost) it has considerable socio-economic benefits over permanent land acquisition. However a flexible approach will be needed and in some areas affected people may for their own reasons favour permanent land acquisition, although the SIA work has indicated that very few people would object to temporary acquisition and soil spreading. Some people were actually keen to have the material and use it for house raising purposes.

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Apart from these two direct socio-economic impacts there are also concerns that the benefits of the intervention, particularly those derived from agricultural intensification due to the provision of irrigation water, will only be fully realised by the richer farmers who have access to the inputs required to maximise returns to this type of operation. This can particularly be a problem in share cropped areas and could result in increased polarisation of income levels and widening of the equity gap. This requires specifically targeted assistance, particularly agricultural credit to poor farmers. In addition there appears to be conflicting views as to the likely pattern of increased demand for agricultural labour. It has been estimated that an additional 4.3million person days per annum will be generated by the increase in agricultural activity. However in some areas of the country most additional labour requirements have been met by existing "surplus" labour available from within the landowning family (see the work of FAP 12). The situation in the study area looks to be different as many already hire in labour at certain times of the year which would indicate a shortage at some times and that any increased agricultural activity will generate significant wage paid labour from outside the household. This is important as it is considered a major way of overcoming the nutritional consequences of common good fisheries losses to occasional fishing households and generally spreading the benefits of the intervention to poorer households. This is also the case with the requirement for construction labour, which whilst temporary is estimated to provide employment for 10 000 people for three dry seasons. However this needs to be well managed if the benefits are to be passed to the most needy local people. It has been proposed that Labour Contracting Societies (LCS) be utilised so that this is more likely to happen. This is discussed in detail, with locals peoples views as to this proposal, in the SIA.

There would also seem to be some justification for broadening the scope of the intervention programme to tackle other related issues that are perceived by local people to be important in the area. These include items that would tackle mitigation measures and be central to an Environmental Management Plan (EMP) for the area which could be implemented with the help of NGO's. These would aim to increase socio-economic levels in the area, particularly to dis-beneficiaries. They include the promotion of fisheries management and aquaculture, replacement protein production programmes (poultry and vegetable production), social forestry, sanitation, water supply and health education. These would need to be designed in an appropriate manner as part of an integrated development programme. Suggestions for this are made in the SIA section in Annex G and included in the implementation programme outlined in Chapter 13 of the Main Report.

H.4.5 Fuelwood and Grazing

The complex linkages and interaction within the rural energy system based around crop residual availability and nutritional status as feed, linked to livestock numbers, draft animal requirements and the availability of power tillers, are likely to change as there is an inevitable reduction in common grazing land availability reduction as agriculture intensifies. This is the case with or without an intervention, but is likely to be made worse under intervention conditions unless there is a targeted programme to address this. A crucial factor is the change in availability and quality of straw for stall fed cattle feed and the competition for its use as domestic fuel and building material. Fuel wood now appears to be in short supply and reserved for commercial users such as brick making and pottery as it is so scarce and expensive. Animal dung is also now being used as fuel, particularly in the peri-urban areas and hence not being used as fertilizer. This tends to result in greater use of artificial fertilizers with a risk of wrong or over application leading to increased risks of algal blooms causing water quality problems in both surface and groundwater.

It would seem likely that the situation in the study area is likely to get more difficult irrespective of any intervention, but the intensification of agriculture could make this more significant. It is likely that demand for draft animals will increase and the lack of grazing land will prove to be a major constraint. However it has been predicted that the overall availability of rice straw will increase, the increase in production of short stalk, lower nutritional rice residues being sufficient to produce a greater useable volume. Whilst this may be able to sustain the same or larger animal numbers, it will require many of the grazed animals to be stall fed in future.

The promotion of social forestry at homesteads and on embankments can go some way to providing domestic fuel sources. In addition the use of power tillers, which whilst having sustainability issues of their own, would seem to relieve pressure on a stressed system.

H.4.6 Changes in Patterns of Specific Waterborne Diseases

The impact rating matrix has indicated that there is likely to be a problem with water borne diseases in the area. This is complex and difficult to predict, but on recent trends it would seem that these are likely to increase irrespective of any intervention but a drainage intervention could increase the risk of these to the point where it becomes a significant issue. At present there are serious diarrhoeal disease problems in Zone D and it is predicted that these are likely to get worse unless there is a targeted programme of sanitation, water supply and health education to tackle these issues. There appears to be evidence that the annual flushing effect of flooding is useful in diluting and removing the sources of diarrhoeal disease. There is a fear that if annual flooding of the land is curtailed then there is likely to be an increased risk of diarrhoeal disease. Surveys carried out for the Gumti Phase II study would seem to indicate that flood protected areas have higher diarrhoeal disease rates.

There has recently (April/May 1992) been a serious outbreak of malaria in Zones A and B, although this is assumed to be the non- fatal Benign Tertiary vivax strain carried by culex mosquitos. There is a strong possibility that conditions in the post construction situation next to Khals with all year standing water and the prevalence of irrigation will increase the habitats for malaria carrying mosquitos (see WHO/Tiffen). This requires a detailed baseline data collection programme and subsequent monitoring to gain sufficient knowledge to tackle this issue.

H.4.7 Human Nutritional Consequences

As mentioned above, the loss of fisheries resources to occasional fishermen is likely to have serious localised problems in the reduced flood plain sections of Zones B, C and D. The total number of households likely to be affected is estimated to be 20 000 which while locally significant is only 5% of the overall population. When compared to the predicted agricultural benefits to the area (a 23% increase in rice production) the loss is less significant, particularly if the predicted increases in agricultural labour (4.3million person days per year which is equal to 4.8 times the predicted losses to fisheries labour) are realised to occasional fishing households and this allows them to earn sufficient income to buy fish in the market. This is especially the case if a targeted pond aquaculture programme were set up to provide alternative livelihoods for the 3500 full and part-time fishermen that are estimated to be dis-benefitted. It also appears that this process is already happening in Zone B where 40% of fisheries consumption in the sample site was from households own ponds.

H.4.8 Soil Fertility Issues

These issues have been outlined in Section H.2.2.8 and apply to any area which is proposed to be drained or come under irrigation. They are not thought to be of immediate concern in the study area, but there are implications for the drained and irrigated areas in the medium to long term (i.e.5-10 years). This is particularly the case if continuous mono-cropping of rice is to be carried out in any areas. An appropriate baseline data collection programme will be required, along with access to the existing SRDI surface soil chemistry data. This then needs to be followed by a monitoring programme and a feedback system that allows crop, soil and water management policies to be modified if these are thought necessary.

H.4.9 Potable Water Issues

The present situation with regard to domestic water supply has been outlined in Section H.2.3.1 and was also addressed in the health and nutrition field work. In addition the public participation studies indicated that in 10 of the 13 responding villages local people considered that the water supply was inadequate. This was reinforced by the health study which showed that ponds were being used as dry season domestic water sources in some places. The analysis of the likely future waterborne disease situation in a with and without project situation has been discussed in Section H.4.6 above. The conclusion would seem to be that irrespective of any intervention there would appear to be a need for increased provision, which is made more important still due to the intervention. However study of the part data from the 1991 census indicates that provision levels in the south eastern part of the study area has improved markedly since 1981, although this is uneven. It would seem necessary to review the position as soon as the full 1991 data becomes available and assess the position. The central issue is that in some areas the provision of safe drinking water is seen by some households to be of a higher priority than flood plain reduction, drainage and the provision of irrigation water.

H.4.10 Change in Flora and Fauna

The assessment of the effects of the detailed interventions on the ecological system are given in detail in the Ecological Annex D. The natural fisheries system is likely to suffer the most serious problems, especially in the floodplain areas of Zones B, C and D. In addition, the clearing of 200km of drainage channels is likely to cause significant changes in the flora and aquatic flora in the Khals. This has implications for future Khal ecology and suitable habitats for improved and managed fisheries.

These resulting changes in habitat and are extremely difficult to predict, especially in the case of an area where the present situation would seem to be in decline irrespective of any intervention. A baseline monitoring system will be required in those Khal areas and also on the impacted and non-impacted flood plain areas.

Construction impacts on the ecology could be severe in the Khal excavation areas if this is not appropriately managed. However many of these issues can be avoided by careful planning and allowing regeneration to occur more quickly in places where there may be some longer term benefits. Development of social forestry on embankments and homesteads may help provide added habitats, but alternative replacement for the two main flooded depressions at Begumganj and Laksham would seem impossible to provide and a decline in water birds seems inevitable. In terms of human use, it would be worth doing a check on important medicinal plants in the Khals to be deepened and also in the impacted flood plain areas, to see if these are important enough to consider the availability of replacement sources.

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In terms of pests, the water hyacinth is a serious problem in the water courses and will need to be continuously cleared if drainage and irrigation supply is to remain unimpeded. Enquiries with the paper making operation at Feni indicate that they can take cut and bundled stalks. Alternatively it may be worth considering setting up a similar operation within the western part of the study area. This would need careful consideration in co-operation with the relevant NGO technical specialist at the Mennonite Central Committee. The incidence of rats and ways of natural control of these need to be investigated as this has proved a serious problem in some drained areas in other parts of the country.

H.4.11 Disruption to Waterborne Navigation

The present use of larger country boats is presently restricted to the Dakatia river as the construction of previous interventions has prevented the movement of such craft into the study area. There is in any case insufficient draught to allow dry season navigation even if access were possible. Of more importance are small passenger and goods boats which are commonly used on the flood plain areas in the monsoon season. These will be restricted to the reduced flood plain areas and reliance will need to be switched to road transport as is the case in the dry season. There is therefore likely to be little problem in provision of a replacement monsoon service, although unsurfaced roads may need improvement to make them suitable for all weather use. It would also help if the existing flood control embankments were adapted for dual purpose use as roads. The unknown factor is the degree of livelihood loss that is likely to be suffered by boat owners, operators and builders along with secondary links to freight transport, if any exist. Study of this requires a highly specific targeted data collection programme and set of analysis. however the issue is not considered to be significant.

H.4.12 External Impacts and Constraints

An indication of the likely upstream and downstream external constraints and impacts to and from the intervention are shown in the matrix. However there is insufficient data to adequately address some of these and overall there are too many unknown factors, especially the likely nature of FAP 6 upstream proposals and the possibility of embanking the right bank of the Padma river. However most of the issues would appear unaffected and the main downstream constraint of Meghna main channel water levels, which is the most crucial aspect of the hydrology of the study area, is the very issue that the intervention addresses. Also the modelling has tested a 15 cm rise in Meghna levels at Chandpur and the proposed intervention seems insensitive to changes of this magnitude.

H.4.13 Direct Construction Impacts

The most serious direct construction impacts are likely to be the requirements for land acquisition which has implications for compensation and resettlement needs. These have been outlined in Section 12.4.4 above and the Social Impact Assessment section of the Sociology Annex. The detailed location and design of the deepened khal need to bear these issues in mind so that they are minimised and if possible avoided. Under World Bank Operational Directive 4.30 it is likely that a resettlement and compensation plan will need to be drawn up. However detailed enumeration and asset inventory work is required before this can be done. This is best done using low level enlarged air photography to update cadastral mapping. A detailed asset inventory will need to be done at some stage, but it may be worth doing this in the following study stage, provided a freeze is enforced on all land transfers and new development in the area to be acquired. In addition a socio-economic assessment survey of directly effected households will need to be carried out to formulate a suitable resettlement and compensation strategy. It would also be worth reviewing the land acquisition experiences of the Coastal Embankment Rehabilitation Project (CERP) to see where problems are likely to arise and how they can be adequately dealt with. The whole question of environmental considerations to contractors operations will need to be reviewed once there is a clear idea as to the likely organisation and prioritorisation of the construction programme and the detailed nature of construction technology that is to be used. The present review being carried out of the CERP Phase 1 construction issues will be valuable in doing this.

There are likely to be significant socio-economic benefits offered by the construction works, especially when this is designed as an intrinsic consideration in the planning of the construction programme. If appropriately phased and using labour intensive construction techniques this is likely to provide some 10 000 dry season wage paid jobs over a three year period. The use of Labour Contracting Societies (LCS) has been mentioned above and in the SIA. This could be particularly valuable for disadvantaged groups and when combined with a responsive public participation institutional structure and supervision, could ensure that the work is carried out to a high standard.

H.4.14 Hazard Risk and Sustainability

It must also be pointed that the area is in a medium risk seismic zone, having experienced two severe events in the last 200 years. Such events have occurred during monsoon times when the drainage system has been full and resulted in localised changes in ground levels and gradients. Whilst this is nothing like as severe a constraint as for a flood protection embankment, it is still a consideration for sustainability of the intervention, even if it is an infrequent occurrence. The issue of relative sea level change has been reviewed and the latest work predicts a possible rise of some 0.1m over the next 30 years due to global warming. This level of increase is insignificant in terms of project viability. Seismic activity may have far more serious consequences to relative land and sea levels than global warming.

The other factor that would seem important is sedimentation of the drainage system. It seems that the system has suffered from siltation in the past, although the source of the material would seem to have to come from within the study area. The main cause of this could possibly be field run-off and drainage bank collapse. It is thus imperative that the Khal deepening work is carried out according to the design so that this can be avoided and prevent the need for recurrent desilting of the drainage network. Even so it is planned that an on-going de-silting operation will be needed, and using the FAP Guidelines operation and maintenance procedures it has been estimated that 1 000 people will be needed to achieve this. Whilst this is likely to provide the benefit of regular employment for these people, a workable system of raising this revenue from beneficiaries is required. The record for achieving this in Bangladesh is presently very poor and the institutional arrangement for doing this need to be carefully established. Recommendations are included in Chapter 14 of the Main Report.

There are a whole group of social impacts, particularly those at individual household level which have implications for risk levels to socio-economic livelihoods. The major issues have been discussed in Section H.4.4 and are dealt with in more detail in the Social Impact Assessment in Appendix G of this report. Other household livelihood risks, including those to boat owners, operators and builders, have been mentioned above. The real difficulty is that it is impossible to assess these realistically in detail as there is insufficient data made worse by the fact that much of the 1991 BBS census work is still unavailable. A detailed social impact assessment component with a baseline monitoring survey will be required in any follow-up work to the study.

In overall environmental terms the engineering design of the intervention is relatively robust, and from an energy use point of view it is very sound indeed, effectively harnessing the tidal power of the sea to use it as a ram pump. Its operation has been deliberately designed to be as simple as possible, with the minimum of human intervention so that a predicable water regime results and potential beneficiaries can then have faith in it to invest their resources to use what it has to offer in the most advantageous way for them.

A major issue in terms of economic sustainability is how any intervention programme is to be funded, be it a grant or a loan, how this is to be paid back and whether there is a better alternative use for this money.

H.4.15 Summary of Principal Impacts by Zone

The impact assessment matrix indicates the differentiation of impacts by planning zone. However the boundaries between the zones delineated prior to the results of the mapped outputs of the hydraulic modelling being available. It now appears that the boundaries do not correspond with the likely limits of the flooding areas and intervention areas. The intervention and impact zones are shown in Figure H.3.17 and a brief summary by zone is given below:

Zone A

Zone A presently experiences no major flooding of agricultural land and the intervention does not change this situation. The deepening of Khals ensures that nearly all the area can be irrigated in the dry season from surface sources. There are no flood plain fisheries, and if anything the fisheries should improve slightly as a result of there being water in the drainage system all year. The area has the greatest possible benefits overall, both in terms of agricultural production (67%), the demand for agricultural labour and construction work opportunities. However the zone is likely to require the largest land acquisition area. There has recently been a serious outbreak of malaria in the area which could be exacerbated by increased all year standing water as a result of the intervention. There remains a serious problem of lack of safe domestic water supply provision to much of the zone and this would seem to be a higher development priority for many households rather than irrigation water. The levels of malnutrition amongst young children are high and there has been a recent occurrence of night blindness. These two factors are possibly the result of unbalanced diets which would probably best be overcome by production of a more diverse cropping system and less emphasis being placed on rice production.

Zone B

Zone B is a very mixed area, a considerable part of it being subject to seasonal flooding, most of which, except the very eastern end, will be stopped as a result of the intervention. However this is likely to result in the most serious fish habitat losses to both the natural ecological system, with implications for bio-diversity, and "common good" fisheries resources which also has nutritional implications for poorer households. It is estimated that the floodplain fisheries will be reduced by 81% and up to 9 800 occasional and 700 full and part-time fishing households could be effected. It requires more detailed studies to find out the proportion of registered fishermen who are engaged in pond aquaculture as opposed to capture fisheries and the ease with which the transition from capture to culture fishermen can be made. Despite the fact that the irrigated area is relatively small, the predicted agricultural benefits are 26% most of this is from increased monsoon season cropping. The wage paid labour that this generates could result in increased incomes and the replacement of "common good" capture fisheries by purchased fish produced from pond aquaculture, a situation which already exists in the zone. There is a large part of the zone which, as a result of the intervention, will be dry all year where as it was previously seasonally flooded. However a considerable part of this piece will not have irrigation water supply and will have to rely upon residual moisture and dryland farming systems. In the south of the zone there are some areas where water availability in Khals could be less than in the pre-intervention situation. There has been a serious malaria outbreak in the area and this be exacerbated further by the year round occurrence of standing water.

Zone C

Zone C is, like Zone B, a very mixed area with the eastern 70% of it that is presently floodplain being reduced to some 30% located in the extreme east part. This remaining flood plain area will start to drain earlier than in the pre-intervention situation. When combined with the provision of dry season irrigation water to most of the post-intervention flooded land, agricultural production is predicted to increase by some 25%. This is likely to produce significant demand for agricultural labour as well as a short term demand for construction workers. However the flood plain fisheries losses are estimated to be 62% and it is estimated that up to 7 650 occasional and 2 070 full and part time fishing households will be effected to some degree. Again this depends upon the proportion already involved in culture fisheries. There is one significant part in the north west of the zone which is exceptional, as it is not flooded at present and will not receive irrigation water. It appears there will be few direct benefits to this area and this could be the cause of social friction. The level of water supply provision would seem to be less of a problem here than in other zones and fewer health problems have been recorded.

Zone D

Zone D will experience a 34% reduction in peak flood plain extent as a result of the intervention but only a very small part will be provided with surface irrigation water. The khals in the rest of the area will drain faster and have slightly less mean annual depth of water in them. The losses to the floodplain fisheries system are predicted to be 34% and 32% for the Khal fisheries system. It has been estimated that up to 3 500 occasional and 3 400 full and part time fishing households could be effected to some degree. This again this depends on the degree to which fishing households have already switched into culture fisheries, although the ratio of pond production to floodplain is lowest in Zone D due to the high levels of floodplain production. The fisheries loss could be offset to some degree by the additional labour requirement that the predicted 7% increase in agricultural production is thought to give. There will be little direct construction work in the zone, but it is likely that the demand for construction labour will be high enough that people from Zone D will find it possible to work temporarily in the construction areas in other zones. There are presently poor levels of nutrition in the zone, including night blindness, and the incidence of diarrhoeal diseases is high and could be made slightly worse as a result of the intervention. There would seem to be justification in targeting what benefits that can be gained from mitigation measures to this zone, as it would appear to have the fewest opportunities to take advantage of the intervention.

Adjacent External Areas

The situation in the adjacent external areas is difficult to assess as there is a lack of data and some of the areas are different than others. The intervention results in the lower Dakatia in the north west edge of the study area being made flood free, whereas the peak flood extent is reduced by 30% for the other areas and the mean flooded annual area is reduced by 40% due to shorter duration flooding. The flood plain fisheries are estimated to fall by 14% in the lower Dakatia and 40% in the other external area, a total loss of 737tonnes. No data is available for fishing dependent households nor the significance of other fishing systems.

H.5 IMPACT MITIGATION AND ENVIRONMENTAL MANAGEMENT PLAN

H.5.1 Impact Mitigation

The aim of impact mitigation is to design the interventions to be as environmentally friendly as possible by minimising environmental dis-benefits and maximising benefits. In addition there should be targeted programmes to tackle specific negative impacts in defined places or amongst particular social groups. Another aspect of mitigation is to ensure that the construction phase is sensitive to environmental concerns and also the design of the operation of the intervention allows the identified environmental issues to be addressed. These mitigation measures need to be drawn-up to be sustainable in both environmental and economic terms. The costs of carrying out the measures should be included in the financial analysis of the intervention and be incorporated in the multi-criteria analysis. The environmental mitigation and management work should be formulated into an integrated programme within the framework of an Environmental Management Plan.

The main negative impacts are given in the residual impacts Table H.5.1 with the major issues being shown, by decreasing order of importance, down the left-hand side. This is then followed by quantification and valuation where possible and also the additional data requirement. The possibilities for mitigation measures are shown in the next to last column. Many of the mitigation measures have already been discussed in the previous Section H.4.1, when dealing with the main negative impacts. The main residual impacts are dealt with below in order of priority.

H.5.1.1 Fisheries Losses

It is envisaged that mitigation for the ecological consequences of floodplain reduction on fisheries (the reduction of bio-diversity and its knock on effects) will be very difficult, if not impossible to achieve. It would appear to be an inevitable cost of wishing to increase agricultural production using a drainage and irrigation intervention. The cash loss of the decline in commercial fisheries and the lost wages will be easily offset against the agricultural benefits in cash terms. A targeted fisheries management programme could however go some way to promoting sustainable fish use on the remaining floodplain. However the loss of socio-economic livelihood to professional fishing households could be severe locally and will require a targeted programme for re-training. The most appropriate role would appear to be as pond aquaculture fishermen, as this seems to be happening already in some parts of the study area. However this is a choice for individual household members and all that can be done is to assist in providing a range of sustainable choices of possible options. It may be that many households will choose to take up wage paid agricultural work for irrigated farming. The latter situation is likely to be the case for part-time fishermen. The nutritional consequences of fisheries losses to occasional fishing households could also be mitigated for by taking up the opportunities offered in increased agricultural wage paid labour. This would allow occasional fishing families to earn greater income and use this to purchase fish produced using pond aquaculture. However studies are required on the nature of likely income levels of such wage paid agricultural work and also work in the construction programme.

H.5.1.2 Livelihood Loss Due to Asset Loss Under Permanent Works

The livelihood losses caused by the need for permanent and temporary land acquisition and loss of immovable assets should all be fairly and adequately mitigated for as part of a compensation and resettlement programme. This is a requirement of World Bank Operational Directives and is proposed to be fully addressed in the next phase once detailed enumeration surveys and assets inventories can be carried out. The aim of any resettlement and compensation programme should be to give the effected households the greatest choice in deciding an equivalent replacement alternative livelihood. The implementation of this work will require close liaison with the effected households. It is proposed to do much of this type of work through locally active NGO's.

H.5.1.3 Fuelwood and Grazing

The fuelwood issue is best resolved by instigating a social forestry programme on embankments and at homesteads. It is proposed to do this through an integrated rural development programme led by an NGO. The grazing issue is likely to resolve itself as greater volumes of rice straw are predicted to be produced as a result of agricultural intensification. However this will need a change from grazed animals to stall fed systems and extension services may need to assist in managing this. Provision of power tillers is also likely to help address this issue and overall it is considered that this can be fully mitigated for.

H.5.1.4 Waterborne Diseases

The issue of waterborne disease levels is best addressed by continuing the increased provision of safe drinking water and also improving sanitation. However such provision needs to go hand in hand with a health education programme if it is to be effective. Such a programme could also be done as a component of an integrated rural development programme, and provided there were commitment to this any increased risk to waterborne disease attributable to the intervention could easily be mitigated for.

H.5.1.5 Soil Fertility

With regard to possible soil fertility issues the need is for an appropriate monitoring system with effective feed back responses from this so that any detected problems can be addressed by timely soil, water and agricultural management practices. If this mechanism is in place it should be possible to avoid or mitigate post-project soil fertility problems.

H.5.1.6 Direct Construction Impacts

The question of livelihood loss due to the requirements of land acquisition has been dealt with above. However other issues need to be addressed at appropriate stages of intervention design, construction and management. This is best done by having a permanent environmental perspective to the work and is not a "one off" process. The environmental considerations of a range of intervention options were considered at the Regional Planning Stage and this report tackles the formulation of the proposed intervention. The detailed study and design phase follows, during which detailed engineering design considerations (e.g. fish friendly gate design and operation) can be addressed. The likely nature of detailed construction impacts can also be addressed at this time and if necessary environmental safeguards built into the construction contracts along with appropriated enforcement procedures for these. If tackled with sufficient forethought most of the significant construction impact issues can be avoided and mitigated for at no great financial cost. If handled well and in a timely manner such an approach is likely to save time and money overall.

H.5.2 Environmental Management Plan

It is not possible at the moment to prepare a detailed Environmental Management Plan (EMP) for the proposed intervention. This requires more detailed data and information, particularly concerning accurate estimates of likely quantities of asset loss, compensation and resettlement. The data collection programme for such work is proposed to be covered in the next phase of the study and is indicated in Section H.6.3 and Appendix H.III. The detailed study work will need to be more adequately resourced than the present study if it is to achieve these aims.

H.5.3 Impact Timing

As explained previously a 6 year period has been used for assessment of the likely impacts of the interventions as indicated on the matrices. For the medium term (about 5 years) and longer term (over 10 years) impacts a baseline data collection and monitoring programme is needed. This would specifically need to address the issues of soil chemistry and structure change, medium and longer ecological impacts and also possible socio-economic issues due to agricultural intensification that may arise.

H.5.4 Negative Residual Impacts

Table H.5.1 gives a summary of the major negative environmental issues for the proposed intervention, quantification and valuation of these if possible and details of the proposed mitigation measures. The residual impacts that are thought to be impossible or very difficult to fully mitigate for are shown in the final column. The most significant residual impact would seem to be the ecological losses to the floodplain area. It is envisaged that all other major negative impacts can be mitigated for to a great degree.

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TABLE H.5.1

Residual Negative Impacts

Principal Negative Impacts By Priority	Quantities	Valuation	Mitigation Possibilities	Residual Impacts	Residual Impact Rating
Fisheries Losses:					
- Ecological Consequences	Data needed - difficult	Not possible	Not possible	Yes (esp. in Zone B)	- 2
- Lost Cash Resource (Financial)	3645 tons (internal) 737 tons (external)	Tk 51 million/ Annum + External Value	Partly possible	Some (external areas)	-1
- Nutritional Consequences	25500 HH	Very difficult but possible	Partly possible	Some	-1
Socio-Economic Livelihoods: - Professional Fishermen	4660 HH	Possible - need more data Estimated 90% of Tk 51 million/ Annum	Partly possible	Some likely (external areas)	-1
Direct Construction Impacts:					
- Permanent Land Loss	Estimate 76 ha	- Tk 43.6 million	Possible	None	0
- Temporary Land Loss	3633 ha	Estimate Tk 58 milion	Possible	None	0
Fuel-wood and Grazing Decline	Detailed Data needed	Not yet possible and difficult	Possible	None	0
Waterborne Disease	Data needed	Not possible	Possible	Some in Zone B	0
Soil Fertility	Data needed	Not yet possible and difficult	Management needed	Very little if careful (monitoring)	0
Floodplain Flora and Fauna	Detailed data needed	Possible but difficult	Partly possible	Some	-0.5

H.6 CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK PROGRAMME

H.6.1 Conclusions

The environmental component to the study has attempted to assess the proposed drainage and irrigation intervention to gauge its overall effect on both the natural and human environment. The broad conclusions are that overall the predicted agricultural benefits are high with a 25% increase in rice production. This additional rice production has been valued at TK 351 m/annum and is estimated to provide an extra 4.3million person days of agricultural labour. The main dis-benefits of the intervention are the nearly 50% loss to the floodplain fisheries system which are estimated to be 3645 tonnes within the study area and a further 737 tonnes outside it when compared to a without project situation six years after completion of construction. The value of this lost fisheries production is estimated to be Tk 47.5 m/annum and the loss in fisheries labour is 0.9million person days per annum, (some 21% of the agricultural labour gains due to the intervention). Although the floodplain losses are high in percentage terms, they are predicted to constitute only 34% of the total fisheries production at present and 27% in the comparative without project situation. The major implication of this is the loss of "common good" directly consumed fish to, at the most some 20 850 occasional fishing households. A maximum of some 4 660 full and part-time fishing households are expected to have their livelihoods jeopardised to some degree as a result of the intervention and this represents some 1% of the total study area population. The resulting nutritional losses could be mitigated by targeting the increased wage paid labour to non-farming occasional fishermen, allowing them to earn sufficient cash to buy fish produced by expanded aquaculture programmes that could be targeted to the effected full time fishing households. There is some evidence that this is already happening in one part of the study area, but further, more detailed studies are required on this. Concern must be expressed that the fisheries dis-benefits in Zone D and the immediate adjacent areas may not be fully matched by agricultural benefits in these areas and this could be socially divisive unless mitigation measures are implemented in this zone.

There are likely to be localised issues of land acquisition for permanent construction works, and in all some 76 ha are required for this purpose. In addition land will be required for disposal of excavated spoil, either 457ha permanently or 3633ha temporarily. The latter is slightly more expensive but is in principle to be preferred on socio-economic grounds. The need for land acquisition raises issues of compensation and possible resettlement. Under the World Bank Operational Directive 4.30 a resettlement and compensation plan needs to be drawn up. This requires detailed cadastral, fixed asset and household livelihood surveys so that a resettlement strategy that maximises effected peoples choices, can be drawn up. However the numbers of people that are likely to be effected are very small when compared to the total population of the study area and the estimated number of beneficiaries. It is however vital that this work is carried out in close co-operation with the effected households and that compensation is seen to be fair, equitable and timely.

There are other less serious negative impacts but these do not detract from the major issues which concerns the justification for increasing agricultural production (specifically rice) by some 25% and valued at Tk 351 m at the expense of the Tk 47.5m value of lost fish production. In the process a maximum of 25 500 fish dependent households (some 6% of the population) are likely to be dis-benefitted to some degree, although targeted mitigation programmes could address this to a great extent. The economic analysis also raises the issue of likely changes in future rice prices and if these will remain at the levels used in the financial analysis for the study, especially bearing in mind the recent falls in these due to increased output.

H.6.2 Recommendations

From the impact assessment work carried out so far it can be seen that the intervention has significant predicted increases in agricultural production, and the losses due to dis-benefits, whilst significant to 6 % of the households in the study area, appear to be heavily outweighed by the cash value of the increased agricultural production. With targeted mitigation programmes it is considered that the major dis-benefits can be overcome. However detailed and highly specific follow-up studies are required over a minimum 12 month data collection period to obtain suitable information to address the design of mitigation interventions and provide baseline monitoring data.

The decision to proceed with the following Detailed Design phase of the study therefore is a matter of policy priorities. Should the floodplain fishing system of Noakhali north, which has already been negatively impacted by past FCD/I interventions, be reduced still further to provide increased agricultural production, specifically rice? Based upon the economic analysis it would appear that due to the relatively simple nature of the intervention, along with significant social benefits that could result during its construction, the Noakhali North area seems to present a better place than many in Bangladesh to promote the development of agriculture.

H.6.3 Future Work Programme

H.6.3.1 Data collection programme

Assuming that the proposed intervention is found to be justifiable, then a highly specific programme of detailed data collection is required that addresses the issues raised in this impact assessment. Data needs to be collected and tabulated using newly delineated impact zone boundaries. It is imperative that the 1991 BBS data and SRDI soil chemistry data is made available to the study before it commences. In addition the hydraulic modelling work needs to be refined and interfaced with a Digital Elevation Model to produce automatic computer mapped outputs. The detailed studies need to cover a full 12 month period and include the following components:

- A detailed fisheries study, including a catch assessment concentrating on the flood plain area inside and outside the designated study area. A study of fish migration and species mix in the floodplain area and how this is likely to change as a result of floodplain reduction and changing inundation patterns. A detailed Socio-economic survey of fishing households aimed at trying to ascertain income levels, the degree of dependency on fishing and the split in this between capture and culture fisheries and the trend in this.

- Nutrition surveys particularly concentrated on the occasional fishing households dependent on the floodplain and also targeted households in Zones A and D.

- A detailed field cadastral survey of the areas for permanent land acquisition, plus a full inventory of immovable assets and a household livelihood assessment. A reconnaissance level assessment of temporary land acquisition requirements. This work should provide sufficient data to produce a resettlement planning and compensation strategy.

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

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

- A baseline socio-economic survey to ascertain the future income generation capability of irrigated agriculture and construction operations and aquaculture in the area. The 1991 BBS data is required before this can be designed.

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

- Soil structure and chemistry monitoring in areas of likely irrigation and drainage areas. This will need access to the existing SRDI chemistry data.

- Detailed flora and fauna surveys of all impacted areas.

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

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 OD 4.30.

- Management of stocked Khals in the irrigation area

- Professional Fishermen re-training, probably capture fishermen into pond aquaculture

- Targeted income generation for occasional fishing households aimed at providing sufficient income to purchase replacement protein, probably pond aquaculture fish.

- Targeted income generation programmes for maximising opportunities for wage paid labour from irrigated agriculture and construction employment

- Social forestry programme

- Health programme including water supply, sanitation and health education

- Soil management guidelines

- Flora and fauna management guidelines

A draft set of Terms of Reference for this work are included as Appendix H.III.

APPENDIX H.I

REFERENCES AND BIBLIOGRAPHY

REFERENCES AND BIBLIOGRAPHY

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APPENDIX H.II

LIAISON AND CONTACTS

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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:

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Forestry Master Plan Project

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David Seckler, Director, Center for Economic Policy Studies

Ben Crow, Food Research Institute- Study into rice market at Noakhali

Neptune Commercial and Taher Brothers Ltd (CPP II Contractor)

Faridur Rahman Khan, Chairman

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APPENDIX H.III

DRAFT TERMS OF REFERENCE FOR SUPPORTING STUDIES TO THE DETAILED DESIGN PHASE

DRAFT TERMS OF REFERENCE FOR SUPPORTING STUDIES TO THE DETAILED DESIGN PHASE OF THE NOAKHALI NORTH DRAINAGE AND IRRIGATION PROJECT

1 INTRODUCTION

The aim of this work would be to provide the necessary supporting studies for the Detailed Design Phase of the Noakhali North Drainage and Irrigation Project. This assumes that a decision can be taken to proceed with the Detailed Design of the proposed intervention on the basis of the work carried out for the Noakhali North 1993 Feasibility Study, produced as part of the FAP 5 Regional Study.

The proposed work programme is based upon the conclusions and recommended follow-up work outlined in the Noakhali North 1993 Feasibility Study. It aims to bring the environmental studies to a level when an Environmental Management Plan can be produced which would broadly follow the requirements of World Bank Operational Directive 4.01 and the FAP Environmental Guidelines.

The work would entail a programme of baseline data collection to permit a full impact assessment to be carried out. This would allow for quantification and valuation of impacts and the drawing up of an Environmental Management Plan which would deal with negative impact mitigation and any residual impacts.

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 drainage and resulting irrigation development intervention is found to be justifiable and the decision is taken to proceed with the Detailed Design phase, then a highly specific and suitably phased programme of detailed data collection is required to addresses the issues raised in the Feasibility Study environmental assessment. The interpretation of the baseline data for impact assessment purposes will require the hydraulic modelling of the intervention to be refined and also interfaced to a Digital Elevation Model (DEM) to automatically produce mapped outputs. Data needs to be collected and tabulated using the newly delineated impact zone boundaries, including extending the study area to the full limit of the modelled impact area. In addition it is imperative that the 1991 BBS census data is made available to the study and access is given to the SRDI detailed soil data for the area. The data collection period for the detailed studies needs to cover, at the minimum, a full 12 month yearly cycle. In addition the results of the national supporting studies for the Flood Action Plan need to be made available so that wider issues can be addressed, particularly concerning fisheries, nutrition and waterborne diseases. Even so it may still be the case that there will be insufficient information to give useable trend data for these issues. The detailed studies need to include the following components:

- A detailed fisheries study, including a catch assessment concentrating on the flood plain area inside and outside the designated study area. A study of fish migration and species mix in the floodplain area and how this is likely to change as a result of floodplain reduction and changing inundation patterns. A detailed Socio-economic survey of fishing households aimed at trying to ascertain income levels, the degree of dependency on fishing and the split in this between capture and culture fisheries and the trend in this.

- Nutrition surveys particularly concentrated on the occasional fishing households dependent on the floodplain and also targeted households in Zones A and D.

- A detailed field cadastral survey of the areas for permanent land acquisition, plus a full inventory of immovable assets and a household livelihood assessment. A reconnaissance level assessment of temporary land acquisition requirements. This work should provide sufficient data to produce a resettlement planning and compensation strategy.

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

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

- A baseline socio-economic survey to ascertain the future income generation capability of irrigated agriculture and construction operations and aquaculture in the area. The 1991 BBS data is required before this can be designed.

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

- Soil structure and chemistry monitoring in areas of likely irrigation and drainage areas. This will need access to the existing SRDI chemistry data.

- Detailed flora and fauna surveys of all directly impacted areas, specifically the Khals and drains that are likely to be stripped of all vegetation as a result of remodelling.

In addition a review of the likely direct detailed construction impacts will need to be carried out, bearing in mind the engineering design, nature of construction contract and the experience with the BWDB implemented Coastal Embankment Rehabilitation Project.

3 ENVIRONMENTAL MANAGEMENT PLAN

The above data will need to be collected so that the following issues can be addressed in the next stage of the study and form the basis for an Environmental Management Plan:

- Land acquisition, compensation and resettlement plan under OD 4.30.
- Management of stocked Khals in the irrigation area
- Professional Fishermen re-training, probably capture fishermen into pond aquaculture
- Targeted income generation for occasional fishing households aimed at providing sufficient income to purchase replacement protein, probably pond aquaculture fish.
- Targeted income generation programmes for maximising opportunities for wage paid labour from irrigated agriculture and construction employment
- Social forestry programme
- Health programme including water supply, sanitation and health education
- Soil management guidelines
- Flora and fauna management guidelines

The aim of the Environmental Management Plan is to draw up a self-sustaining programme of targeted interventions that address the mitigation and minimisation of the likely negative impacts of the intervention. The capital costs of these would normally be included as part of the project costs but would be designed to be economically self-sustaining and require no on-going continuous need for funding.

4 STAFFING

It is envisaged that the studies will be an integrated programme to ensure full interaction between all elements. Many of the staff would in any case be required to apply their discipline to a wide variety of issues. It is estimated that the following staff disciplines/expertise will be need to be covered in order to carry out the work:

- Environmental Planning and Management
- Hydraulic Modelling
- Fisheries
- Health and Nutrition
- Resettlement Specialist
- Socio-Economics and Environmental Economics
- Soil and Land Resources
- Ecology (both aquatic and terrestrial)
- Social Forestry
- Water Quality Chemistry

It has been estimated that the total programme will require in the order of 45 foreign specialist person months of input along with 90 local person months. Of these, the fisheries studies will probably require in the order of 15 person months of foreign specialist staff inputs and 36 person months of local staff inputs. The division of these by discipline will depend on the specific staff proposed, as some may be able to cover more than one specialisation. The proposed supporting studies work is in addition to that proposed for the engineering component of the Detailed Design phase, the latter of which includes a full cadastral and fixed asset survey.

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APPENDIX H.IV

HEALTH AND NUTRITION CONSULTANTS REPORT

APPENDIX H.IV

HEALTH AND NUTRITION STUDY

The widespread public health problems of the country and the unacceptably high rates of acute and chromic undernutrition are also prevalent in the Noakhali project. Focusing on the prevalence of waterborne diseases (diarrhoea, dysentery, cholera and skin disease), malaria, Kalazar (Leishmaniasis) and nutrition disorders which might he 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)	Noakhali project area This study
Diarrhoea	4.57 (Dec., 1990)	3
Night blindness	1.0% (Oct., 1992)	1.3%
Chronic undernutrition among children (stunting)	69.7% (Oct., 1992)	70%
Acute undernutrition among children (wasting)	17.6% (Oct., 1992)	17.9%

However the study found pockets of high prevailing Dysentery. No Kalazar cases are reported by the GOB health MIS system.

Use rates of Tube well water and Sanitary latrines in the project area are much higher than the national use rate. 99% of households use tube well water for drinking and 4.8% for washing purposes. 24% households 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 and vitamin B deficiencies), Diarrhoeal and skin diseases. Study findings area presented by zone in tabular form.

Table H.IV.1 presented landholding by the households interviewed from the four zones, their number and percentages in different categories. Zone B and C appeared to be better off areas with less landless families (about 30%). The land capability association study also depicted availability of good (class II) and of good and moderate (class II and III) respectively agriculture land in the sample area under Noakhali Sadar, Begumganj and Lakshmipur Sadar thanas. The zone D sample has over 75% household either landless or with land below 0.5 acres (not confirmed by census data).

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TABLE H.IV.1

Households' Landholding Zone Wise

Zones		Landless	Upto 0.5 Acres	0.51-1.5 Acres	1.51-2.5 Acres	2.51-5.0 Acres	Above 5 Acres
A	No.	26	16	12	05	07	05
	%	36.6%	22.5%	16.9%	7.0%	09.9%	07.0%
B	No.	17	12	14	11	03	03
	%	28.3%	20.0%	23.3%	11.3%	4.9%	5.0%
C	No.	15	16	16	04	02	02
	%	27.3%	29.1%	29.1%	7.3%	3.6%	03.6%
D	No.	34	14	11	00	01	04
	%	53.1%	21.9%	17.2%	00.0%	1.5%	6.3%

Table H.IV.2 shows the use of water from different sources for drinking, washing and bathing purposes. Overall use of tube well water for drinking purposes in the project area is higher than the national norm. However it is noticed that some 1.67% and 1.56% population from zone B and D are using pond water for drinking respectively.

TABLE H.IV.2

Source of Drinking, Washing and Bathing Water for the Households

Zones	Drinking Water Source				Water Source for Washing #				Water Source for Bathing ##			
	Tubewell %	River %	Pond %	Khal %	Tubewell %	River %	Pond %	Khal %	Tubewell %	River %	Pond %	Khal %
A	100.00	0	0.0	0	04.23	0	95.71	0	00.00	0	100.0	0
B	98.33	0	1.67	0	03.33	0	96.67	0	00.00	0	100.0	0
C	100.00	0	0.0	0	07.29	0	92.73	0	01.82	0	98.18	0
D	98.44	0	1.56	0	04.69	0	95.31	0	00.00	0	100.0	0

Note:

Some households using multiple source of water for washing

Some households using multiple source of water for bathing.

Table H.IV.3 presents the doctor's examination results (point prevalence) of some common diseases among the surveyed 540 children in the four zones. Night blindness and anemia are caused due to lack of vitamin A and B nutrient deficiencies. High prevalence of these two common nutrient deficiencies; night blindness (2.03%) anemia (34.46%) are found among the under five years population in zone D area.

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

TABLE H.IV.3

Point Prevalence of Common Disease Among Children < 5 years of Age

Zones	Night Blindness	Angular Stomatitis	Anemia	Oedema
A	0.62%	30.86%	25.31%	1.85%
B	0.85%	12.71%	02.54%	0.85%
C	0.89%	32.14%	12.50%	2.68%
D	2.03%	27.70%	34.46%	1.35%
Overall	1.3%	27.2%	20.4%	2.04%

250 households were surveyed and the disease profiles of their 1562 members were asked. Table H.IV.4 presents the sicknesses at the time of the survey. Diarrhoea in general and night blindness among children under 15 years were found at a higher rate in zone C and D villages. A higher rate (2.07%) of malaria in zone A and Scabies (21.72%) in zone B were noticed.

TABLE H.IV.4

Common Diseases in the Surveyed Households.
Percentage of Population Currently Suffering (Point Prevalence)

Zones	Diarrhoea	Dysentery	Malaria	Scabies	XN
A	0.23%	3.23%	2.07%	13.13%	0.46%
B	0.00%	3.92%	2.02%	21.72%	1.52%
C	1.78%	3.25%	0.89%	19.53%	0.30%
D	0.49%	5.67%	1.23%	13.79%	2.22%

Table H.IV.5 shows the use of water sealed latrines in the four zones. The use rate of sanitary latrine in the project area being higher than the national figure (7%) except in zone B (5%).

TABLE H.IV.5

Use of Water Sealed Latrine by the Households

Area	Having Water Sealed Latrine		Using Water Sealed Latrine	
	#	%	#	%
Zone - A	10	14.08	05	07.04
Zone - B	08	13.33	03	05.00
Zone - C	27	49.09	15	27.27
Zone - D	17	26.57	09	14.06

Table H.IV.6 presents the results of the anthropometric measurement of the 540 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 B.

TABLE H.IV.6

Nutritional Status of Children < 5 Years of Age

Zones	Wt/Age < 60%	Wt/Ht < 80%	Ht/Age < 90%	MUAC < 12.5%0
A	22.22	72.84	12.96	40.74
B	13.56	71.19	10.17	39.83
C	17.86	58.93	08.93	25.89
D	17.57	77.70	03.38	35.14

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 mention intake of dal (pulse), meat, fish and dry fish during their last meal, in the last three days and the last week. Table H.IV.7 presents percentage of households from the four zones responding under each category.

TABLE H.IV.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	23	24	35	06	07	24	35	38	21	10	13	20
Zone B	15	28	38	03	03	12	43	37	17	07	12	10
Zone C	24	29	36	07	09	35	53	40	04	00	00	16
Zone D	11	24	34	00	05	22	53	28	13	02	08	09

As regards meat, households of zone B reported a very low intake. Only 12% of the households from this zone consumed meat during last week as against 22% - 35.% form other zones. Though consumption of Dal a cheap source of protein is also very low in our study area. Only 34% - 38% of the households took Dal during the previous week.

Fish and vegetables were the main food items consumed in addition to a staple grain. Fish was the leading source of protein. Around 50% of households reported consumption of fish during the last meal.

Regular consumption of vegetable is quite high in the project area. 96% of the households from zone A, 97% from zone B, 98% from zone C and 98% from zone D reported regular consumption of vegetables.

Table H.IV.8 projects the source of fish for the households studied. Fishes area mostly purchased from the market. In zone B about 40% of households have fish from their own pond with only 10% and 3% respectively from zone A and C.

TABLE H.IV.8

Source of Fish by Household

Area	Own Pond		Market		Khal	
	No.	%	No.	%	No.	%
Zone - A	07	10.00	59	84.29	04	05.71
Zone - B	24	39.99	35	58.33	01	01.69
Zone - C	02	03.63	51	92.73	01	01.82
Zone - D	02	03.13	57	89.06	02	03.13

Table H.IV.9 shows the source of dry fish. Like fresh fish, most dry fish was also purchased from the market. Zone A (42.2%) and D (26.6%) have higher dependency on market source. 15% from zone B have home dried dry fish.

TABLE H.IV.9

Source of Dry Fish by Household

Area	Home Dried		Market	
	#	%	#	%
Zone - A	00	00.00	30	42.25
Zone - B	09	14.99	13	21.67
Zone - C	00	00.00	09	16.36
Zone - D	00	00.00	17	26.56

Table H.IV.10 shows that most households have to purchase Dal from market while a very insignificant number of houses (1.82% and 1.56% in zone C and D respectively) get dal from their own field.

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

TABLE H.IV.10

Source of Dal by Household

Area	Home Field		Market	
	#	%	#	%
Zone - A	00	00.00	64	91.43
Zone - B	00	00.00	58	96.67
Zone - C	01	01.82	51	92.73
Zone - D	01	01.56	61	95.31

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APPENDIX H.V

WATER QUALITY CONSULTANTS REPORT

APPENDIX H.V

WATER QUALITY CONSULTANTS REPORT

1. INTRODUCTION

Noakhali North Project lies on the east bank of the river Meghna and is bounded by the river Dakatia on the north. This project has an extensive waterways system including the two major rivers - Meghna and Dakatia, a number of natural and man-made khals such as Noakhali Khal, Rahmatkhali Khal, Oder Khal, Kamta Khal, etc. beels, ponds and tanks. In addition, Laksham depression and Begumganj depression along with internal flood lands and charlands constitute a reasonable area of seasonal water bodies within the project area. The major water related problems of Noakhali North Project are in the field of agriculture and health. Flood in the monsoon season, insufficient water in the dry season and sea water intrusion high salinity in the surface water as well as in the ground water are the main constraints for agricultural production. The main health problem is the bacterial water pollution which causes thousands of lives almost every year in the southern Bangladesh in different water borne diseases like cholera, diarrhoea, dysentery, etc.

2. REVIEW OF DATA

Department of Environment, Government of Bangladesh has been monitoring water quality for 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, 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 the Meghna river water at 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, no information is available on the water quality of Dakatia river and other surface water channels such as Noakhali khal, Rahmatkhali khal, Oder Khal, Aral Beel, different flood lands, ponds, tanks, etc. of the Noakhali North project area.

3. WORK PROGRAMME

This work programme aims at water quality study for the lower Meghna and Dakatia rivers in the upstream and downstream areas, khals inside and outside the embankment, confluences of rivers and khals, beels, flood lands, ponds, tanks, etc. A total number of twenty water bodies, as listed in Table H.V.1 and Table H.V.2, were included for this study. Exact location of all the water bodies and project area for the Noakhali North study are shown in the Figure H.V.1. Water samples were collected from all the sampling sites during the months of October and November and then analysed for parameters as in Table H.V.1 for wet season data. Seasonal variation was also measured for some selected water bodies by collecting another set of samples during the months of February and March from exactly the same locations and analysing the parameters as in Table H.V.2 for dry season data.

TABLE II.V.1

Spreadsheet for Wet Season (Oct.–Nov.) Water Quality of Noakhali North Project

Sl. No.	Name of the Water Body	Sample Code	Description	Date/ Time	Temperature degree C	pH	DO mg/L	CO2 mg/L	CaC03 mg/L	CHEMICAL ANALYSIS 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	MICROBIOLOGICAL ANALYSIS Total Coliform n/100 mL	Faecal Caliform n/100 mL	Total Bacterial Count/ml	RESIDUAL PESTICIDES ANALYSIS DDT µg/L	DDE µg/L
1.	Gabua Beel (Flood land)	6	Stagnant water; Greenish brown colour; Floated algae partly; Sunny morning.	10.11.92 09:40 Hrs.	26.5	7.4	12	10	50	13	0.25	0.05	1.2	0.68	6	1.3	0.18	90	200	50	>1000	?	?
2.	Datta Dighi (Pond)	7	Stagnant water; Greenish brown colour; Domestic use; Sunny day.	10.11.92 10:10 Hrs.	28	7.3	11.5	7	15	10.5	0.7	0.01	10	2	29	0.82	0.71	100	2450	1300	>1000	?	?
3.	Noakhali Khal	8	Stagnant water; Brown colour; Very turbid; Water hyacinth partly; Sunny day.	10.11.92 10:30 Hrs.	26.5	7.9	11	26	408	11	0.75	0.05	34.4	2.7	31.8	61	1	1600	150	100	>1000	?	?
4.	Masjid Pond	9	Stagnant water; Deep greenish brown colour; Domestic use; Sunny day.	10.11.92 11:15 Hrs.	28	7.6	9	15	47	9	1.2	0.01	5.6	3	12.5	1.2	1.4	140	4100	3250	>1000	?	?
5.	Oder Khal	10	Slowly running water; Brown colour; Slightly turbid; Sunny day.	10.11.92 13:10 Hrs.	29	8.2	11.5	22	204	7.5	0.95	0.05	11.2	3.2	6.3	3.3	1.4	600	800	600	>1000	?	?
6.	Noakhali Khal	5	Slowly running water; Pale brown colour; Submerzed vegetation; Water hyacinth; Sunny morning	12.11.92 07:30 Hrs.	26	7.4	11	15	118	10	0.35	0.02	6.4	1.2	19.6	2.5	0.41	450	1800	1450	>1000	?	?
7.	Meghna River	11	Running water; Pale brown colour; Navigation use; Sunny day.	12.11.92 09:30 Hrs.	27	8	12	12	68	9	1.2	0.01	30.4	1	8.2	2.2	0.7	60	750	550	>1000	?	?
8.	Chokidar Dogi (Flood land)	13	Stagnant water; Pale browsn colour; Floated algae; Submerzed vegetation; Sunny morning.	12.11.92 11:00 Hrs.	28	7.3	11.5	11	85	6	0.6	<0.01	2.8	1.3	15.1	1.2	0.75	200	1450	1100	>1000	?	?
9.	Dohadar Dogi (Flood Land)	12	Stagnant water; Pale brown colour; Covered with paddy field; Completely dries in mid Jan.; Sunny day.	12.11.92 11:50 Hrs.	28.5	7.7	7	26	204	10	0.45	<0.01	14.4	1.1	15.7	2	0.74	270	450	320	>1000	?	?
10.	Rahmatkhali Khal	14	Slowly running water; Blackish brown colour; Covered with water hyacinth; Sunny day.	12.11.92 12:30 Hrs.	26	7	6.5	22	136	3.5	0.95	0.02	6.8	1.9	17.6	0.82	0.6	350	10400	2400	>1000	?	?
11.	East Kazir Khil Dighi (Pond)	16	Stagnant water; Greenish brown colour; Red algae partly; Domestic use; Sunny day.	16.11.92 13:40 Hrs.	28	7.6	13.5	8	35	14.5	2.7	<0.01	9.6	2.6	3.4	2.8	0.23	40	2150	1600	>1000	?	?
12.	Ramgonj Khal	17	Slowly running water; Pale brown colour; Water hyacinth partly; Domestic use; Partly Cloudy weather.	16.11.92 14:15 Hrs.	25.5	7.6	10	26	152	10	3.2	0.03	26.4	5.1	1	0.82	0.1	160	6000	1250	>1000	?	?
13.	Dakatia River	19	Slowly running water; Deep green colour; Water hyacinth partly; Navigation use; Cloudy afternoon.	16.11.92 16:40 Hrs.	25	7.2	9.5	11	48	3.3	3.7	0.01	10.8	1.8	8	1.3	0.23	110	3200	2700	>1000	?	?
14.	Aral Beel	18	Stagnant water; Deep brown colour; Water hyacinth mostly; Cloudy evening.	16.11.92 17:20 Hrs.	23	7	9	18	46	11	1.8	<0.01	21.6	0.75	4.5	1.7	0.1	70	5100	4250	>1000	?	?
15.	Meghna River	20	Running water; Pale green colour. Water hyacinth partly; Navigation use; Sunny morning.	17.11.92 07:15 Hrs.	25.5	7.8	12	7	65	3	3.4	<0.01	29.2	1.7	3	5.1	0.18	40	3050	2400	>1000	?	?
16.	Birendra Khal	15	Stagnant water; Blackish brown colour; Covered with hyacinth; Animals slaughtering site; Cloudy morning.	18.11.92 10:00 Hrs.	22	6.9	5	24	66	3	0.45	<0.01	5.6	2.7	6.1	0.49	1.5	60	1100	300	>1000	?	?
17.	Nather Petua Shajir Dighi (Pond)	4	Stagnant water; Pale green colour; Water hyacinth partly; Domestic use; Cloudy day.	18.11.92 11:10 Hrs.	24	7	10	13	30	3	1.8	0.01	8	1.1	10.3	0.99	0.2	36	2600	1750	>1000	?	?
18.	Confluence of Dakatia River and Laksham Khal	1	Running water; Pale green colour; Water hyacinth partly; Slightly turbid; Cloudy afternoon.	18.11.92 13:30 Hrs.	24	7.6	10.5	22	86	3	0.25	0.04	29.6	4.7	3.8	1.8	0.31	50	38000	13000	>1000	?	?
19.	Nateshor Dighi (Pond)	2	Stagnmant water; Green colour; Fishing pond; Water hyacinth partly; Cloudy afternoon.	18.11.92 15:40 Hrs.	24.5	6.6	10.5	6	15	5	0.9	<0.01	5.6	0.96	2.7	1.7	0.12	40	2100	1300	>1000	?	?
20.	Uttorer Dogi (Flood land)	3	Stagnmant water; Pale brown colour; Partly covered with paddy field; Floated algae; Fogy morning.	19.11.92 07:00 Hrs.	21.5	6.9	8	11	30	6	0.2	0.01	14.4	2	6.9	1.7	0.62	25	20000	7200	>1000	0.0196	0.00046
	ENVIRONMENTAL QUALITY STANDARDS 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; C02 = Carbon-di-Oxide; Nacl = Sodium Chloride; DDT = Dichloro Diphenyl Trichloroethane; DDE = Dichloro Diphenyl Ethylene Dichloride; NYS = Not Yet Settled.

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TABLE II.V.2

Spread Sheet for Dry Season (Feb.–Mar.) Water Quality of Noakhali North Project

Sl. No.	Name of the Water Body	Sample Code	Description	Date/ Time	Temperature 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/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.	Gabua Beel (Pond)	6	Mostly dry and irrigated.	21.02.93 14:18 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
2.	Datta Dighi (Pond)	7	Stagnant water; Deep brown colour; Domestic use; Sunny morning.	24.02.93 09:45 Hrs.	22.6	7.2	12	10	103	35	?	?	?	?	?	?	?	?	85	8000	7000	>1000	?	?
3.	Noakhali Khal	8	Stagnant water; Pale brown colour; No tidal effect since two months; Cloudy day.	21.02.93 11:45 Hrs.	25	7.8	12	13	3010	512	4	0.8	0.05	12	15.2	26.8	166	0.12	1870	42000	30000	>1000	?	?
4.	Masjid Pond	9	Stagnant water; Greenish brown colour; Partly cloudy day.	21.02.93 10:55 Hrs.	25	7.7	11	9	261	62	?	?	?	?	?	?	?	?	168	22000	16000	>1000	?	?
5.	Oder Khal	10	Stagnant water; Brown colour; Sunny morning.	21.02.93 08:40 Hrs.	22.2	7.7	12	11	2280	393	?	?	?	?	?	?	?	?	1260	27000	12000	>1000	?	?
6.	Noakhali Khal	5	Stagnant water; Deep brown colour; Partly turbid; Hyacinth partly; Cloudy day.	21.02.93 13:10 Hrs.	24.5	7.7	11.5	15	2520	411	3	1	?	?	?	?	?	?	1455	12000	9000	>1000	?	?
7.	Meghna River	11	Running water; Pale green colour; Sunny morning.	26.02.93 09:20 Hrs.	23.5	8.1	12.5	10	184	103	3.5	2.6	?	?	3.5	15.5	?	?	70	120	90	>1000	?	?
8.	Chokidar Dogi (Flood land)	13	Completely dry & irrigated.	26.02.93 12:18 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
9.	Dohadar Dogi (Flood Land)	12	Completely dry & irrigated.	26.02.93 13:40 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
10.	Rahmatkhali Khal	14	Stagnant water; Blackish brown colour; Water hyacinth; Sunny morning.	26.02.93 11:00 Hrs.	25	7.6	10.5	30	1683	380	7	0.55	?	?	?	?	29.5	?	930	10000	8000	>1000	?	?
11.	East Kazir Khil Dighi (Pond)	16	Stagnant water; Deep brown colour; Domestic use; Sunny day.	24.02.93 13:20 Hrs.	27	8.6	14	5	54	22	4	?	0.01	?	3.6	?	?	?	70	2000	1000	>1000	?	?
12.	Ramgonj Khal	17	Stagnant water; Deep brown colour; Hyacinth mostly; Sunny day.	24.02.93 13:45 Hrs.	23	7.4	11	28	650	220	?	1.4	?	?	?	?	?	?	314	9000	9000	>1000	?	?
13.	Dakatia River	19	Slowly running water; Pale green colour; Hyacinth partly; Sunny day.	19.02.93 12:50 Hrs.	28.3	7.5	11	16	198	103	4	2	<0.01	19.2	4.4	20.2	14.7	0.1	84	16000	5000	>1000	?	?
14.	Aral Beel	18	Completely dry.	19.02.93 13:22 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
15.	Meghna River	20	Running water; Pale green colour. Navigation use; Sunny day.	19.02.93 14:30 Hrs.	25.5	8	11.5	10	175	100	7.5	1.9	<0.01	18.8	13.8	10.7	17.6	0.08	66	10000	6000	>1000	?	?
16.	Birendra Khal	15	Stagnant water; Deep Blackish brown colour; Water hyacinth; Sunny day.	24.02.93 12:10 Hrs.	22	7.1	8	35	777	223	?	?	?	?	28.7	?	9.3	2.1	335	36000	25000	>1000	?	?
17.	Nather Petua Dighi (Pond)	4	Stagnant water; Pale green colour; Water hyacinth; Sunny day.	24.02.93 11:00 Hrs.	22.5	7	11	10	72	36	3.5	1.2	<0.01	6.8	0.92	29	3.8	0.4	70	250000	200000	>1000	?	?
18.	Confluence of Dakatia River and Laksham Khal	1	Stagnant water; Grey colour; Partly turbid; Sunny morning.	19.02.93 08:45 Hrs.	25	7.5	10.5	12	246	68	6	4.2	0.02	58	9.1	17.1	16.7	3.6	136	135000	93000	>1000	?	?
19.	Nateshor Dighi	2	Stagnmant water; Pale green colour; Water hyacinth; Fishing pond; Sunny day.	19.02.93 11:20 Hrs.	27	6.5	12	7	19	15	?	?	?	?	?	?	?	?	42	35000	17000	>1000	?	?
20.	Uttorer Dogi (Flood land)	3	Completely dry & irrigated.	24.02.93 11:40 Hrs.	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
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	750	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; C02 = Carbon–di–Oxide; EC = Electrical Conductivity; CaCo3 = Calcium Carbonate; Nacl = Sodium Chloride; DDT = Dichloro Diphenyi Trichloroethane; DDE = Dichloro Diphenyl Ethylene Dichloride; NYS = Not Yet Settled.

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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. sheets was used for this purpose. All collected samples were filled in 1L polyethylene bottles except those for organochlorine pesticides analysis where 1L amber glass bottles were used. Standard washing procedure (WHO, 1987) was followed for cleaning sample bottles before filling with 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 zinc, potassium 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 CaC03 and NaCl was completed following EDTA and silver nitrate titrimetric method, 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, Saver using PU 4500 gas chromatography (DFG, 1987).

5. RESULTS AND DISCUSSION

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

Results of temperature measurement for the wet season and dry season varied from 21.5^0C to 29^0C and 22^0C to 28.3^0C, respectively and all recorded figures were within standard limit of 20^0C to 30^0C.

Wet season data for pH measurements showed that Meghna river water and two khals water from the southern part of the project area (codes 8 and 10) had pH values greater than 7.7. Higher pH for the Meghna river was quite expected and those for Noakhali Khal (Code 8) and Oder Khal (code 10) might have influenced by the sea water from the coast. Ph for other water bodies, except sample codes 2,3 and 15, ranged in between 7 and 7.7 showing slightly alkaline trend in nature. Water samples from Uttorer Dogi (code 3), Nateshor Dighi (code 2) and Birendra khal (code 15) were slightly acidic (pH <7). Data for dry season varied from 7 to 8.6 except in case of code 2 where it was measured 6.5. However, none of the recorded values exceeded the limit for recreational water standard of 6 to 9.5.

Dissolved oxygen (DO) for beel/flood land, pond/tank and river/khal waters varied from 7 mg/L to 12 mg/L, 9 mg/L to 13.5 mg./2 and 5 mg/L to 12 mg/L, respectively during wet season and all the determined values, except that for sample code 15, are well above the standard limit of 4-5 mg/L. Lower DO (5 mg/L) for sample code 15 might be due to presence of organic matter and insufficient saturation of atmospheric oxygen into this khal water. It was found during field visit that organic wastes such as blood, dunk, etc. from an animal slaughtering site was dumped into Birendra khal water and this sampling site was mostly covered with water hyacinth. Data for dry season indicated increased DO for almost all locations and varied from 11 mg/L to 14 mg/L and 8 mg/L to 12.5 mg/L for the pond and river waters, respectively.

Measurements for free carbon-di-oxide showed wide variations in all water bodies during both wet season (6 mg/L to 26 mg/L) and dry season (5 mg/L to 35 mg/L) and most of the experimental values were high enough compared to 6 mg/L of fishing water standard.

Electrical conductivity (EC) was measured only for dry season and results of measurement as shown in Table H.V.2 indicates lower values for rivers (175 μS/cm - 246 μS/cm) and ponds (19 μS/cm - 261 μS/cm) in comparison to 500 μS/cm of recreational water standard. But in case of all khal waters a higher trend in EC measurement is observed. Among all khal water samples, those from the Noakhali khal (sample codes 5 and 8) exhibited 4-5 times higher EC than the standard value. Rahmatkhali khal (code 14) and Oder khal (code 10) also showed 3.3 times and 4.5 times higher values, respectively. In case of Ramganj khal (code 17) and Birendra khal (code 15) it was just above the standard. Sea water inlet at the time of high tide and gradual evaporation during dry season might be the main reasons for higher EC in these khal waters.

Calcium carbonate (CaC03) concentration in pond waters ranged from 15 mg/L to 47 mg/L and 15 mg/L to 62 mg/L for wet season and dry season, respectively and these data predicted an average soft water quality in all these water bodies. Data for beel and flood lands for wet season varied from 30 mg/L to 85 mg/L except in case of sample code 12 where it was measured abnormally high (204 mg/L). Comparison of data between sample codes 12 and 13 revealed that flood land water outside the embankment was very hard (CaC03 >180 mg/L) whereas that inside the embankment was medium-hard (61 mg/L - 120 mg/L CaCo3). Water quality for the rest beels and flood lands was soft (CaC03 <60 mg/L). Data for river waters showed that CaC03 content varied from 48 mg/L to 86 mg/L and 68 mg/L to 103 mg/L for wet season and dry season, respectively indicating soft to medium-hard water in these rivers. But in case of khal waters higher concentrations ranging from 66 mg/L to 408 mg/L for wet season and 220 mg/L to 512 mg/L for dry season were recorded. Average water quality for these khals was hard and very-hard in nature during wet season and dry season, respectively.

Results of wet season nitrate determination showed that beels and flood lands had an average concentration of 9.2 mg/L which is approximately one fifth of Bangladesh drinking water standard (10 mg/L nitrate N i.e., 45 mg/L nitrate). Pond/tank and river/khal waters also showed lower average concentrations than the standard value. Data for dry season ranged in between 3 mg/L and 7.5 mg/L for the pond and river waters indicating both increasing and decreasing trends in nitrate value from wet season results. Water samples from the Noakhali khal (code 8), Datta Dighi (code 7), Gabua Beel (code 6) and those from the north-western region (codes 16 and 18) showed comparatively higher nitrate concentrations than the others.

Phosphate concentration is beel, pond and river waters varied from 0.2 mg/L to 1.8 mg/L, 0.7 mg/L to 2.7 mg/L and 0.25 mg/L to 3.7 mg/L respectively during wet season. Maximum value was recorded for the downstream of Dakatia river (code 19) whereas minimum was observed for Uttorer Dogi (code 3). Average concentration for the beels and flood lands was calculated 0.66 mg/L which is approximately one ninth of the recreational water standard of 6 mg/L. Pond and river waters also showed one fourth average concentrations. Confluence of Dakatia River and Laksham khal (code 1) exhibited the highest phosphate concentration (4.2 mg/L) during dry season. However, no one of the measured data satisfied with the standard concentration of 6 mg/L.

Wet season results for iodine measurements showed very low levels of iodine (<0.01 mg/L to 0.01 mg/L) for the beel and pond waters with the exception of Gabua Beel (code 6) which contained unexpectedly higher amount of 0.05 mg/L. Meghna river in the upstream area (code 20) and Birendra khal (code 15) also showed very low levels (0.01 mg/L of iodine). But in case of other rivers and khals slightly higher concentrations were observed with an average value of 0.02 mg/L for rivers and 0.03 mg/L for khals. Among all rivers and khals, those located outside the embankment (codes 8 and 10) exhibited maximum levels of iodine (0.05 mg/L). Dry season results for rivers and khals did not show any increase in iodine concentration which was expected due to evaporation effect. Rather iodine levels decreased for sample codes 1 and 19, and remained same for the other two locations with codes 8 and 20.

Pond waters contained very low amount of silica during both wet season (5.6 mg/L to 10 mg/L) and dry season (6-8 mg/L. Silica content for beel and flood land waters was also low (1.2 mg/L - 21.6 mg/L). But river and khal waters showed usually higher values. Average concentration during wet season and dry season was 19.08 mg/L and 27 mg/L, respectively. Noakhali khal (code 8) showed the maximum concentration (34.4 mg/L) during wet season whereas confluence of Dakatia River and Laksham khal (code 1) had the highest value (58 mg/L) during dry season.

Results of potassium determination for the wet season varied from 0.68 mg/L to 2 mg/L, 0.96 mg/L to 3 mg/L and 1 mg/L to 5.1 mg/L for beel, pond and river water samples, respectively. All these determined values were less than drinking water standard of 12 mg/L and average concentrations in beds, ponds and rivers were calculated as one tenth, one sixth and one fifth of the standard value, respectively Data for dry season showed increased potassium concentration in all rivers and khals. Potassium content in Noakhali khal (code 8), Meghna River (code 20) and Confluence of Dakatia River and Laksham khal (code 1) closely approximated the drinking water standard. Birendra khal (code 15) showed unusually higher concentration of 28.7 mg/L, whereas the Dakatia River (code 19) and Meghna River (code 11) showed lower values (<5 mg/L). It is evident from all these data that all the studied water bodies were very poor in potassium content except two khals and two rivers (codes 1,8,15 and 20)during dry season.

Wet season data for zinc varied widely in all water bodies ranging from 1 μg/L to 31.8 μg/L. Maximum and minimum zinc concentrations were measured for the Noakhali khal (code 8) and Ramgonj khal (code 17), respectively. Comparison of average zinc concentrations showed that pond waters had slightly higher values of 11.5 μg/L than the beel (9.6 μg/L) and river (10.5 μg/L) waters. Data for dry season showed increased zinc concentrations in almost all cases and varied in between 10.7 μg/L to 29 μg/L with the maximum value recorded for Nather Petua shahjir Dighi (code 4). However, all the measured zinc concentrations were far below from the drinking water standard (5000 μg/L) for Bangladesh and these facts predicted very poor water quality in terms of zinc as a micro nutrient in all the water bodies.

Sulphate in beel and pond water was measured very low (average 1.7 mg/L) in comparison to 400 mg/L of drinking water standard. River and khal waters also showed lower values ranging from 0.49 mg/L to 5.1 mg/L and 9.3 mg/L to 29.5 mg/L for wet season and dry season, respectively, with the exception of Noakhali khal water (code 8). This khal water showed the maximum sulphate concentrations of 61 mg/L during wet season and 166 mg/L during dry season and these higher values are due to presence of sea water in the Noakhali khal.

Data for wet season iron determinations varied from 0.1 mg/L to 0.75 mg/L, 0.12 mg/L to 1.4 mg/L and 0.1 mg/L to 1.5 mg/L in case of beel, pond and river waters, respectively. Birendra khal, oder khal and Masjid Pond (codes 15, 10 and 9) showed higher concentrations whereas those from sample codes 2,4,6,16,17,18,19 and 20 showed lower concentrations than the drinking water standard limit of 0.3 mg/L to 1 mg/L. In regional context it is seen that water samples from the north-western region (codes 20,19,18,17 and 16) usually have lower values.

Sodium chloride content in rivers, ponds and beel ranged from 40 mg/L to 110 mg/L, 36 mg/L to 140 mg/L and 25 mg/L to 270 mg/L, respectively during wet season and all these concentrations are far below from recreational water standard of 600 mg/L chloride i.e., 989 mg/L of sodium chloride. Data for khal waters showed higher values than river, pond and beel waters and varied from 60 mg/L to 1600 mg/L. Downstream of Noakhali khal (code 8) showed the highest concentration of 1600 mg/L, which was the only value exceeding the standard. Results for dry season measurements showed an average increasing trend and varied from 66 mg/L - 136 mg/L, 42 mg/L - 168 mg/L and 314 mg/L -1870 mg/L in case of river, pond and khal waters, respectively. Sodium chloride content in Noakhali khal and Oder khal (codes 5,8 and 10) exceeded the standard value whereas that in Rahmatkhali khal (code 14) closely approximated the standard.

Results of total coliform analysis indicated that out of twenty water samples only two samples (codes 6 and 8) in the wet season and one sample (code 11) in the dry season had reasonable counts when compared to recreational water standard of 200 total coliforms bacteria per 100 ml of sample. Total coliform count for the rest water bodies varied widely ranging from 450 per 100 ml sample to 250,000 per 100 ml sample with the maximum value recorded for Nather Petua Shahjir Dighi (code 4) during dry season. Confluence of Dakatia River and Laksham Khal (code 1) also showed higher value of 135,000 total coliform per 100 ml of sample during dry season. However, average of all the counted values gave clear indication of serious bacterial pollution during both wet and dry season in almost all the water bodies.

All data for faecal coliform count exceeded the drinking water standard of zero faecal coliforms per 100 ml of sample. Maximum number of faecal coliforms for wet season and dry season was counted as 13,000 per 100 ml of sample and 200,000 per 100 ml of sample in case of location codes 1 and 4, respectively. It is clear from these data that all water bodies were faecally contaminated.

Analysis for residual pesticides detected trace quantities of DDT (0.0196 μg/L) and DDE (0.00046 μg/L) in the Uttorer Dogi flood land water sample with code 3.

6. SUMMARY AND CONCLUSION

All the recorded temperatures were within normal ranges. Water samples from the river Meghna, Noakhali khal and Oder khal were highly alkaline ($p^H > 7 < .6$), whereas those from uttorer Dogi, Nateshor Dighi and Birendra Khal were acidic ($p^H < 7$). Water quality for the rest water bodies was slightly alkaline. Dissolve oxygen for all the water bodies was within good range usually greater than 6.4 mg/L and upto a maximum of 14 mg/L except for Birendra khal during wet season. Disposal of organic waste arising due to animal slaughtering near Birendra khal (code 15) must be stopped and this water body should be completely cleared from water hyacinth. All water bodies, except few ponds, contained higher concentrations of free carbon-di-oxide. River and pond waters showed lower EC values whereas most of the khal waters had higher values. Ponds usually contained

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soft water whereas in case of rivers, beels and flood lands it was soft to medium-hard. Water quality in khals was hard to very-hard. Water bodies outside the embankment and those inside but linked with coastal water via other channels dominated in hard water quality. All river, beel and pond waters showed very poor concentrations of nitrate. Maximum measured concentration (14.5 mg/L) was approximately one-third of the drinking water standard. Water samples from south-central and north-western part showed comparatively higher nitrate values. Beel and flood land waters contained lower concentrations of phosphate than river and pond waters and all measured data indicated phosphate deficiency in all these water bodies. Iodine level was very low in beel and pond waters. But in case of rivers and khals average good amount of iodine was observed. Khals located outside the embankment showed maximum concentration of 0.05 mg/L. Pond and beel waters contained lower amounts of silica, but rivers and khals had reasonable average concentration of 21.3 mg/L. Meghna river in the upstream area, southern part of Noakhali khal and Birendra khal showed comparatively higher concentrations of potassium (>13 mg/L) during dry season. All the rest water bodies contained insufficient concentrations of potassium (<10 mg/L). Recreational water quality of the whole project area was extremely poor in zinc as a micronutrient and average zinc concentration was approximately four hundredth of the drinking water standard. All the beels, ponds, and rivers contained very low amount of sulphate. Average iron content in all the water bodies was 0.68 mg/L and those from north-western part had comparatively lower values. All water bodies, except Noakhali khal and Oder khal, contained low amounts of sodium chloride during both wet season and dry season. Higher salt content in the Noakhali khal and Oder khal has been reported by the local peoples as the major problem in agriculture in these areas and this may be partially solved by controlling coastal water inflow in these two khals. Results of microbiological analysis indicated severe bacterial pollution in almost all the water bodies and all the analysed water samples were faecally contaminated. Residual pesticides analysis detected DDT and DDE in micro level and these concentrations were within safe limits.

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