Flood Action Plan
FAP 3
North Central Regional Study

Supporting Report V
Environment

February 1993

Financed by: Commission of the European Communities and Caisse Française de Développement; Project ALA/90/03

Consortium:
BCEOM, Compagnie Nationale du Rhone
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***in association with*:**
Desh Upodesh Ltd.
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The Regional Water Resources Development Plan - Final Report consists of the following:-

Main Volume REGIONAL WATER RESOURCES DEVELOPMENT PLAN

Supporting Reports:-

SR I	LAND RESOURCES AND AGRICULTURE
SR II	WATER RESOURCES
SR III	FISHERIES
SR IV	HUMAN RESOURCES SOCIO-ECONOMICS AND INSTITUTIONS
SR V	ENVIRONMENT
SR VI	INFRASTRUCTURE AND EXISTING SCHEMES
SR VII	ENGINEERING
SR VIII	DEVELOPMENT OPTIONS
SR IX	PLANNING UNITS AND REGIONAL SCHEMES
SR X	ECONOMIC, AND MULTICRITERIA IMPACT ASSESSMENT

NORTH CENTRAL REGIONAL WATER RESOURCES DEVELOPMENT PLAN

FAP-3

SUPPORTING REPORT V - ENVIRONMENT

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AEZ	Agro-Ecological Zone
BADC	Bangladesh Agricultural Development Corp.
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BCAL	Bangladesh Census of Agricultural Livestock
BCAS	Bangladesh Centre for Advanced Studies
FDC	Bangladesh Fisheries Development Corp.
BIDS	Bangladesh Institute of Development Studies
BIWTA	Bangladesh Inland Water Transport Auth.
BJRI	Bangladesh Jute Research Institute
BKB	Bangladesh Krishi Bank
BNPP	Bangladesh National Physical Plan. Board
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engg.Technology
BWDB	Bangladesh Water Development Board
CA	Catchment Area
CAS	Catch Assessment Survey
CAT	Coordination Advisory Team
CCCE	Caisse Centrale de Coopération Economique
CEC	Commission of European Communities
CIP	Chandpur Irrigation Project
CPM	Coarse Pilot Model
CS	Consultants' Studies
DAE	Department of Agricultural Extension
DAE	Department of Agricultural Extension
DANIDA	Danish International Development Agency
DDT	Dichlorodiphenyl-trichloroethane
DHI	Danish Hydraulics Institute
DOE	Department of Environment
DOF	Department of Fisheries
DOS	Disk Operating System
DSSTW	Deep Set Shallow Tubewell
DTW	Deep Tubewell
DUL	Desh Upodesh Ltd.
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIP	Early Implementation Programme
FAO	Food & Agricul.Organ.of the United Nations
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCDI	Flood Control,Drainage & Irrigation Project
FFYP	Fourth Five Year Plan
FHS	Flood Hydrology Study
FMM	Flood Management Modelling
FPCO	Flood Plan Co-ordination Organisation
FRI	Fisheries Research Institute
FRSS	Fisheries Resources Survey System
FSR	Farming Research System
FWP	Food for Work Programme
FY	Financial Year
GOB	Government of Bangladesh
GW	Groundwater
HTW	Hand Tubewell
HYV	High Yielding Variety
ICDDR	Int. Centre for Diarrhoeal Disease Research
IDA	International Development Agency
IPM	Integrated Pest Management Programme
IRRI	International Rice Research Institute
JICA	Japanese International Cooperation Agency
JPPS	Jamalpur Priority Project Study
LAD	Least Available Depth
LGEB	Local Government Engineering Bureau
ME	Ministry of Education
MF	Ministry of Finance
MIWDFC	Minist.of Irrig., Water Dev.& Flood Control
ML	Ministry of Land
MLGRDC	Minist.of Local Govt.,Rural Dev.& Coop.
MOA	Ministry of Agriculture
MOEF	Ministry of Environment and Forestry
MOFL	Ministry of Fisheries & Livestock
MOSTI	Manually Operated Shallow T/W for Irrig.
MP	Ministry of Planning
MPO	Master Plan OrgaNisation
	National Agril.Research Sys.in Bangladesh
NCA	Net Cultivable Area
NCR	North Central Region
NCRM	North Central Regional Model
NCRMG	North Central Regional Model Group
NCRS	North Central Regional Study
NFMP	New Fisheries Management Policy
NGO	Non Government Organisation
NGR	Natural Growth Rate
NWP	National Water Plan
O&M	Operation and Maintenance
ODA	Overseas Development Administration (UK)
PA	Planning Area
PFDS	Public Foodgrain Distribution System
POE	Panel of Experts
PSO	Principal Scientific Officer
PU	Planning Unit
PWD	Public Works Datum
RARS	Regional Agricultural Research Station
RHD	Roads and Highways Department
SOB	Survey of Bangladesh
SPARRSO	Space Research & Remote Sensing Organ.
SRDI	Soil Resources Development Institute
SRP	Systems Rehabilitation Project
SRTI	Sugarcane Research and Training Institute
STW	Shallow Tube Well
SWMC	Surface Water Modelling Centre
SWSMP	Surface Water Simul.Model. Programme
TOR	Terms of Reference
Tk	Taka
UFO	Upazila Fisheries Officer
UNDP	United Nations Development Programme
UNHCR	United Nations H.Commission for Refugees
WFP	World Food Programme

Summary and Conclusions

This Initial Environmental Evaluation has identified the following issues; which have subsequently been incorporated into the regional plan:-

1. Subsequent planning must accept that optimal modes of flood protection should be predicated on water control and management needs throughout the year.

2. To achieve "sustainable development" and the conservation of a diverse resource base for future generations, subsequent planning of water management systems of the NCR must include design and operational criteria that allow most of the characteristic ecological processes to continue. This requires the maintenance and management of a minimum area for open water fisheries and for the adoption of project design and components to better address public health, general nutritional needs and equity issues.

3. The major Dhaleswari/Kaliganga waterways are still generally devoid of continuous embankments. The NCR remains the one region with floodplain fisheries least impacted by direct obstruction of migratory pathways. The embankment of even one side of the Dhaleswari/Kaliganga could thus have impacts on floodplain fisheries of national significance. This national interest cannot be ignored or under-valued in future planning in the NCR.

Biological resources and ecological processes provide the life support systems which underpin the rural and urban economy of the NCR. Yet the most elementary technical knowledge required to answer a range of basic questions remains absent or under-developed. These following questions are typical:

How, exactly, does changing the biological interactions in the flood-to-floodplain regimes affect soil fertility?

Is there, in fact, a "sustainability threshold" - whether measured in biological, social or economic terms - for agricultural intensification in different soil types and under different farming systems beyond which short-term production gains will be eventually negated?

In terms of actual fish consumption by the rural poor (who may already comprise 80-90% of the population in the NCR) which species are important, and which, if any, are not?

Do flood-synchronous and inundation-dependent recruitment and reproduction strategies characterize the inland fishery as a whole and will a modified hydrological cycle produce system failure by crossing critical thresholds?

Species by species, what is the basic ecology and utilitarian/economic value of the 260-odd components of the inland openwater capture fishery ?

These are only a few of the questions in basic ecology which so far it has proved either impossible to answer, or to give any reliable priority to in this Initial Environmental Evaluation. Similarly, the study has come to a similar impasse on most of the issues that comprise the checklist of potential major environmental issues. This includes the likely public health effects, the effects on water quality and the effects on navigation. The reasons include the lack of adequate data and/or the opportunities for new research and interdisciplinary analysis; and the pre-feasibility level of schemes planning which cannot indicate what will be the actual impacts once schemes have passed through feasibility and detailed planning.

The need for more basic research before major decisions are made to proceed must be strongly emphasised. In spite of these inadequacies sufficient understanding exists to highlight that a range of important environmental issues and hazards exist that must be considered in much more detail at the next phase of planning.

Proposals are made to institute, as soon as possible, a properly funded and resourced researched programme <u>in advance of</u> any further feasibility studies to establish the first full years data base on a range of biological-related issues. Without this immediate response it is unlikely that any future Environmental Impact Assessments (EIAs) could be completed satisfactorily. More importantly it will prove very difficult to integrate proper environmental management criteria into the process of project planning, whether this be for either structural or non-structural interventions for flood protection and water management.

CHAPTER 1
INTRODUCTION

1.1 The Setting

Lowland Bangladesh is characterized by an intricate overlay of hydrological, landscape and socio-economic features which condition both the possibilities and the problems of development. The North Central Region (NCR) under study is indicated in **Figure V.1.1** This encompasses a great contrast of land forms, waterways and waterbodies. Micro-scale variations of local elevations or substrates result in radically different natural communities, land capabilities and human occupation patterns. Any meaningful environmental assessment of a regional water development plan should be postulated on an environmental data base that is adequately comprehensive and refined. The data base in Bangladesh is limited and although the present study was not equipped to collect or assemble significant amounts of primary data, an attempt has been made at an Initial Environmental Evaluation (IEE). Further details will be required at subsequent feasibility level of study. The key features of the NCR landscape are:

- hydraulic processes of enormous physical power;

- vast, but seasonally variable, aquatic ecosystem which is species-rich and highly productive of protein; both these features apparently being in a state of decline;

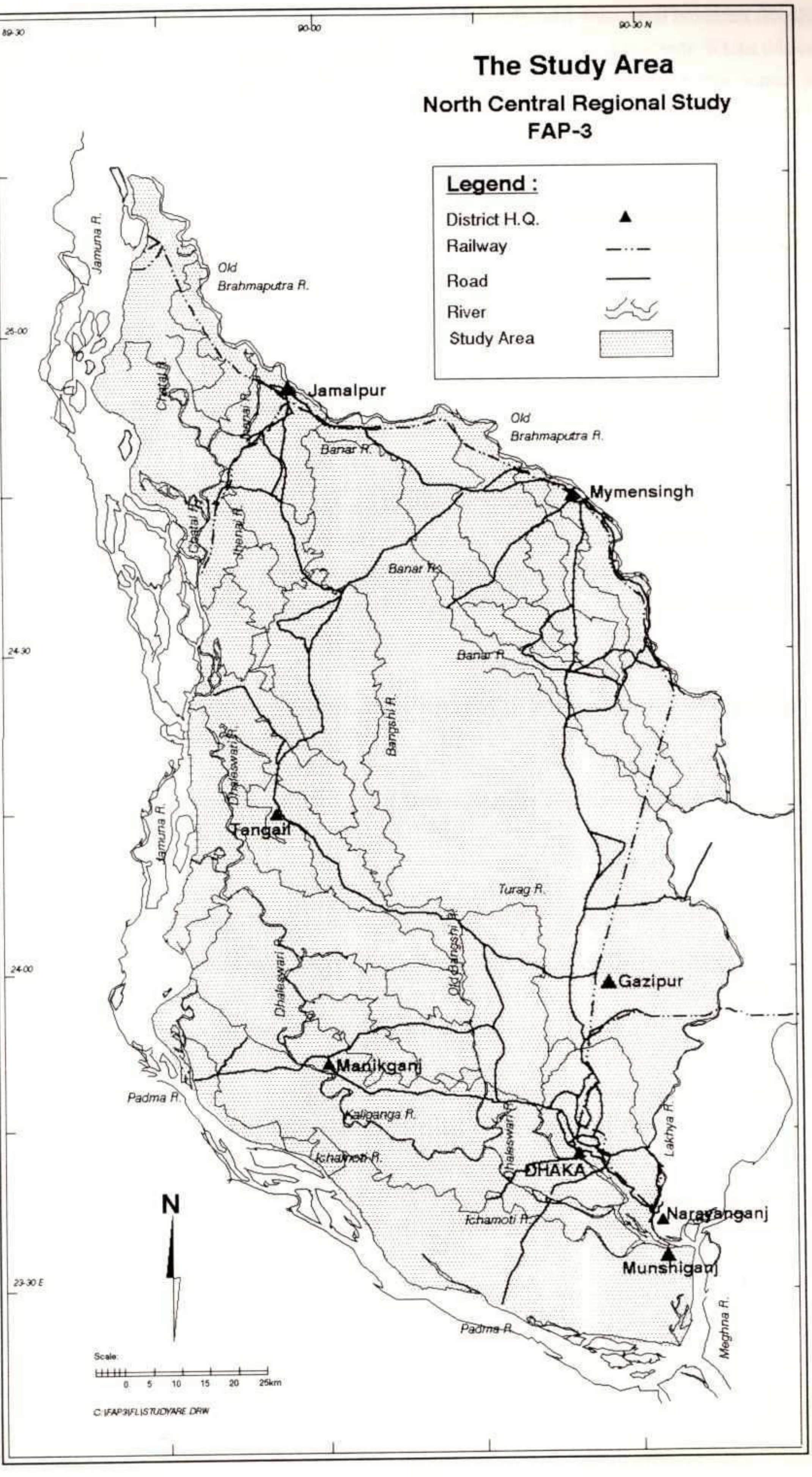
- an intensity of human occupation almost unequalled elsewhere in the world; and

- rapidly evolving social problems of a scale and urgency that cannot be ignored in planning.

Living upon the active alluvial delta laid down by the confluence of three of the world's largest rivers is a mixed blessing. The attractions include access to fertile alluvial soils and renewed fertility provided by the ebb and flow of the flood waters; an abundance of fish protein; a sufficiency of fresh water; and easy navigable access from the ocean to the inland river trade centres. The hazards are an awesome array of high-energy natural processes of flood, and cyclone recurring at relatively short intervals, and a less frequent earthquake hazard.

Bengali civilisation was historically characterised by highly evolved strategies for coping with the "ordinary" monsoonal floods that inundate between a third to a half of the delta. These strategies traditionally included elevating rural homesteads ("baris") on fill pads with the borrow pits being used for dry season water storage; and the adoption of agricultural terrace landscaping and cropping patterns very finely adjusted to the micro-topography of bar-and-swale terrain. An estimated 10 000 varieties of rice and particularly numerous cultivars of long-stemmed "floating" rice which have been bred to grow at rates keyed exactly to local flood conditions made cultivation practicable and less risky. Sites that were too vulnerable to extreme flood situations were either left unoccupied or were inhabited only seasonally. As demographic pressures have increased this option has become less possible and accordingly the inconveniences of flood disruption and damage increasingly more evident and costly. While systems of accommodation that had worked satisfactorily for millennia may be rendered increasingly inadequate by recent demographics, the rural population still retains extraordinarily flexibility and remains well-adapted to deltaic hydrological realities.

Figure : V.1.1


89-30
90-00
90-30 N
The Study Area
North Central Regional Study
FAP-3
Legend :
District H.Q.
Railway
Road
River
Study Area
Jamuna R.
Old
Brahmaputra R.
25-00
Jamalpur
Old
Brahmaputra R.
Banar R.
Mymensingh
Banar R.
24-30
Banar R.
Bangshi R.
Dhaleswari R.
Tangail
Jamuna R.
Turag R.
24-00
Gazipur
Dhaleswari R.
Old Bangshi R.
Manikganj
Padma R.
Kaliganga R.
Ichamoti R.
DHAKA
Lakhya R.
N
Ichamoti R.
Narayanganj
Munshiganj
23-30 E
Padma R.
Meghna R.
Scale:
0 5 10 15 20 25km
C:\FAP3\FL\STUDYARE.DRW

Clearly the present Bangladesh population cannot be sustained by traditional monsoonal broadcast floodplain aman rice culture, in spite of its excellent adaptability to deeply-inundated floodplain and lowlands. Whilst this culture was formerly the mainstay of carbohydrate production, it now provides less than 15% of the total annual production having been replaced in importance by dry season boro rice cultures. This crop is only in certain locations threatened by flood damage in the harvesting season.

Under extreme demographic pressure and, under the management of very adaptable farmers, land use and cropping intensity is already very high in the NCR as it is elsewhere in Bangladesh. Also, groundwater is generally easily available to meet dry-season irrigation requirements.

1.2 Scope of Work

The three major categories of interaction between the FAP-3 environmental assessment and the requirements of regional water management planning are:

- The implications of the "existing situation" for the eventual selection and design of interventions- "structural" as well as "non-structural". Structural options are mainly limited to hydraulic works for flood control and drainage. Non-structural elements may eventually encompass a wide array of institutional and social factors to assist in flood proofing but could not be studied in any detail at this stage.

- The implications of prospective project activities on the future environment should proposals be carried through for implementation.

- Iterative contributions derived from assessing impacts at various stages in the formulation of the regional planning ideas.

The objectives of this study are:

- to enable regional planners to comprehend fully the nature and significance of the probable environmental costs and benefits of the various proposals; and to ensure that environmental considerations are not externalized and thence ignored.

- to participate in the ranking and selection of alternative project proposals, by providing qualitative and, where possible, quantitative input to the cost-benefit analyses.

- to offer technical assistance to project designers so that negative environmental effects might be removed from the overall scheme where possible; and conversely, that positive environmental effects be enhanced. This applies to prospective operating regimes as well as to project designs themselves.

- to devise other mitigation mechanisms and monitoring programs.

1.3 Planning Limitations

At this pre-feasibility level of planning and modelling insufficient details on actual construction and operation and maintenance details are available to make a comprehensive Initial Environmental Evaluation (IEE). Only general principles of scoping potential problems has been possible and little resources were available for extensive public participation. The analysis of a range of potential impacts will need to be considered in more detail in the later phases of planning.

Many impacts related to FCD(I) have been identified in the studies of FAPs 2, 5, 12, 13 and 16, and more detailed, elaboration at a feasibility study level is currently in preparation for FAP 3.1.

At feasibility study level GPA (FPCO 1992) requires Environmental Impact Assessments (EIA). The incorporation of EIA procedures into the FAP planning processes is intended to help assure that its development initiatives be both "sustainable" and "environmentally sound".

This Initial Environmental Evaluation was prepared before any final version of the Guidelines for Project Assessment pertaining to environmental impact assessment were available. However, the contents of this report, taken together with the other SRs and the Main Report do, in their entirety, go some of the way to satisfying the coverage expected of an IEE.

The hydrological model, upon which much of the regional analysis and planning has been done, is still at coarse pilot stage. This limits the potential reliability of priorities which have been assigned to impacts at this pre-feasibility stage.

More importantly, there is an essential absence of any baseline or monitored database for the biology and ecology of the NCR. Without the basic biological data base a proper identification of key ecological impacts is externalised from the planning process and requires impact assessors to embark on a high degree of subjective judgement in identifying impacts and giving priority to them. This limitation should be redressed of the feasibility study level.

The evaluations made here are based on the professional research, interviews, observations and judgements of the team. Many important issues which policy makers must address, are identified only in qualitative terms at this prefeasibility level of study.

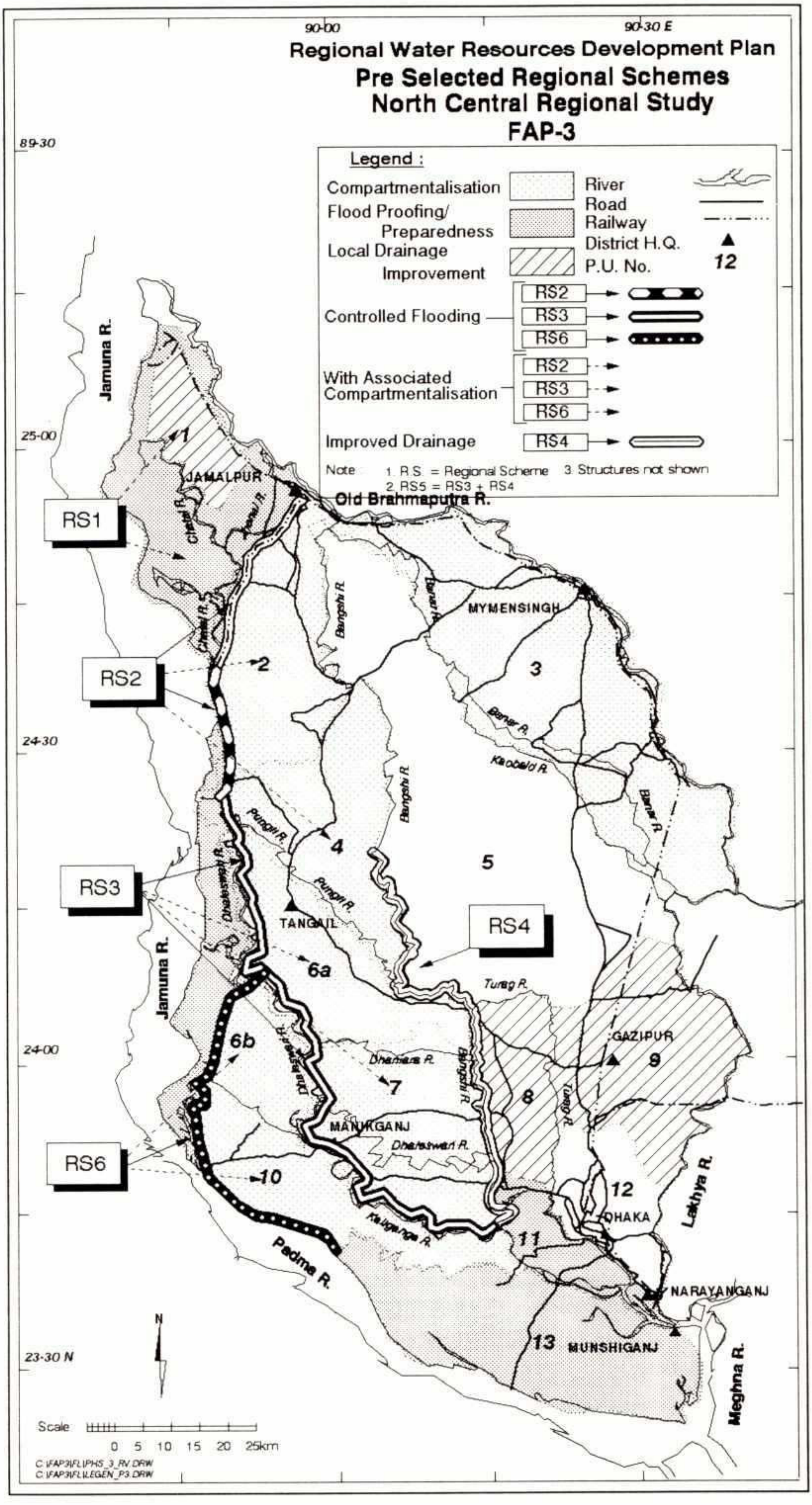
1.4 Scope and Format of the Report

This Supporting Report concentrates on ecological assessments to support the specialist analysis and planning of other SRs. The final multi-disciplinary impact analysis is taken forward into the multi-criteria analysis presented in the SRX.

1.5 Project Alternatives and Regional Scenarios

The basic setting, rationale and alternatives considered for each planning unit and regional planning scenarios are discussed in SR IX and SR X. These are visually displayed in **Figures V.1.2**. The alternatives which have been considered under FAP 3 have been derived from a preliminary set of criteria to give priority to perceived problems of floods and impeded drainage within each planning unit and then to consider controls and development options through structural means supplemented or not by non-structural measures.

Figure : V.1.2



Regional Water Resources Development Plan
Pre Selected Regional Schemes
North Central Regional Study
FAP-3
Legend :
Compartmentalisation
Flood Proofing/ Preparedness
Local Drainage Improvement
River
Road
Railway
District H.Q.
P.U. No.
12
Controlled Flooding
RS2
RS3
RS6
With Associated Compartmentalisation
RS2
RS3
RS6
Improved Drainage
RS4
Note 1. R.S. = Regional Scheme 2. RS5 = RS3 + RS4 3. Structures not shown
90-00
90-30 E
89-30
25-00
24-30
24-00
23-30 N
Jamuna R.
JAMALPUR
Old Brahmaputra R.
RS1
RS2
RS3
RS4
RS6
MYMENSINGH
TANGAIL
GAZIPUR
MANIKGANJ
DHAKA
NARAYANGANJ
MUNSHIGANJ
Pungli R.
Banar R.
Turag R.
Dhaleswari R.
Kaliganga R.
Padma R.
Lakhya R.
Meghna R.
1
2
3
4
5
6a
6b
7
8
9
10
11
12
13
N
Scale
0 5 10 15 20 25km
C:\FAP3\FL\PHS_3_RV.DRW
C:\FAP3\FL\LEGEN_P3.DRW

The selection of the Planning Units, PU's **Figure V.1.3** judged as the best candidates for hydrological improvements, and the preliminary selection of engineering works to accomplish that task was done in the following manner:

1. Agricultural surveys in each of the PU's established the existing cropping patterns and the land coverage (see SR I). Particular attention was paid to the relative inundated area during the monsoon, and to the proportion of land under broadcast aman. It was thought that major improvements in rice production would arise if the inundation regime now suitable only for low-yielding broadcast aman was altered to allow cultivation of high yielding varieties (HYV) of transplanted aman.

2. A computer hydrodynamic model (MIKE 11) was run for each scenario of possible interventions, see SR II.5. The software simulated several possible hydrological interventions, including drainage improvements; embankment schemes providing "full flood protection", "controlled", and "semi-controlled" flooding; and various combinations of the above (see **Chapter 4** for a discussion on these different approaches). The initial output, expressed only in terms of altered river stage, was then converted by an additional program into the amount of cultivable land released from flooding.

3. The possible interventions were then re-evaluated as related to each PU.

4. A preliminary benefit/cost analysis was then performed on the more promising scenarios, projecting the incremental yield of HYV transplanted aman, and then deducting the costs of earthworks and other infrastructures. The costs of one quantifiable category of "disbenefit" was also appropriately deducted - the estimated reduction in value of open-water capture fisheries.

5. A ranking of the Regional Schemes (RS) was prepared, based on economic feasibility, technical practicability and a multicriteria analysis. The highest-ranking among them were then to be recommended for detailed, further review at future "feasibility study" level.

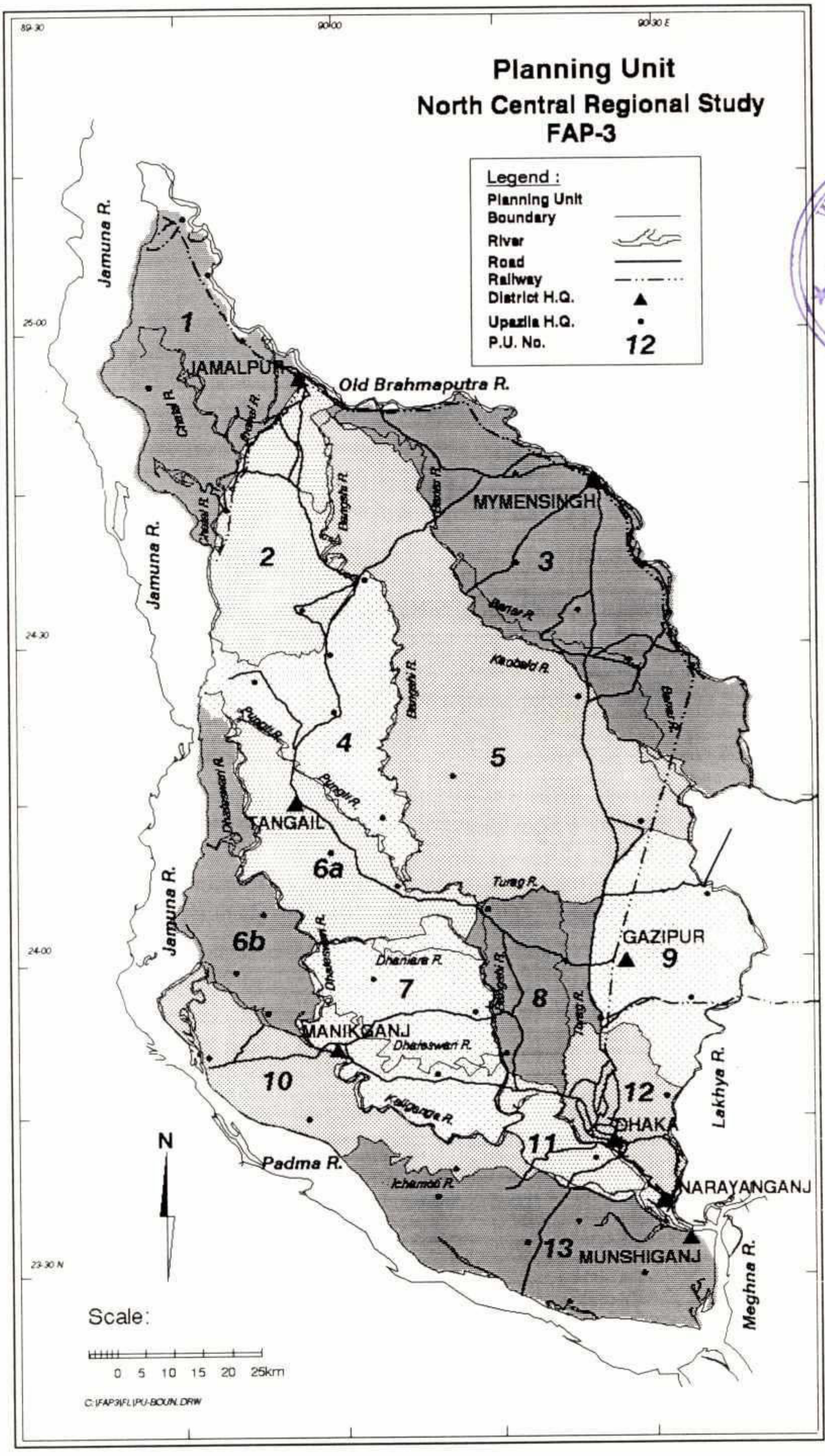
The approach to regional water planning has a main objective of improving agricultural development. The identification, the prioritization, and the economic justification of Regional Schemes (excluding the Jamalpur priority area) have all included the objective of augmenting production of HYV transplanted aman at the expense of the diverse "native" cultivars of broadcast aman rice. Cropping intensity are already at 218% in some of the areas to be "released" and would probably not be augmented by more than 5-8%.

The potential benefits or logic of planning for other sectorial requirements has also included for other considerations, i.e. improved quality of life. These are assumed to derive from increased agricultural incomes and employment, to be secondary improvements, and where any adverse impacts are anticipated would be dealt with through mitigation, rather than giving these a preferential position with respect to agricultural development through FCD.

Outside of the FAP 3.1 project area - "non-structural" options (or "flood proofing") have not been analyzed in any level of detail for the NCR's preliminary Regional Schemes. This does mean that they will not be relevant as more detailed planning continues in the future. Flood proofing may be, either an integral component of any future schemes, or else a preferred alternative in particular areas where structural measures do not have a meaningful role to play.

The overall planning approach has been dealt with further, and a multi-criteria analysis carried out as described in SR X.7.

Figure : V.1.3



Planning Unit
North Central Regional Study
FAP-3
Legend :
Planning Unit Boundary
River
Road
Railway
District H.Q.
Upazila H.Q.
P.U. No.
12
Jamuna R.
Old Brahmaputra R.
JAMALPUR
MYMENSINGH
TANGAIL
GAZIPUR
MANIKGANJ
DHAKA
NARAYANGANJ
MUNSHIGANJ
Padma R.
Lakhya R.
Meghna R.
Banar R.
Turag R.
Dhaleswari R.
Ichamati R.
1
2
3
4
5
6a
6b
7
8
9
10
11
12
13
N
Scale:
0 5 10 15 20 25km

1.6 The Limitations of the Main Planning Tool

The present hydrodynamic model has several defects (see SR I.5) in terms of its immediate usefulness in ecological and environmental assessment of the interventions now proposed; however these defects should be redressed at feasibility study level:-

1. The coarse pilot model used at the pre-feasibility level cannot distinguish adequately between the rainfed from the riverine components of floodplain inundation. River-induced flooding may amount to no more than 60% of the overall flood problem in most of the NCR. Thus, the actual effects on the landscape of the proposed interventions for altering stream hydrology are not yet predictable, except in very general terms whether quantitatively or spatially. Caution is required in the determination of the gross impacts of dewatering on the aquatic biota and more particularly upon migratory fish species by multiplying hectarage "released" from the project by estimated fish yield per hectare as, in reality, the recruitment of floodplain fish stocks is a function of unimpeded streamflow, and not a simple expression of areal inundation.

2. The model presently lacks the ability to spatially discriminate the specific areas inside the overall planning units that would be "released" by the proposed works. Thus, even if it had been possible to establish a list of sites of potential ecological significance within each Regional Scheme (which it has not been), the model does not provide localized information on hydrological impacts. These impacts may be areas less flooded and also areas more flooded due to impeded drainage behind structures.

3. Elevations within the project area are aggregated by the model, which ignores "discontinuities" in the floodplain section: depressions, bils, khals, and minor channels where wetland and aquatic habitats are likely to remain. It is exactly the question of whether or not these low lying features continue to be made "seasonally-contiguous" by floods that is the most critical predictive element required for the ecological analysis.

   An advanced digital floodplain model may soon become available (through FAPs 19 and 25) which will partly rectify these problems, and which might eventually prove more useful to feasibility-level studies of Regional Schemes.

4. The model assumes relevance of the time series data base it is using. The mass wasting and morphological changes upstream which create additional surges of flooding over years or decades is not part of the modelling basis. Although the model has a morphological sub-routine these two elements are dis-aggregated while, in reality, the inter-dependence and inter-relationship between these two processes determines the real landscape and timing of flood regimes.

5. Flood stages and peaking are determined by flows and friction coefficients. The model uses some assumptions in its representation of these very variable and dynamic physical forces. The assumed cross sections of river "channels" do not yet take into account the type and forms of vegetation which cover the floodplain. Yet, in the main floods, there is often considerable overland flow which takes places outside of any recognisable form of consistent channel.

These limitations are amongst some which the hydrologists and hydraulic modellers are wrestling to resolve to provide a better tool. The current usefulness of the modelling is thus limiting the degree to which reliable planning for sustainable development can occur. It also limits the degree to which impact analysis can address a real set of site specific issues resulting from the implementation of possible schemes. However provided these limitation are kept in mind the model does provide an additional tool, that assists our understanding of the situation.

CHAPTER 2
THE EXISTING ENVIRONMENT

2.1 Introduction

A number of the other SRs give basic details on the existing environment of the NCR: SR 1 (Land Resources and Agriculture), SR II (Water Resources), SR III (Fisheries), SR IV (Human Resources and Socio-Economics, SR VI (Infrastructure and Existing Schemes) and SR VII (Engineering). This section will deal with an ecological assessment of the terrestrial and aquatic environments and refer to various other issues which are not dealt with in other SRs, such as water quality, pollution and navigation.

The North Central Regional planning area comprises an area of approximately 1.2 million hectares, lying between latitudes N. 23° 40' and N. 25° 10', and longitudes E. 89° 40' and 90° 40'. It supports a present population of about 18 million people. Its original boundaries were delineated on the west and the south by the left banks of the Rivers Brahmaputra/Jamuna, and the Ganges/Padma, respectively; and similarly on the north and the east by the right banks of Old Brahmaputra, and the Lakhya. However, the recognition of important potential social and hydrological impacts of the FAP on the thousands inhabiting the unstable islands or "chars" (located mostly within the braided, active floodplain of the Jamuna), means the *de facto* planning area of NCR has been extended to include the impact zones.

Metropolitan Dhaka covers only about 1% (1,200 sq.km) of the region's surface area but contains a disproportionate share of the urban landscape and its human population. While Dhaka comes under a separate FAP study (FAP 8) for engineering planning, it nonetheless cannot be ignored in the environmental impact analysis of FAP 3, particularly with regard to hydrology and water quality.

2.2 Human Setting

Bangladesh is presently the sixth most populous country on Earth, and it will conceivably overtake eventually two of the other five countries so far still ahead: the United States, and the former Soviet Union. A 1989 study by the World Resources Institute concluded that, given present demographic trends, the overall human population of Bangladesh could eventually reach 340 million before stabilizing or declining. This is a full tripling of present numbers. The population of the NCR would then be about sixty million.

Although the reliability of such projections has to be questioned, the present population growth rate of about 2.2% per annum has not displayed any striking downward trend. There is also little doubt that as the population expands, a disproportionate share of the Bangladesh "surplus rural population" will migrate to the area around Dhaka which is still relatively underpopulated, when compared with the main cities and developing mega-cities of other countries in similar economic and social conditions.

The present demographic crisis has evolved out of the traditionally dense human population of deltaic Bengal, which possibly had already reached ten or fifteen million even six centuries ago. Such a high level was a function of the natural wealth of this deltaic land and waterscape. While famine and misery were hardly unknown in the region (the population boom only really began in the 1930s) it is really only in the present generation that landlessness, economic marginality, and social deprivation has become the dominant lifestyle in deltaic East Bengal. Increasingly environmental problems are being given a more prominent position in the regional and international political agenda.

The sociology annex (SR IV) provides the basic data base on the people of the NCR, but offers little analysis of culture and heritage issues. These will warrant particular attention in the feasibility study phase (the NCR has a diverse cultural environment with minority ethnic groups, mainly Garo, being well-represented in the Madhupur). Historically there is a long pattern of human settlement which is poorly researched. **Figure V.2.1** provides the available data on the sites of known archaeological and cultural sites of importance that might be influenced by future development. The map is supplement by comments which are provided in **Appendix H**.

2.3 Hydro-physical Setting

The region's climatic and hydrological regime is dominated by the influence of the Himalayan mountain ranges and the monsoonal systems in the Bay of Bengal. The climate is sub-tropical with summer, monsoon and winter seasons. Rainfall is either monsoonal, inter-monsoonal or cyclonic in origin.

During summer (March to June) Bangladesh is frequently visited by nor' westers and the weather remains hot and humid. The monsoon season (June to October) has high humidity and 80% of the rainfall occurs. The winter (November to February) has only occasional rain and the weather remains dry and the sky is clear. Early morning fog and mist are then common.

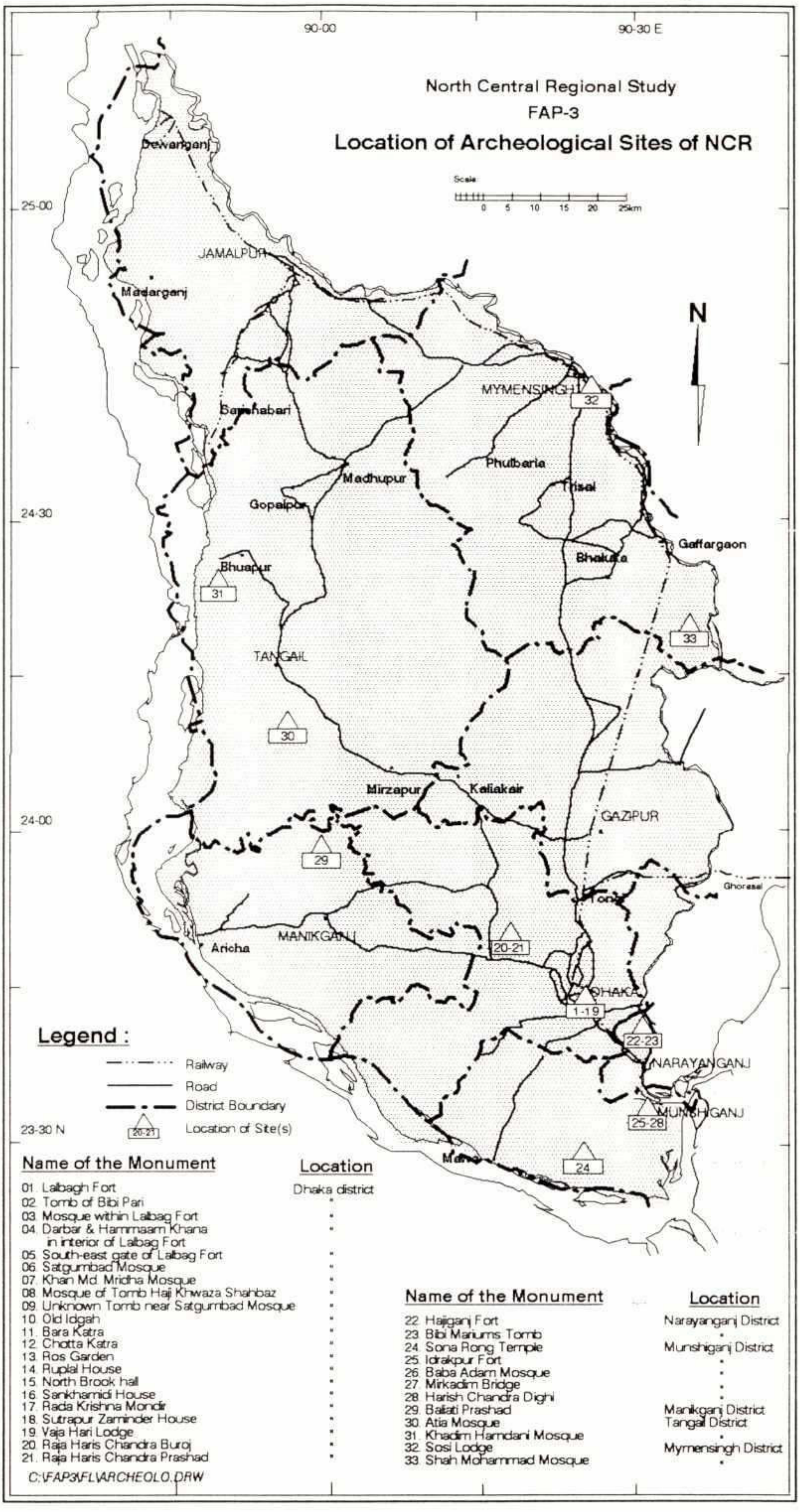
The Ganges and the Brahmaputra, two of the world largest rivers, have their confluence at the southeastern extremity of the NCR. Immediately downstream these have another confluence with the River Meghna which, while draining a comparatively smaller basin, receives much of its discharge from the highest-rainfall watershed on the planet.

The Ganges and the Brahmaputra originate on both the northern and the southern slopes of the Himalayas. They drain an aggregate area of which Bangladesh is only a relatively small part. Bangladesh is itself eighty percent occupied by the combined young alluvial deltas of these two rivers and includes that of the Meghna. Similarly, at least 80 percent of the NCR is recently alluvial in origin, and much of the remainder - lying within the slightly uplifted Madhupur tract (some 240,000 ha) - is also depositional in origin. The older Madhupur alluvium originated during a previous geological era. Much of the alluvium is unconsolidated, or poorly consolidated, and comprises of particles having little cohesiveness. Thus, the landscape as a whole is easily erodible, and can be readily displaced, transported, and otherwise re-arranged by fluvial processes. Liquefaction during seismic events is possible and this raises issues of the risks and contingency planning entailed with major embankments. **Figure V.2.2** provides a earthquake risk hazard map for Bangladesh.

The uplift of the Himalayan region is ongoing over the last 25 million years. Its stratigraphy and geology is particularly prone to weathering and mass-wasting through processes of freezing and snow melt, and also as a function of a monsoonal climatic regime providing large amounts of rainfall within a relatively compressed time frame. Typically these processes lead to the release and downbasin transport of very high sediment loads with annual deliveries of sediment to both the subareal and the subaqueous deltas in the order of about three billion metric tonnes.

Although not fully proven, it is generally believed that the recent deforestation of the middle and upper slopes of the Ganges/Brahmaputra watershed in India, and particularly in Nepal, are directly responsible for accelerated sedimentation in Bangladesh.

Figure : V.2.1


North Central Regional Study
FAP-3
Location of Archeological Sites of NCR
Scale
0 5 10 15 20 25km
90-00
90-30 E
25-00
24-30
24-00
23-30 N
N
Dewanganj
JAMALPUR
Madarganj
Sarishabari
Madhupur
Gopalpur
Bhuapur
TANGAIL
MYMENSINGH
Phulbaria
Trisal
Gaffargaon
Bhaluka
Mirzapur
Kaliakair
GAZIPUR
Ghorasal
Tongi
Aricha
MANIKGANJ
DHAKA
NARAYANGANJ
MUNSHIGANJ
1-19
20-21
22-23
24
25-28
29
30
31
32
33
Legend :
Railway
Road
District Boundary
Location of Site(s)
Name of the Monument
Location
01. Lalbagh Fort — Dhaka district
02. Tomb of Bibi Pari — "
03. Mosque within Lalbag Fort — "
04. Darbar & Hammaam Khana in interior of Lalbag Fort — "
05. South-east gate of Lalbag Fort — "
06. Satgumbad Mosque — "
07. Khan Md. Mridha Mosque — "
08. Mosque of Tomb Haji Khwaza Shahbaz — "
09. Unknown Tomb near Satgumbad Mosque — "
10. Old Idgah — "
11. Bara Katra — "
12. Chotta Katra — "
13. Ros Garden — "
14. Ruplal House — "
15. North Brook hall — "
16. Sankhamidi House — "
17. Rada Krishna Mondir — "
18. Sutrapur Zaminder House — "
19. Vaja Hari Lodge — "
20. Raja Haris Chandra Buroj — "
21. Raja Haris Chandra Prashad — "
C:\FAP3\FL\ARCHEOLO.DRW
Name of the Monument
Location
22. Hajiganj Fort — Narayanganj District
23. Bibi Mariums Tomb — "
24. Sona Rong Temple — Munshiganj District
25. Idrakpur Fort — "
26. Baba Adam Mosque — "
27. Mirkadim Bridge — "
28. Harish Chandra Dighi — "
29. Baliati Prashad — Manikganj District
30. Atia Mosque — Tangail District
31. Khadim Hamdani Mosque — "
32. Sosi Lodge — Mymensingh District
33. Shah Mohammad Mosque — "

Related to the continued tectonic activity associated with the Himalayan orogeny, the entire region is a nexus of seismicity **Figure V.2.2** with both the uplands and the lowlands subject to not-infrequent minor and major earthquakes. Such events may have severe hydrological consequences. These may induce sudden major course changes in principal rivers, and may release, through seismically triggered landslides, sediment loads sufficient to alter river and floodplain morphology in comparitively short timeframes. These factors have been associated with the re-routing of the lower Brahmaputra into the Jamuna, and the conversion of its habit from a comparatively stable meandering form to an unstable braided form. The overall trend in the Ganges Delta is toward the sequential abandonment of its western distributaries, with a generalized migration of the mainstem eastwards in a direction contrary to coriolis effects.

The Jamuna has a principal channel sometimes migrating several kilometres across the floodplain in the course of a single year: within such channels themselves, trenches several kilometres long have been excavated overnight to a depth of 50-60 m.

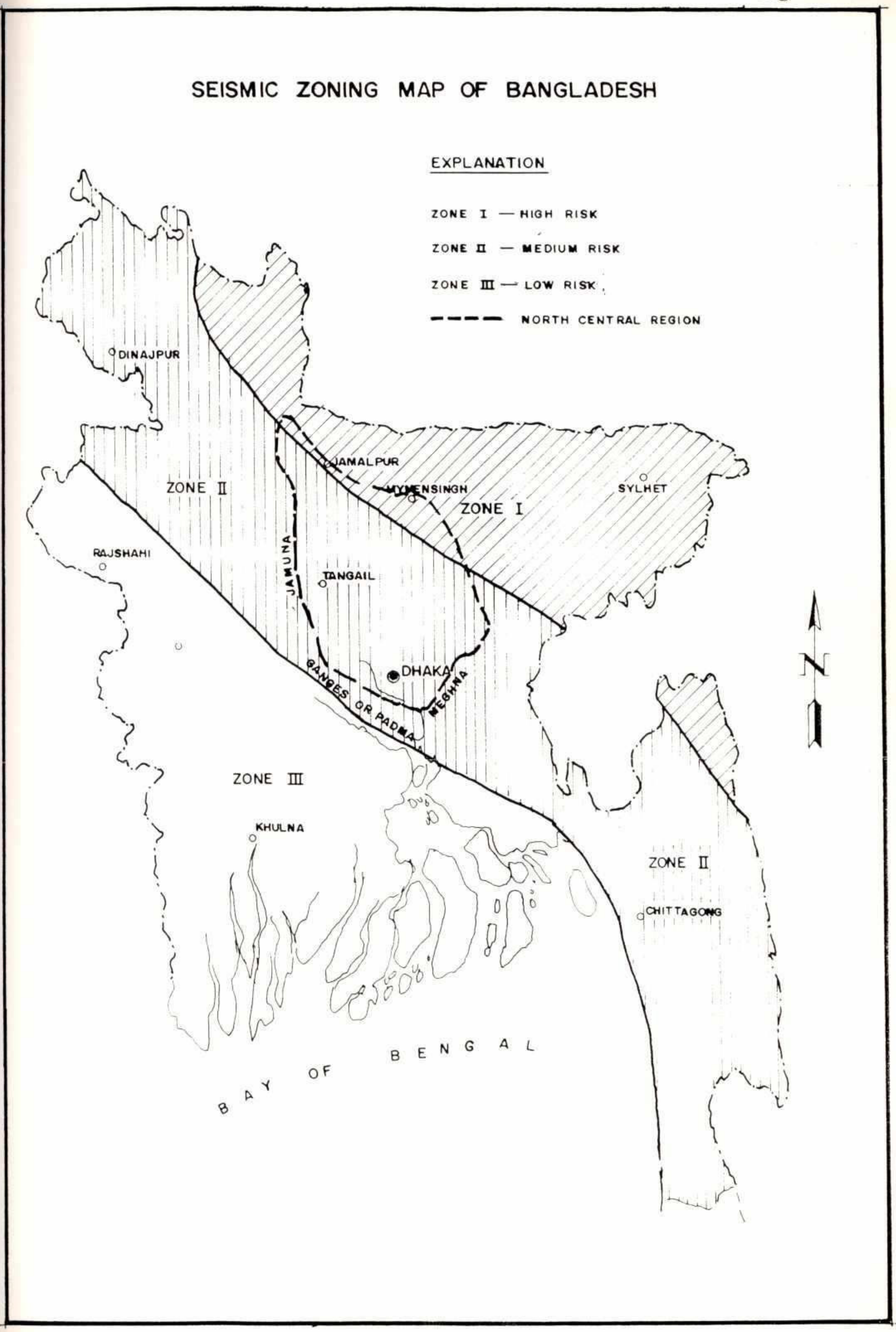
The principal rivers do not ordinarily peak completely in phase with each other as the volumetric and temporal contributions from glacial and snow melt waters, from pre-monsoonal storms, and from the monsoon itself vary within the three larger watersheds. However, the rare times that their peak discharge occurs in close congruence results in floods of unusual intensity, magnitude, and duration. The 1988 flood - which was produced by such a congruence - displayed a maximum discharge below the Jamuna/Padma confluence in excess of 160,000 cumecs.

In addition to the main rivers along the periphery of the NCR, there exists a net of internal rivers generally functioning as, distributaries and overspill channels. Thus, while a "minor" interior stream might have some component of its discharge derived from purely local drainage, some other portion of that discharge may be comprised of floodwater delivered from half a continent away.

Topographically slopes of only several centimetres per kilometre make this region extremely flood prone. Tidal influence from the Bay of Bengal is manifest almost to the very foot of the NCR study area. The site of the upstream point of tidal influence varies with the seasonal variation in river discharge. This, combined with the minimal stream gradient, creates a situation conducive to extreme drainage congestion.

Even if the predicted "greenhouse" induced sea-level rise materializes, and/or the minimum April discharge of the mainstem rivers is further reduced by man or by nature, only a small proportion of the NCR will lie within the zone of tidal influence in the middle-term future.

The NCR's lowlands generally display the "bar and swale" topography. As a particular site may be regularly subject to flood depths of several meters, the relatively slight variation in elevation between the bars and the swales determines which sites are more "semi-aquatic" and which are more terrestrial. Adjacent points on a short transect across an active bar and swale terrain are thus exposed to quite different depositional and moisture regimes and may evolve quite different soil types and thus lend themselves to colonization by different vegetational and faunal communities.


SEISMIC ZONING MAP OF BANGLADESH
EXPLANATION
ZONE I — HIGH RISK
ZONE II — MEDIUM RISK
ZONE III — LOW RISK
NORTH CENTRAL REGION
DINAJPUR
JAMALPUR
MYMENSINGH
SYLHET
ZONE II
ZONE I
RAJSHAHI
JAMUNA
TANGAIL
DHAKA
GANGES OR PADMA
MEGHNA
ZONE III
KHULNA
ZONE II
CHITTAGONG
BAY OF BENGAL
N

In an ordinary year up to 40% of the region is inundated for weeks, or months, by standing or moving floodwater up to 3 m in depth. The proportion rises to 60% or 80% during the major flood event. The micro-topography, so significant to the ecology of the native landscape, has great significance in the patterns of human settlement and the types and timing of agriculture. The ecological boundaries are as difficult to fix as the hydrological boundaries which makes assessment within the borders of the planning area very problematic.

2.4 The Biological Environment

2.4.1 General

Bangladesh is situated at the complex interface of the Indian, the Himalayan and the Southeast Asian biogeographic regions, and historically was well-endowed with a very diverse complement of terrestrial and aquatic flora and fauna. Today, while species and habitat depletion (or alteration) is prevalent, this diversity still remains within the avifauna and the freshwater icthyifauna. While the NCR, like most of Bangladesh, is amongst the most thoroughly man-modified ecological landscapes of South Asia. A rampant reduction of biodiversity has apparently only occurred very recently.

2.4.2 Land Use and Habitats

With the exception of the uplands of the Madhupur, the NCR could be broadly described as a semi-aquatic, deltaic environment which, in the absence of anthropogenic intervention, is regularly inundated by several of the world's largest rivers; the confluence of which lies adjacent to, or within, the planning area.

The whole area is already under intensive human management and this is the context within which any environmental management proposals must be seen. Only in the area of open water fisheries is there any need to consider high priority being given to pure conservation strategies to "set aside" and manage land and water bodies to ensure that the system does not go beyond a minimum critical threshold. This, in itself, will produce a range of benefits for biological controls assisting food and cash crop production and assist in public health.

As described in SR I and IV (Agriculture and Socio-Economics), the NCR has an overall rural population density of 700 people/sq.km., most of whom are comparatively poor or landless. Concomitantly there is already a large (and rising) share of the landscape now under permanent cultivation. The pressure driven by demography and poverty have important implications, quite indepent of any FAP interventions, for the status of native and introduced flora, fauna and wildlife independently of any FAP interventions. Any changes to the basic hydrological regime, and by definition the morphology, on a deltaic floodplain, will affect in different ways this same status and the inter-relationships between the physical, biological and socio-economic environments.

Of the 73% of the overall NCR presently under agriculture, aggregate cropping intensity is 188%. The remaining 27% of the NCR includes the metropolitan Dhaka conurbation, as well as a number of smaller, but still-substantive cities, such as Mymensingh, Tangail, and Jamalpur, and all of the existing roadways and embankments. Habitat-wise it also includes the open fields, artificial and natural waterbodies (lentic and lotic), rural homesteads and villages, monoculture tree plantations and agro-forests, degraded and former forests which are neither reafforested nor presently in agriculture; its fallow lands, sandbanks, and uncultivable charlands; and, finally, its remaining natural forests and wetlands. Each of these constitute geographically or seasonally distinct habitat types contributing to the basic diversity of the terrestrial and aquatic species and physical environments. These in turn are the foundations of the quality of life of humans, flora and fauna alike.

With some exceptions, the faunal species most likely to have survived the human transformations of the landscape were those which, first, were not absolutely dependant upon primary forests or other pristine habitats and, second were not threatening to man and accommodate themselves to the human presence. For large mammals in particular, the diversity and density of relic populations is certainly only a small fraction of that which existed even a generation ago. Middle-aged interviewees from formerly-forested districts remember when bears and leopards were quite common there, and tigers and wild elephants were still occasionally seen.

Some of the remaining species of wild flora and fauna survive at the fringes of cultivated fields and in water bodies. For others, lands either actively under agriculture, or in a temporarily fallow or submerged state, comprise acceptable habitat. This category probably includes a large proportion of the resident and migratory avifauna. Wherever the crops themselves attract and support wildlife, as is the case with several species of ring-necked parakeet, they are regarded as pests or alternative food sources and are actively destroyed.

2.4.3 Biodiversity

General

Appendices A through G provide a collection of the available database on flora and fauna from secondary sources. These data are crude and are not supported by extensive field research. They are nonetheless indicative for this stage of planning.

Increasingly, the general perspective on biodiversity is changing. The critical contributions which natural ecological processes make to agricultural and fishery systems to the nutrition and economy of the country are becoming more widely accepted and understood. Indeed, there exist official policies of the Bangladesh government, of the various donor governments and agencies that require the fullest consideration, if not preservation, of biodiversity as a major element in the evaluation and design of development projects. These policies range from the requirement that "sectoral policies be modified as necessary to incorporate conservation of bio-diversities"; to the more specific "bils should be reserved for fish habitat (both appearing in the Draft National Conservation Strategy for Bangladesh.)

The TOR, and in the emerging guidelines for FAP's environmental components contain statements that projects under FAP must be "environmentally sound", or at least show how "environmental soundness" is to figure in the comparison of various alternative project scenarios. "Environmental soundness" would be widely accepted by professionals to directly include measures to promote the conservation, protection, or even enhancement of biodiversity.

Biodiversity might be defined as "the fullest range of floral and faunal species ordinarily displayed in a pristine region or ecosystem." This would not reflect an ecologists understanding of the real world and therefore would not be supportable in all situations. This is because, although some ecosystems (especially in the tropics) are naturally enormously diverse, others are quite naturally very thinly speciated.

As environmental change (man-made or natural) occurs at a site, those species unadapted to the particular changes that have taken place or, in some cases, unadapted to any changes at all in environmental parameters, are gradually or quickly removed from the system, and the site eventually becomes depauperate. This does not mean that nothing lives there, or that productivity is low; it means only that the biotic component of the ecosystem has become extremely simplified. Thus, even while the population of *Homo sapiens* has increased very substantively in recent years, overall, the large mammalian fauna of Bangladesh has become depauperate during the same period. Similarly, the vast and complex flora that once characterized the seasonal or permanent wetlands in the NCR has been largely replaced by one high-yielding genetic strain of rice.

A generation ago, Bangladesh was extraordinarily species-rich. Due to the combined effects of loss of habitat and hunting (for sport, food and skins) and the increased settlement and population density, the originally rich wildlife of the area appears to have been severely impacted and depleted; although no recent botanical and zoological surveys are available to substantiate this. This has affected birds, reptiles, amphibians, fish and mammals alike. The main losses have been of large mammals and ungulates, birds of prey, water fowl and certain reptiles and amphibians. The role of species in the nutritional and survival strategies of poor and minority groups is an essential component of the socio-economic and eco-system environment.

Some of the reasons behind the disappearance of species are not so clear and would require more detailed research. For example, *Nandus* ("mendi" or "bheda" in Bangla) formerly made up 2-10% of non-riverine dry-season fish landings country-wide. Recently, *Nandus* has almost completely disappeared from regional markets and some specialists believe this species may well be approaching extinction. Why *Nandus* is more vulnerable to environmental change (and/or fishing pressure) than many other species is unclear. Its popular name, "mud perch", suggests its preferred habitat is lentic waterways displaying high turbidity or habitats subject to seasonal drying and shrinking.

This apparent sudden removal should have ready answers. In practise, due to a total lack of basic research there are none. It cannot even be said that the perceived is not imaginary. Alternatively it may have been directly due to either a single or multiple set of changes involving temperature changes, seasonal depressions of groundwater following irrigation development, agrochemical pollution or Epizootic Ulceration Disease?

The "Utilitarian Aspects" of Biodiversity

"Terrestrialization" of the semi-aquatic landscape of deltaic Bangladesh has the principal objective of intensification of agriculture to satisfy the "need" for food grain self-sufficiency. Yet, as the human population becomes increasingly marginalized and landless, the survival strategies of those at the bottom have increasingly fallen back upon the remaining physical and biological diversity of regional ecosystems: tiny fish trapped in floodplain depressions are caught for consumption (by those who have rice but cannot buy fish) or for sale (by those who have to buy rice and salt/chilly); turtles and frogs are speared for export (or are eaten by non-Muslim Bengalis and tribals); waterfowl and wading birds are captured for the pot or the market; Gangetic dolphins are netted and boiled down into panacea medicinal oils for sale on the sidewalks of Dhaka.

But all development options furthering "terrestrialization" unavoidably reduce the contribution to biodiversity made by the relic wetlands and permanent bils, and by its fragmentary wildlife habitats. Insofar as the poorest of the rural poor continue to eke out precarious livelihoods predicated upon "applied biodiversity", it appears that in the absence of, at best, uncertain environmental mitigation protecting the widest range of habitats and niches, biodiversity-reducing hydrological manipulations will make some human lives all the more precarious.

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Drainage improvement schemes, which would cutoff or straighten river meanders, "improve" channel cross-sections by steepening banks, and excavating or grading stream floors, similarly reduce the range of available niches and habitats, with concomitant effects on biodiversity. In this case, "terrestrialization" is only the indirect object of the drainage scheme, but dredging a semi-aquatic landscape into fully aquatic landscape impacts biodiversity even as filling it and drying it out would.

Reduced biodiversity also means reduced populations of species benevolent to agriculture: insectivore or rodentivore birds, predator mammals, amphibians and reptiles. There is a danger that certain species will be driven to extension at a time when these species may become of importance in the Integrated Pest Management (IPM) route toward sustainable crop production.

Other Issues

There are significant non-utilitarian issues connected with biodiversity. Emphasizing the utilitarian arguments in its favour may be an evasion of difficult or unpleasant policy questions. Are endangered species to be absolutely protected on the basis of purely ethical consideration, e.g. the responsibility of humanity for the stewardship of nature? If so, who accepts the largest share of the necessary sacrifices: the street vendor of shishu oil in Mohakhlai, his suppliers in Bhuapur, or the international taxpayers who ultimately finance donor projects?

Capture fisheries appear to be in decline, but this has get to be fully quantified. Fulltime fishing has traditionally been a low-status occupation left to the "jhele" , who fished exclusively, rather than opportunistically (i.e. as one of several marginal or seasonal enterprises). Field survey teams repeatedly encountered groups of 5-6 jhele whose daily catch collectively amounted to 1 kg or less. The unvarying story told was of how "ten or only five years ago, a dozen fishermen could earn a living here where now even one man now can not support his family."

Flora

It is not known how many of the estimated 5 000 floral species of Bangladesh are to be found in the NCR, or the full ecological and economic significance of the diversity of the remaining native flora. The predominant species are of cultivated crops and tree crops. Whether any endangered species could be affected by any particular projects could not become clear unless detailed field work were carried out. Provisions for this should be made in the feasibility stage.

The main future approach needs to focus on the inter-relationships between different habitats and pest and disease relationship. FCDI will change habitats and access to water which affect species composition, trophic relationships and inter-actions of species and nutrient transfer from the wetland and natural floodplain flora and micro-flora.

The trends on resource availability are reasonable clear from the national statistics. Fertiliser and agro-chemical usage has at least doubled over the last decade with the rapid conversion to HYVs. FCDI projects have continued to be implemented and increased population density in rural areas continues to reduce the diversity of habitats. These factors have led to a loss of grazing areas and fodder, and the loss of timber important as fuel supplies and building materials. Animal manure is being diverted from its use as an organic manure and used as a household fuel.

Fauna

Appendix D indicates that some 160 species of birds have been identified since 1971 in regions within or adjacent to the NCR; this encompasses approximately 20% of the country's avifauna. Of these there are almost 80 species which could be affected by project interventions through habitat loss or alteration.

Writing before 1989, Harvey (1990), makes special mention of the critical importance of the Madhupur Forest to what he calls the Central Region, noting that "its protection is of national importance." Virtually the entire remaining area still under good *Sal* cover in the Madhupur has been clearcut within the last several years, with a devastating effect on avian biodiversity which has yet to be scientifically documented. Similarly, during the 1980's, the two largest bils in the NCR - Belai Bil near Kapasia, and Arial Bil, southwest of Munshiganj, both of which were outstanding dry-season habitat for aquatic and piscivorous bird species, resident and migratory - have been subjected to major drainage schemes, dewatering them seasonally for boro cultivation. Accordingly, the NCR's present complement of bird species may be considerably lower than indicated here.

Harvey (personal interview, 1989) also noted it had become common practice among Bangladesh farmers to intersperse among their paddy fields temporary perches intended to attract drongos *(Dicrurus spp.)* which feed on insect pests, such as grasshoppers. Drongos had been becoming scarcer with the intensification of agriculture, particularly after the widespread removal of hedgerows and shrubs. (Drongo feeding behaviour requires elevated resting sites). Farmers recognized a simple method of drongo habitat improvement and implemented it widely.

Harvey went on to express his amazement at the depth of ornithological knowledge still embedded in the Bangladesh countryside, which led him to wonder that there may exist a substantive rural base of ecological knowledge that remains unperceived in Dhaka. He considered the energizing and mobilizing of that constituency as a priority task in environmental management; sentiments that cannot be emphasised strongly enough for the future studies under FAP in the NCR if environmental management planning is to be at all successful.

From over 200 species of mammal that were once common in Bangladesh over half have now disappeared or are seldom found. The impacts in the floodplain have occurred in the last century and through to the 1970s and in the Madhupur only in the last two decades. The loss of habitats has been so significant that little can now be done to restore the balance in the areas. This study does attempt to highlight the few last remnant systems which need urgent consideration and planning for conservation under FAP. The focus of current attention in Bangladesh has shifted to the remaining forested and hill tract areas and to the Sundarbans.

Most of the 19 species of amphibian and 150 reptiles recorded have regularly been exploited. The problems of export of frog legs has led to a ban on trade in some species. BRRI research has confirmed that frogs and toads play an important role as predators on field pests. Together with the fish and other insect predators, they offer considerable economic opportunities for biological pest controls and income generation under an integrated pest management programme (IPM). These issues need to be taken up in the feasibility stage and evaluated more rigorously in the economic analysis.

There are 260 freshwater fish species which utilise the nation's rivers and floodplain and ponds. 13 exotic species of freshwater fish have been introduced. It is estimated that there may be 200 species to be found in the NCR. Over 100 species are known to be marketed and another 40 are thought to be of local economic or social importance. Five

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species are already extinct and about 10 are threatened. There are 20 species of freshwater prawn and 4 species of freshwater crab.

The diverse fish species reflects a wide range of habitats and feeding requirements from bottom feeders, herbivores, carnivores, omnivore leading to controls on aquatic weeds, secondary disease vectors and crop pests. They provide humans with a concentrated form of protein, oils and vitamins. Presently, as a common property resource, poor people and fishing families depend on them for the survival strategies, both in terms of nutrition and income particularly the minor species which have less commercial value. Increasingly, however, this common resource is being leased to individuals.

Little information is available on the diversity and role of insects and fungi. Some data on field pests is available from BRRI and BARC. There are economically important symbiotic relations involving fungi and bacteria in tree and field cropping. Fungi play a crucial link in the decomposition, and the formulation of plant nutrients and a healthy soil environment.

Micro Flora and Fauna

The primary basis of the food chain, energy and nutrient cycling is controlled by micro-organisms, in both the aquatic and terrestrial environments. The role of micro-organisms in flood-carried deposits from upper catchments is not yet understood. Their role has been outlined in work by FAO and BRRI/IRRI.

2.5 The Aquatic Environment

2.5.1 Overview

Aspects of the hydrology and ecology of the lentic and lotic surface waterways of the NCR are also described in SRs II and III (Fisheries and Water Resources).

The extremes of seasonal variation of local hydrological and meteorological conditions in the wettest and driest months record river discharge changing by three orders of magnitude. Similarly, stream stage and the groundwater tables can vary by over ten meters in some places. The principle rivers not only carry large seasonal water flows, but also silt loads which mean a rapidly changing layout of habitats and landscapes as erosion and deposition proceed from year to year.

The evolutionary problem facing organisms colonizing such landscapes is to accommodate these extremes and habitat dynamism. This favours species with physiological and behavioral mechanisms which can cope with the resultant stresses and exploit the powerful dynamic systems which transport and deliver massive quantities of materials, nutrients and energy. Thus, the deltaic and estuarine eco-systems of Bangladesh are characterised by mechanisms (such as migratory feeding and reproduction patterns) which are adjusted to the temporal and spatial boundaries encompassing the full span of annual and seasonal changes. The evolutionary task is quite different to other types of environments where the range of variation is less.

If not in the overall proportion of species, then in the relative share of biomass, fish populations throughout the Indo-Himalayan drainage have evolved floodplain-dependant strategies for reproduction, distribution, and growth.

Such strategies entail the unhindered movement of adult, juvenile, and larval fish between seasonal and permanent or semi-permanent waterbodies synchronized with the advance and recession of monsoonal floodwater across vast lowland landscapes functioning, hydrographically, as annual floodplains.

Current knowledge of the ecology and behaviour of even those floodplain-dependent species is relatively undeveloped. This is a function, mainly of an institutional bias towards culture fisheries, in spite of the continued dependence of cultured fisheries on naturally-spawned and wild-caught fry (Figure V.2.3).

The reproductive ecology of several principal economic fish species - particularly the "Indian major carps" - involves a migratory pattern adapted to the characteristic hydrology of delta. It is believed that initiation of migration and spawning of Indian major carps is cued by increased stream velocity, as small spates of river flow from Himalayan snow melt begin augmenting dry season discharge. The onset of snow melt precedes by some weeks the arrival of the monsoon. This interval is somewhat longer in the Brahmaputra basin than it is in the Ganges.

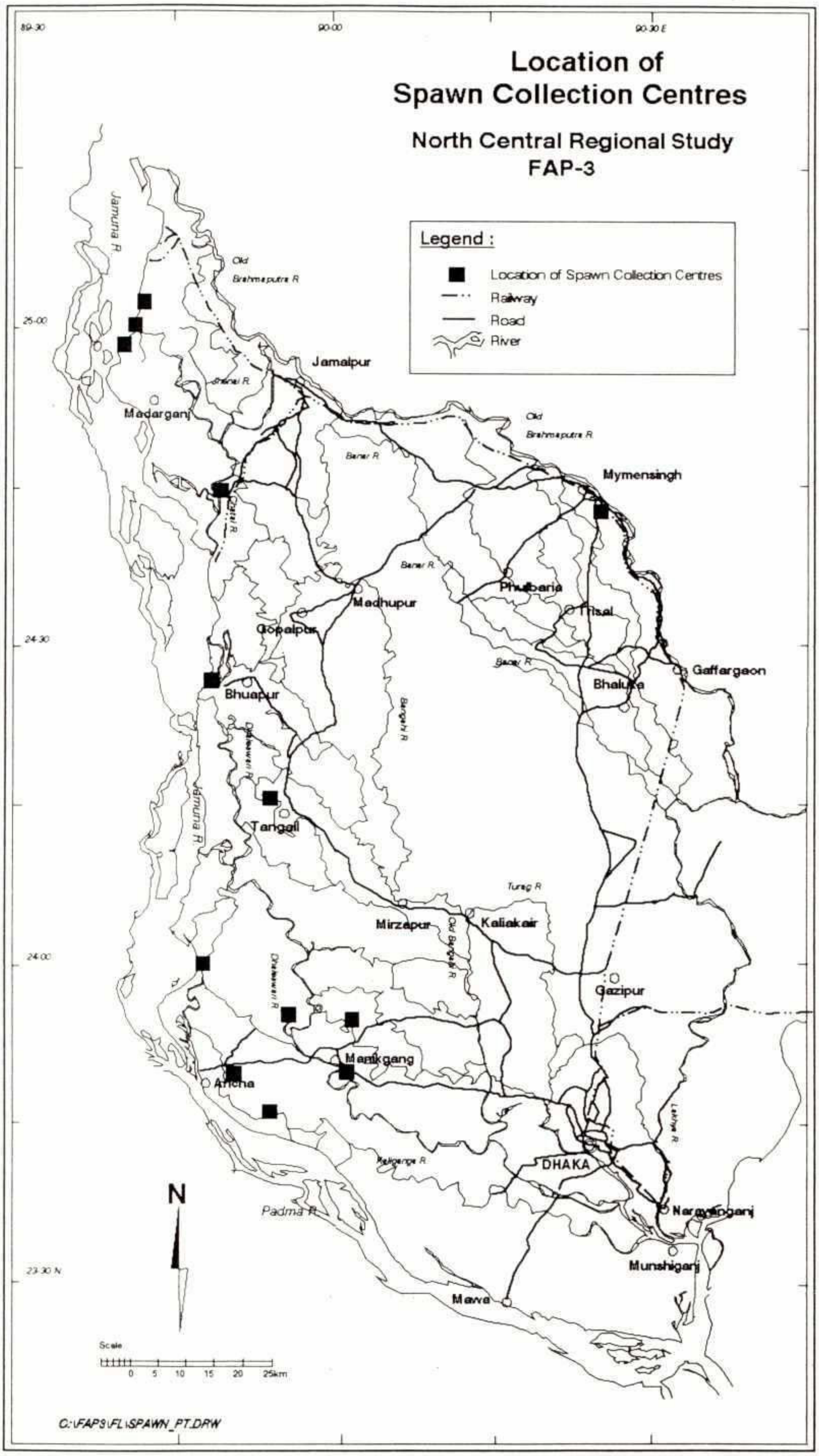
Adult fish in the larger rivers would move upstream before the onset of the monsoon, reaching full reproductive capacity just as overbank flow entered the backswamps shoreward of the natural levees; thence onto and across the larger floodplains. Spawning would thus be initiated so that fry and larvae were produced in time to be carried shoreward with the monsoonal floods, maximizing their spatial distribution, and allowing rapid growth and development (with considerable protection from larger predators) within the nutrient and plankton-rich shallow waters overlying the entire lowland landscape for several months during the height of the monsoon.

As the recession phase begins, the fast-maturing juveniles would be concentrated increasingly in the bils and the khals, where they would remain temporarily isolated from the exterior river system. The degree of development occurring within the bils would vary with the species but, with the arrival of the following monsoon, the previous year class would ordinarily migrate from the bils down the khals to the main rivers, where they would reach full maturity to begin the cycle anew.

Recruitment potential describes the "capacity of a year-class to effectively colonize a habitat" (Cross, 1992). For the major carps of interest, this term refers not only to the actual number of larvae released, but also to how "well-placed" in time and space those releases are, so that the optimum transport and survival of fry occurs before the flood recession impedes or limits those processes. Thus, both the upstream migration, and the sexual maturation of the adult fish, are initiated adequately far in advance of the actual movement of waters across the floodplain so that recruitment potential is maximized. In simple terms, *biology and hydrology must be synchronised for survival.* The precise systems of synchronicity determine the physiology, the behaviour, and the distribution of the fish.

The significance of this cannot be overstated, as any hydrological parameters which are substantively altered by man could increase the likelihood that recruitment could, either fail, or cross a catastrophic threshold beyond which the whole system could not be sustained. The significance for the FAP and policy makers is that there are direct linkages in the food chain and in the cycling of nutrients, chemicals and energy back to the capacity of humans to also sustain their settlement of the floodplains.

Figure : V.2.3


Location of
Spawn Collection Centres
North Central Regional Study
FAP-3
Legend :
Location of Spawn Collection Centres
Railway
Road
River
89-30
90-00
90-30 E
25-00
24-30
24-00
23-30 N
Jamuna R.
Old Brahmaputra R.
Jamalpur
Madarganj
Mymensingh
Madhupur
Phulbaria
Trisal
Gopalpur
Gaffargaon
Bhaluka
Bhuapur
Tangail
Mirzapur
Kaliakair
Turag R.
Gazipur
Manikgang
Aricha
DHAKA
Padma R.
Narayanganj
Munshiganj
Mawa
N
Scale
0 5 10 15 20 25km
C:\FAP3\FL\SPAWN_PT.DRW

FCD implies a major trade off. On the one hand is the productivity inherent in an open aquatic floodplain system where cycling processes are provided free by nature. Against this are the closed systems implied under FCD interventions. These will require, strategically and in perpetuity, inputs of finance, energy, organisation and institution building, not only to "control", but also to sustain and protect, this more rainfed terrestrial environment.

The desired outcome of the FCD interventions, both past and present, is to manipulate river and floodplain hydrology according to the perceived hydro-physical or socio-economic requirements of floodplain settlement, agriculture and economic development. Sometimes the desired change is temporal, as with projects designed to delay the submergence of a particular site long enough to assure a particular crop. Other schemes are essentially spatial when projects move water away from one site and onto another.

2.5.2 Wetlands and Bils

Figure V.2.4 provides the distribution of standing water bodies identified from satellite imagery taken during the dry season. This representation gives an under-sized impression of the size of bil area as they operate seasonally. In Bangladesh, a bil (or beel) is a term loosely applied to seasonal or perennial lentic waterbodies of varying morphologies and origins. Most are saucer-shaped depressions within a flood plain, but also include low-lying regions adjacent to active watercourses. Many smaller bils are connected to the exterior river system only through overland flow of floodwater during the monsoon. Larger bils are sometimes linked to primary or secondary rivers through natural channels (or artificial canals) called "khals". Floodplain bils are usually intimately connected to groundwater, and their filling and draining closely corresponds with local phreatic levels.

As the monsoonal floodwater recede following the onset of the dry season, the water depth and surface area of a bil gradually decline. The smaller bils sometimes become completely dry before the next monsoon arrive. Larger bils tend to be more perennial. The very largest bils in the NCR (Arial Bil in PU 13, and Belai Bil in PU 9), traditionally supported substantial numbers of professional fisherman. Until significant dewatering of Belai Bil began in the 1970s, an estimated 15,000 "Jhele' (fishing caste) families subsisted there year-round. Historically, Belai and Arial bils also served as winter habitats for large populations of migratory and resident waterfowl, and for a host of other piscivorous avian species.

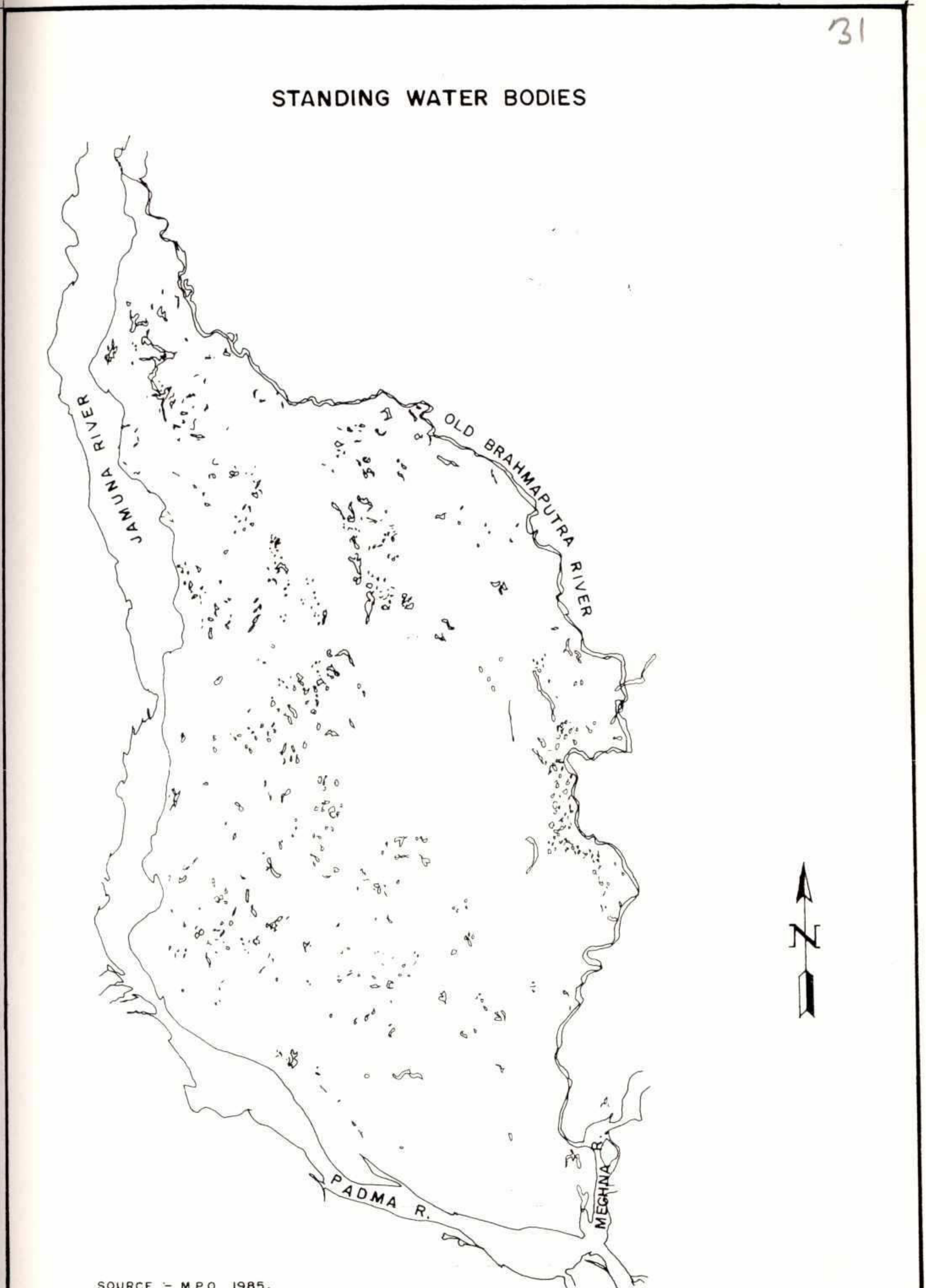
The ownership of bils is complex, with the floor beneath those parts of larger bils which remain permanently inundated usually classed as "khas" (i.e., public, or state-owned) land. Conversely, the ring of recession around the floors of a semi-permanent bil was usually under private ownership.

The high levels of residual soil moisture and enhancement of soil fertility by organic debris brought in with the floodwater, together with its inherent primary productivity, means that ephemeral bils have always served as good sites for agriculture, particularly in the dry season.

However, what has been, and still is, under-appreciated is the value of the bils in contributing to a series of "wetland processes" which contribute directly or indirectly to the support of nutrition, economics, quality of life and wildlife systems both at the regional, national an international level. The primary biological mechanism driving these processes is the diversity of migratory and resident fish species.

Figure: V-2.4

31



In terms of landings and catch, bil fisheries often displayed high natural levels of "productivity"; as much as 5,000 kg per ha per year. Such figures did not reflect processes only of production within the narrow confines of the bil, but were indicative of fluxes of organisms, nutrients and energy transfer throughout a much larger interconnected fluvial and food chain system; and thus by outputs of use to man into the economic and nutritional sectors.

Any physical impediment obstructing, or perhaps even delaying, the bi-directional passage of waters, and of adult and juvenile fish, between river, floodplain, bil, and khal could have grave consequences for recruitment and production of migratory carps. Even graver would be the consequences of completely removing perennial bils from the systemic chain, by isolating and dewatering them. This has been the outcome of many previous drainage, reclamation and agricultural improvement projects and care is required to minimise such impacts with those presently underway. It also occurs when food-for-work (FFW) embankments or roadway projects are sited irrespective of hydro-biological considerations. The same repercussions occur when tubewell irrigation schemes in the vicinity of a bil lower the local groundwater table sufficiently to dry them out through the downward percolation of waters toward the depressed surface aquifer.

Seasonally dewatered bils are especially attractive for conversion to HYV boro rice which can take advantage of the residual soil moisture. Even where some residual segment of the bil remains perennially inundated, the repeated applications of biocides essential to HYV boro rice culture are usually inimical to the aquatic community. Although ecologically benign pesticides might be deployed, or special internal embankments constructed to isolate agricultural runoff from fish production areas, in practice, the farmers most likely to benefit from reclamation schemes are also those who are least likely to engage in incidental, subsistence fishing. Therefore, seldom do interests converge to ensure that additional investments are made to protect floodplain fisheries.

2.6 The Madhupur Tract

Bangladesh contains two large areas of slightly uplifted "old alluvium"; the Barind Tract in the north west region and the Madhupur Tract in the NCR. These are topographically and pedologically quite distinct from the rest of the deltaic landscape which has considerable effects on the zonation of natural and agricultural systems they contain, and on the ecology of their human and non-human populations. The larger of the two, the Madhupur Tract, lies entirely within the NCR and occupies approximately 240,000 ha, about 19% of the overall NCR and extends nearly as far southwards as Dhaka.

The extent of the Madhupur system is generally defined by the rivers Bangshi on the west, and Banar on the east. While they receive some portion of their discharge from watersheds outside the Madhupur tract, the hydrology, morphology, navigability, and hydro-biology of the Banar particularly (and perhaps the Bangshi as well) appear to have been strongly impacted by the cutting and conversion of the former forest. Similar effects may also be manifesting in lowlands subject to the overflow of the Banar and the Bangshi, as well as those ponds, bils, and tanks also receiving such floodwater. The influence of recent landuse changes on the Madhupur's internal streams and on its baids and bils, would be relatively greater.

Up until the early-1960s, virtually the entire Madhupur Tract remained under cover of relatively large trees, with a nearly-continuous canopy. Certain sectors were on short rotation for poles or coppiced for firewood. While there had been managed exploitation, with appropriate reforestation, of major parts of the Madhupur for hundred of years, other large portions had never been cut. Although the Madhupur was usually referred to as a "Sal" forest, after the common name for *Shorea robusta* the dominant tree species, there was still considerable floral diversity, in both the understorey and canopy vegetation.

Given the park-like open structure that characterizes a natural *Shorea* forest, the term Madhupur Jungle was technically a misnomer, and referred probably as much to its fabled wildlife populations. The bulk of the forest has so recently been removed, that people in Dhaka still ordinarily speak of the area extending northward from Tongi as the "Madhupur Jungle."

Topographically, the Madhupur consisted of forested plateau complexly dissected by low valleys, some which formed rather large seasonal lakes ("bils") during the monsoon. The narrower interior valleys, locally known as "baids" were probably herbaceous wetlands in their pristine state. These were mostly converted to rice culture long before the upland forest was itself cut or converted.

There exists a considerable population of Tibeto-Burmese tribal people in the Madhupur, subsisting on rice from the baids, and formerly from game from the forests. They may themselves have been relatively recent migrants to the area, possibly arriving only within the last century or two.

As with the non-tribal population of the NCR, the population of tribals has risen sharply in the last several decades, and it is problematic as to whether their traditional custodianship of large parts of the Madhupur forest could have been indefinitely maintained in the face of their own demographic realities, even if there were no outside forces brought to bear on the system.

By 1985, the largest part still remaining of old-or-intermediate growth forest was in the northeast area of the Tract, where 30-40,000 ha was afforded the greater protection by its gazetting under the "Madhupur National Park". Despite this, loss of forest continues.

The almost final demise of the original forest resources has come between 1985 and 1991 despite "agro-forestry" and "social forestry" schemes. There has been the unofficial involvement of the private sector and nearly the entire Madhupur National Park has been deforested by clear cutting. All that remains now of the northern Madhupur forest is the "high-visibility" protected zone around the Park Village itself; the roadside corridors along the routes still accessible to Park visitors; and along a portion of the Muktagacha highway. It can be inferred that the Park's associated flora and fauna and wildlife populations were reduced proportionate to the loss of their habitat. This southern remnant forest between Kapasia and Sripur is not under any such protection, and intensive logging of *Sal* is clearly underway there.

The present remnant of once high-quality "deciduous monsoonal forest" still extant on two isolated tracts within the Madhupur amounts to only about 3,000 ha - approximately 0.025% of the total NCR area. Virtually no other natural forest remains, although rural homesteads, as throughout Bangladesh, generally incorporate significant plantings of a wide variety of useful trees, native and exotic.

A reafforestation programme has been proposed but for various reasons has not been carried out. The plantation species proposed were *Hevea* and *Eucalyptus*, neither of which would provide replacement habitat for the native fauna already extirpated by the project.

The recently deforested sectors of the nominal Park comprise a large component of the 90,000 ha of former Madhupur forest lands now neither forested or cultivated, a reflection of the relative infertility of Madhupur soils (see SR I), although overall cropping intensity within the cultivated 150,000 ha of Madhupur forest lands is still an impressive 166%. Thus, from a habitat and forestry perspective, the latter figure suggests that the restoration of the Madhupur's previous floral and faunal communities - artificially or "naturally" through secondary succession - is no more likely there then in the remainder of the NCR.

2.7 Water Quality and Pollution

While the massive flood and monsoonal dilution effect might be expected to guarantee good water quality, this cannot automatically be assumed. For potable water, and human and biotic health there are a complex set of seasonal, chained and assimilation processes which have to be researched and understood before reliable planning of interventions into the control of water systems can take place. Some issues relate to general development trends which have to be accommodated in any case, others relate to the direct need for good design, operation and integrated planning of hydraulic structures and community health and sanitation programmes.

Bangladesh is the venue for the International Centre for Diarrhoeal Disease Research (ICDDR); a reflection of the scale of this problem in Bangladesh. Cholera is known to be endemic and widespread. Agro-chemical pollution has become an increasing topic of debate in the media, and the continued production and use of DDT throughout the sub-continent can only be having many cumulative effects in the food chain, affecting fish, animals, birds and humans alike. Foci of unplanned and un-assisted industrial units have already been identified to be responsible for pollution of atmosphere, groundwater and surface water. Such pollution is evident in the industrial centre of Dhaka and in the satellite towns of Savar, Tongi and Narayanganj.

In spite of the massive flows of river and rain waters, shortages of surface water occur in some places in the dry season. The ground water reserve is adequate except in areas like Madhupur, Mymensingh and Gazipur, at least under the present flood inundation and recharge regimes.

Both lentic (standing) and lotic (flowing) waterways are being impacted, either by induced or natural siltation, by discharges of effluent and sewage, by encroachment of landfills or agriculture, and by changes in the groundwater regime. At least seasonally, the assimilation capacity of some of the region's major flowing waterways is exceeded by the wastes delivered into them. The visual evidence includes numerous sites around Dhaka showing anoxia and putrefaction. Many standing waters in rural areas are being smothered by water hyacinth which can choke the water body and depriving the water column of adequate sunlight to support oxygen generating photosynthesis. In these circumstances this aquatic macrophyte is a prolific exotic pest which can be difficult to control. However, there are also some areas in Bangladesh where it is not only controlled, but also managed to provide habitats for fish, a soil manure when dried and floating beds for young rice seedlings.

Due to the low absolute solubility of oxygen at ambient water temperatures in the tropics, tropical aquatic ecosystems are, in principle, particularly sensitive to further depression of dissolved oxygen (DO) levels which might be induced by natural or anthropogenic eutrophication, by increased turbidity (thus reducing aquatic photosynthesis), or by heightened water temperatures following reductions in volume or depth.

Eutrophication problems have also to be seen in the context of the estimated 4,000 metric tons of human faeces generated daily in the NCR. Only a minor portion is subject even to primary sewage treatment and is eventually mostly delivered to aquatic environments with the onset of the monsoon and flood season. Here it enters into the food chain and can be assimilated into the primary productivity of micro-organisms and aquatic flora and fauna which has a finite threshold before the waters become polluted and eutrophic.

Many genera of tropical fishes have evolved quite dissimilar physiological and behavioral adaptations to cope with eutrophication; notably an array of differing structural mechanisms enabling aerial, as well as aquatic respiration. Whereas, many of the predatory icthyifauna inhabiting the bils and ditches (e.g., *Channa, Heteropneustes*, *Clarias*, *Anabas*, etc.) are "facultative air breathers", *Nandus* is not and would thus be at risk in any eutrophic water bodies.

The adverse pressures are most evident on urban waterways because in the cities, the population explosion is most extreme and the value of dewatered real estate is maximum. The services and benefits yielded by urban waterways are now widely acknowledged in the popular press, but have yet to be developed to their potential. Many of these degraded water bodies could be restored to more productive roles in transport, agriculture, fisheries and enhancement of the quality of life in urban areas through advances in planning and management. However, there exist institutional, and technical constraints against so doing.

Zones of potential contamination of biocides include several areas of intensive agriculture around the Chatal, Banar and Bangshi rivers near Jamalpur, as well as the old course of the Brahmaputra river. The most critical areas of industrial effluent discharge other than Dhaka are Savar, Tongi, and Narayanganj where there are a variety of industries as shown in **Table V.2.1** and **Figure V.2.5**. These include jute, textile and cotton, chemicals, foods, pesticides, pharmaceutical, plastics and paint industries. Predictably Dhaka produces the highest contamination of urban and industrial wastes released into waterways. The tanneries at Hazaribag, other industries around Tejgaon industrial area, and the extensive sewage pollution and urban runoff released into the Buriganga river are of particular significance. From Sadarghat to Pagla, extending up to Narayanganj and the adjoining Sitalakhka river, there are an array of jute, textile, paper and pulp, fertilisers, pesticide and pharmaceutical industries; none of which have adequate effluent treatment or control facilities.

The NCR study had limited resources to collect water samples and there is no existing reliable database on water quality. The NCRS team did collect and analyze a limited number of samples of different selected water bodies as shown in **Figure V.2.6** and given in **Table V.2.2** and **Table V.2.3**.

The samples were collected during October at the end of the wet season, when dilution levels were still high. This limited analysis compares indicators against the standards set out in the Environmental Quality Standards set by the DOE for various parameters. The preliminary data show some areas where pH readings are high. DO is generally good, and BOD is within the allowed range of 8 mg/L. However, the COD of some samples taken near Hazaribagh are much higher than the permissible standards. There is also evidence, even in the rainy season, of industrial pollution in the Lakhya, Dhaleswari and Meghna rivers as the recipient of Narayanganj industrial wastes.

Figure : V.2.5

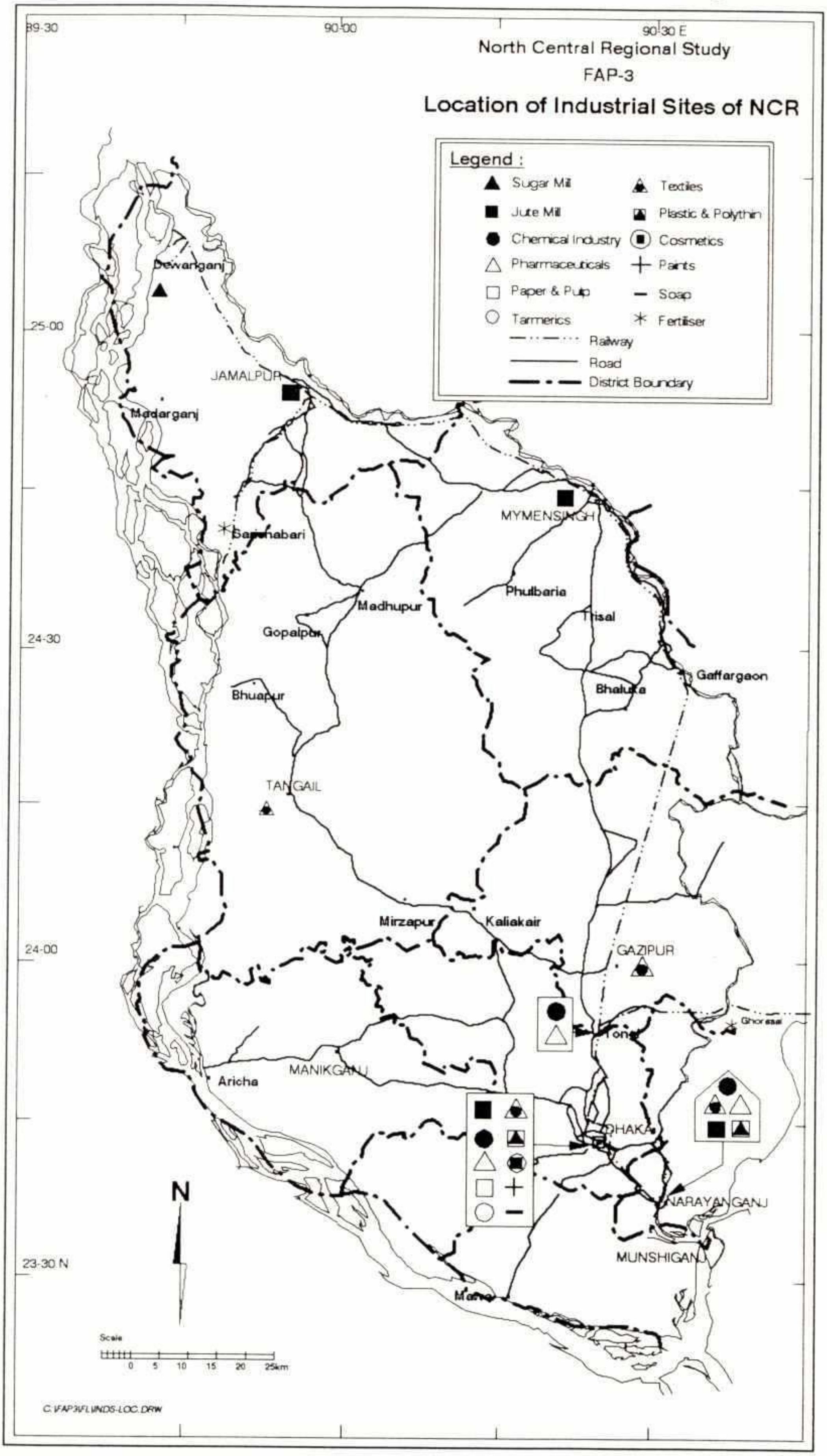
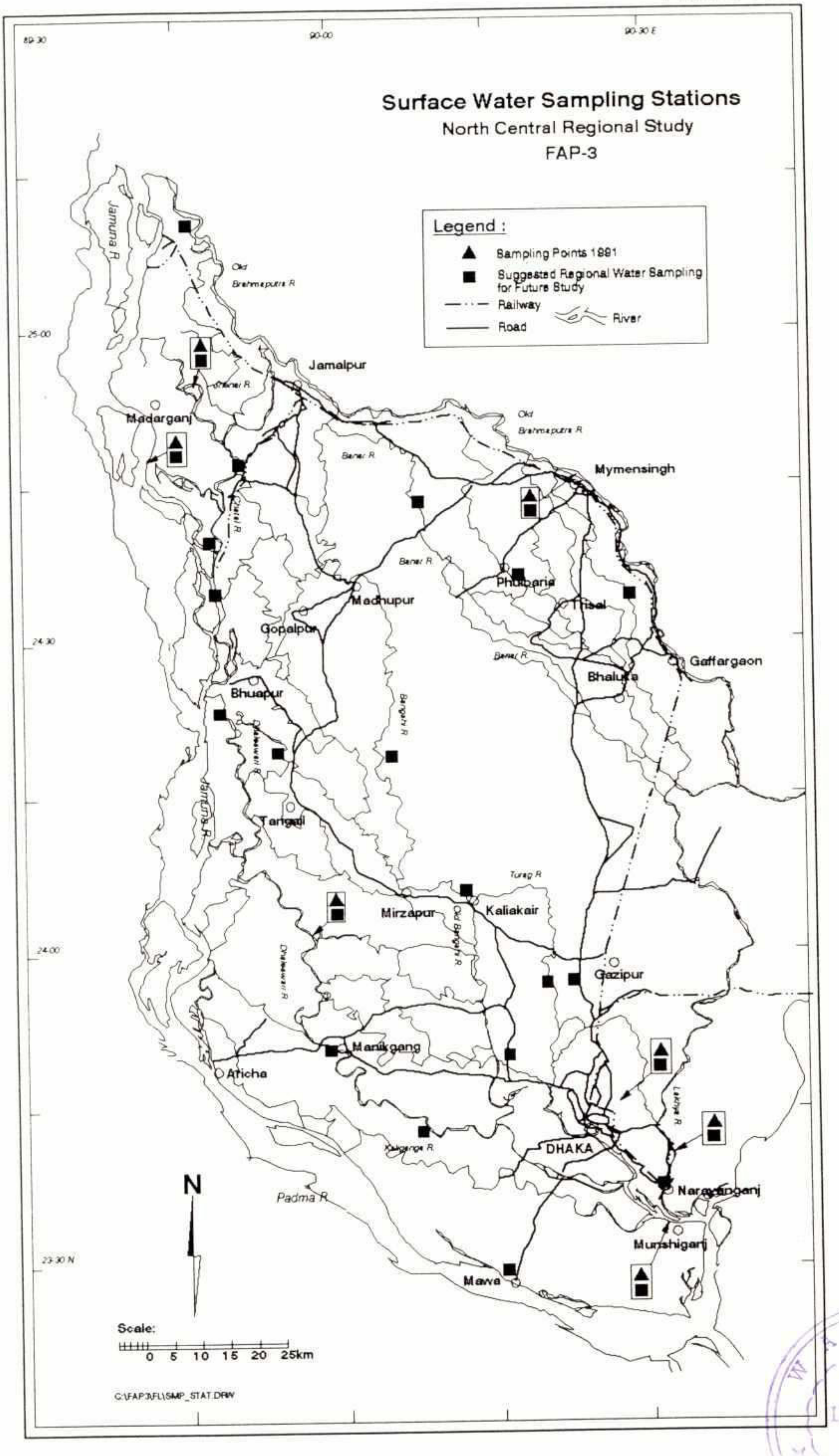

89-30
90-00
90-30 E
North Central Regional Study
FAP-3
Location of Industrial Sites of NCR
Legend :
Sugar Mill
Textiles
Jute Mill
Plastic & Polythin
Chemical Industry
Cosmetics
Pharmaceuticals
Paints
Paper & Pulp
Soap
Tannerics
Fertiliser
Railway
Road
District Boundary
25-00
24-30
24-00
23-30 N
Dewanganj
JAMALPUR
Madarganj
MYMENSINGH
Phulbaria
Madhupur
Gopalpur
Trisal
Gaffargaon
Bhaluka
Bhuapur
TANGAIL
Mirzapur
Kaliakair
GAZIPUR
Ghorasal
MANIKGANJ
Aricha
DHAKA
NARAYANGANJ
MUNSHIGANJ
N
Scale
0 5 10 15 20 25km
C:\FAP3\FLUNDS-LOC.DRW

Figure : V.2.6


Surface Water Sampling Stations
North Central Regional Study
FAP-3
Legend :
Sampling Points 1991
Suggested Regional Water Sampling for Future Study
Railway
Road
River
Jamuna R
Old Brahmaputra R
Jamalpur
Madarganj
Mymensingh
Banar R
Madhupur
Gopalpur
Phulbaria
Trisal
Gaffargaon
Bhaluka
Bhuapur
Tangail
Jamuna R
Turag R
Mirzapur
Kaliakair
Old Bangshi R
Dhaleswari R
Gazipur
Manikgang
Aricha
DHAKA
Lakhya R
Narayanganj
Padma R
Munshiganj
Mawa
N
Scale:
0 5 10 15 20 25km
C:\FAP3\FL\SMP_STAT.DRW

Ammonia, nitrate, phosphate, sulphate and chloride contents were satisfactory. The total suspended solids showed slightly higher counts in the Brahmaputra river. The total viable biota counts were very high (10^6-10^7 per 100 ml). The maximum limit being 5 x 10^3 whereas pathogenic bacteria were absent. This indicates poor quality of waterbodies and severe bacterial contamination with high local pollution (COD).

It is clear that a proper, well-resourced national monitoring programme is required to assess seasonal water quality variations. Water quality and biological sampling of selected ponds should also be initiated to monitor pollution-related problems with aquatic flora and fauna. Non-degradable and soluble pesticides and fertiliser find their way into the drainage network; other biocides become locked in the soil bio-system and food chain; and thus, residues and trace metals released must also be determined. UNICEF and CARE have carried out a number of preliminary water quality studies orientated to water supplies for potable uses, and their data base should be integrated into the national system.

2.8 Aerial Pollution

Rural aerial pollution from local sources are low in Bangladesh. Pollution from industry and urban areas is growing. Some pollution is being generated from rural mechanisation in terms of physical damage to river banks and turbidity associated with the conversion of country boats to motorised power using the shallow tubewell engines. The growth in demand for kiln bricks has also led to a rise in the use of fossil and timber fuels and the output of smoke and particulates. There is very little data available on which to make any assessment of its significance.

TABLE V.2.1

Industrial Locations in the NCR

Locations	Tannery Chemical	Sugar Mills	Jute Mills	Indust. Mills	Pharma ceutical	Paper Mills	Polythene	Textile	Cosmetic	Paint	Soaps	Fertilizer
Dhaka	1	28	35	99*	3	22	39	39	15	55	98	3
Narayanganj	1	9	4	*	--	4	16	--	--	14	--	--
Tongi	--	--	--	*	--	--	--	--	--	--	--	--
Savar	--	--	--	*	--	--	--	--	--	--	--	--
Gazipur	--	--	--	--	--	1	--	--	--	--	--	--
Mymensingh	1	3	--	--	--	--	--	--	--	--	--	--
Tangail	--	--	--	--	1	--	--	--	--	--	--	--
Jamalpur	1	1	--	--	--	1	--	--	--	--	--	1

* = Figure inclusive Dhaka, Narayanganj, Tangail, Savar

Source: Selected Industrial Director ate 1988.

TABLE V.2.2

Preliminary Water Quality Data from Selected Waterways

Sample\Source	pH	Temperature (oC	DO* (Mg/L)	BOD* (MG/L)	COD* (Mg/L)
Berry Bad, Satmasjid Road, Dhaka	7.76	29.10	7.00	1.20	40
-Do- (inside)	7.62	29.50	6.20	1.50	
-Do- (inside)	8.18	29.00	3.30	3.60	
River Buriganga	8.33	29.00	3.00	3.00	20
-Do- (inside)					
Muktapur Ferry Ghat					
Munshiganj (Dhaleswari)North	7.21	31.80	7.60	0.60	10
Munshiganj (Dhaleswari River) South Pond	7.53	31.80	7.80	2.40	80
Munshiganj (Dhaleswari River)	7.18	12.00	7.60	1.80	
Munshiganj khal(Dhaleswari River)	7.53	31.90	7.80	0.60	
Mymensingh Sombhuganj (Sutia River)	8.10	31.60	8.00	1.20	
-Do-	7.97	31.50	7.60	0.60	20
Sombhuganj (Old Brahmaputra)	7.80	31.50	7.20	0.60	10
Baushi Bridge Jamalpur	8.03	31.80	7.60	0.90	
-Do- (Baushi Bridge)	7.87	31.70	7.50	1.80	5
-Do-	7.28	32.00	3.20	7.80	
Baushi river, Jamalpur	7.33	31.80	2.50	6.00	
Jamalpur Circuit House khal	7.80	27.40	7.80	3.00	
Jamalpur (Old Brahmaputra)	8.00	32.00	8.00	1.80	
Patharia, Jamalpur(Old Brahmaputra)	7.97	31.50	7.6	0.90	
	8.05	31.50	7.6	2.10	25
Standards, (EQS, DOE, July, 1991)					
Drinking Water	6.5-8.5	20-30°L	6.0	0.2	4.0
Industrial Water	6-9.50	20-30°L	5.0	10	3-10
Irrigation Water	6-8.50	20-30°L	5.0	10	NYS
Fishing Water	6.5-6.5	20-30°L	4-6	6.0	NYS
Recreation Water	6-9.50	20-30°L	4-5	3.0	4.0

Note: * Do = dissolved oxygen, BOD = biochemical oxygen demand, COD = chemical oxygen demand

** NYS = not yet settled.

Source : CS 1992

TABLE V.2.3

Water Quality Sampling-(Electrolyte Composition and Pathogenic Bacterial Counts per 100ml)

Sources	Ammonia Mg/L	Nitrate Mg/L	Phosphate Mg/L	Sulphate Mg/L	TSS (Mg/L)	Chloride Mg/L
Buriganga	0.04	0.80	0.12	7.0	12-50	4.3
Dhaleswari	0.06	NIL	ND	ND	5.0	3.6
Sitalakhya	0.72	0.1	ND	ND	0.94	ND
Brahmaputra	0.21	NIL	0.03	12.0	52-72	6.4
Standards	0.075-3	NYS(250)	6-10	400-1000	10-75	150-600

	Total Viable Coliform count/100ml	Total Pathogenic Count/100ml
Buriganga	$7x10^6$	Nil
Dhaleswari	$8x10^6$	Nil
Sitalakhya	TNTC	Nil
Brahmaputra	$1x10^7$	Nil
Standards	$10\text{-}5x10^3$	-

Note : TNTC : Too numerous to count

Source: CS 1992

2.9 Health and Nutrition

Health problems are intimately connected with the socio-economic status of local communities and the institutional capabilities of the public health and sanitation services. There are a complex set of interactions which are affected by the management of water. The annual flood is believed to help control the habitats of pests and diseases and the population of some diseases and disease vectors. FCDI interventions risk the spread of habitats suitable for the mosquito vectors responsible for malaria, lymphatic filariasis, Japanese encephalitis, dengue virus fever and the sandfly vector of leishmaniasis. Increased populations of biting insects can lead to skin irritation and infections. Filariasis and leishmaniasis seem to be confined to areas in the north west and malaria to the hill tracts and higher ground in the north central and north west regions of the country.

Water-related disease can be spread through different transmission routes including water-borne, water-washed, water-based or through a water-related insect vector. The main disease groups which need to be considered include the faeco-oral disease (these include the diarrhoea, dysentery, cholera and typhoid types); the skin and eye infections, (like trachoma or scabies which are transmitted from person to person due to a lack of water for personal sanitation); insect vector diseases (such as malaria, filariasis and leishmaniasis, involve mosquitoes and sandflies which breed in or bite near water). All these could be affected (beneficially or adversely) by FCDI. Schistosomiasis is not present in the NCR but there are a number of water-related disease which affect the large and small farm animals.

The problems of poor nutrition for humans and animals are widespread. It is a complex area of research which the environmentalists have had few resources and insufficient time to appraise properly at this stage. There is a significant prevalence of vitamin deficiency and goitre in the NCR. The latter being associated with iodine deficiency in free draining soils and noted along the left bank of the Brahmaputra in the FAP 3.1 planning area.

The role of common property resources, particularly fish, and the diversity of food and tree crop types, have been identified as important dietary implications which ought to be integrated into the agricultural planning. These factors need to be considered carefully in the next stage of the FAP planning. It is recommended that both public health and nutrition are given specific specialist inputs in the feasibility stage.

2.10 Navigation

Three types of navigation systems are important in the NCR.

i) Navigation along routes recognised and classified by the Bangladesh inland water transport authority (BIWTA).

ii) Navigation along other unrecognised routes.

iii) Non-routed short and long distance navigation particularly on F3 land during the rainy season.

Routes are classified by the BIWTA on the basis of sustainable least available depth (LAD) as shown in **Tables V.2.4, V.2.5** and indicated in **Figure V.2.7**. There are four types of river routes in the NCR see **Table V.2.4.**

Class 1 to 2 river routes are useable year round. Class 3 to 4 river routes are seasonal with the exception of Lakya to Ichamoti. Country boats and mechanized boats may ply all year round in the Class 4 route. There are many class 4 river routes in the NCR but those rivers have not been identified officially as yet. From Dewanganj (Old Brahmaputra) to Katiadee have been seriously degraded. The reason according to BIWTA seems to be due to siltation and also change of river course.

Other unrecognised routes/passages are generally along shallower parts of rivers and khals plied by mechanised and non-mechanised country boats, basically serving as feeders to the classified routes. These routes serve the minor regional market centres and other settlements. All of these routes are seasonal.

Non-classified navigation routes are mainly during the rainy season for inter-village communications. In particular, most of the deep flooded land is open to navigation by small or large country boats connecting commercial centres with far - flung villages.

Figure : V.2.7

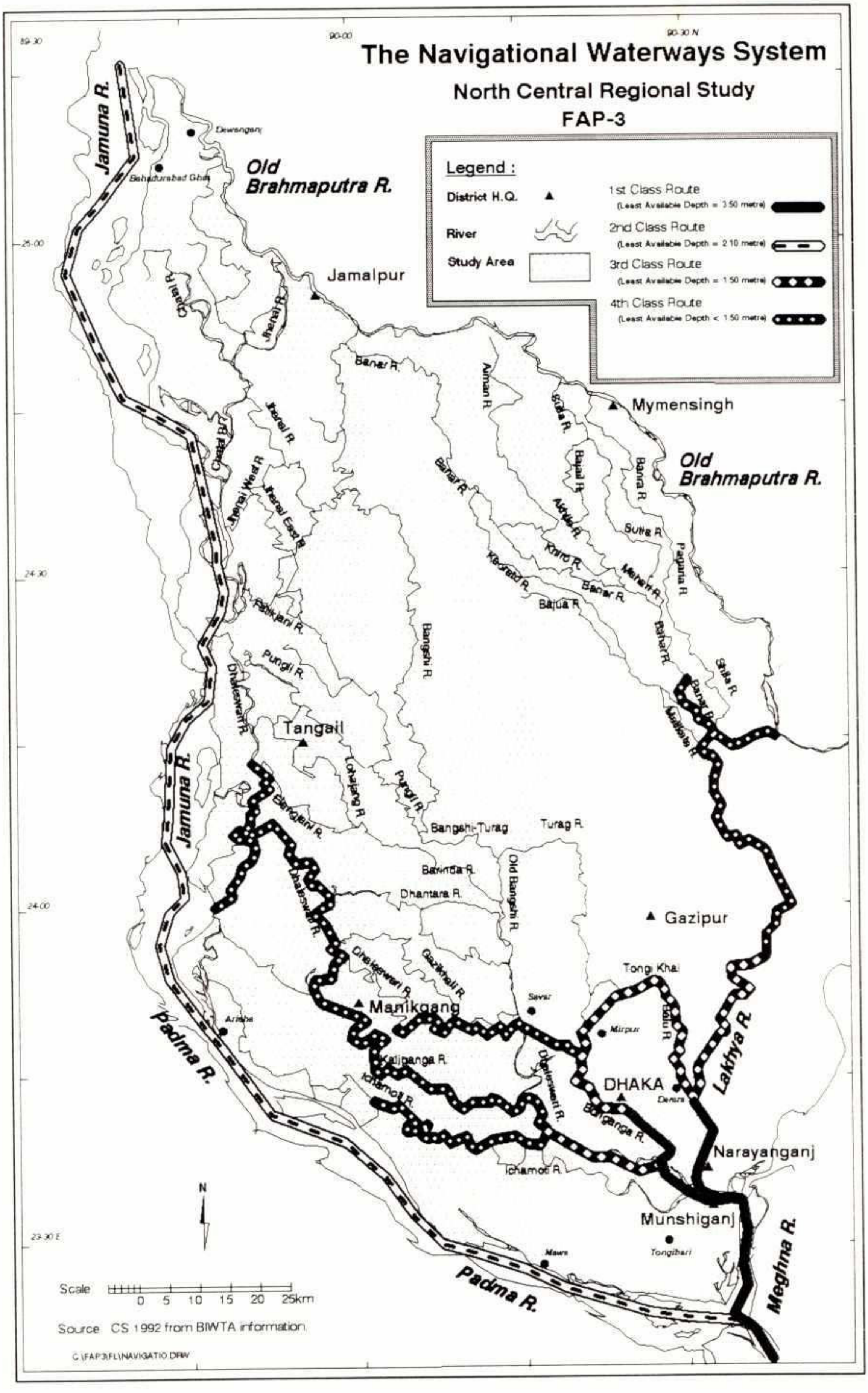

The Navigational Waterways System
North Central Regional Study
FAP-3
Legend :
District H.Q.
River
Study Area
1st Class Route
(Least Available Depth = 3.50 metre)
2nd Class Route
(Least Available Depth = 2.10 metre)
3rd Class Route
(Least Available Depth = 1.50 metre)
4th Class Route
(Least Available Depth < 1.50 metre)
Jamuna R.
Old Brahmaputra R.
Dewanganj
Jamalpur
Mymensingh
Tangail
Gazipur
Manikganj
Savar
Mirpur
DHAKA
Demra
Narayanganj
Munshiganj
Tongibari
Mawa
Aricha
Padma R.
Meghna R.
Lakhya R.
Tongi Khal
Turag R.
Bangshi-Turag
Bangshi R.
Old Bangshi R.
Dhantara R.
Dhaleswari R.
Kaliganga R.
Ichamoti R.
Buriganga R.
Banar R.
Sutia R.
Scale
0 5 10 15 20 25km
Source CS 1992 from BIWTA information
C:\FAP3\FL\NAVIGATIO.DRW

TABLE V.2.4

Navigation Types of River Routes

		Route	River	Length
Class I Routes (LAD = 3.5m)				
	(a)	Dhaka-Chittagong	Buriganga-Lakhya	30 km
	(b)	Demra-Narayanganj	Dhaleswari-Meghna	22 km
Class 2 Routes (LAD = 2.1)				
	(a)	Tongibari-Dewanganj	Padma-Jamuna	190 km
Class 3 Routes (LAD = 1.5m)				
	(a)	Demra-Ghorashal	Lakhya River	37 km
	(b)	Dhaka-Mirpur	Turag River	53 km
	(c)	Buriganga mouth Saidpur	Dhaleswari	15 km
Class 4 Routes (LAD <1.5m)				
	(a)	Ghorashal-Toke	Lakhya, Old Brahmaputra	62 km
	(b)	Sadar-Nayarhat Dhamrai	Baushi River	10 km
	(c)	Mirpur - Savar	Kamapare Dhaleswari	15 km
	(d)	Rustampur-Kaliakoir	Turag River	55 km
	(e)	Saidpur-Singair	Dhaleswari	80 km
	(f)	Katpatty-Gourganj	Ichamoti River-Taltala	22 km
	(g)	Saidpur-Sreenagar	Ichamoti River	18 km
	(h)	Saidpur-Salna	Dhaleswari River	10 km
	(i)	Bahadurabad	Old Brahmaputra	22 km
	(j)	Paragaon-Tara-Shijani	Dhaleswari River	86 km
	(k)	Toke-Kaoraid	Banar/Kaoraid River	20 km

Note : LAD = Least available depth

Source : BIWTA 1989

TABLE V.2.5

Navigation Route Classification and Lengths

Class	LAD(m)	National(km)	NCR(km)
1 - Perennial routes	>3.5	683	52
2 - Perennial routes	>2.1	1000	190
3 - Seasonal routes	>1.5	1885	105
4 - Seasonal	<1.5	2400	400

Source : BIWTA 1989

CHAPTER 3
MATRIX IMPACT ASSESSMENT

3.1 Introduction and Approach

A preliminary matrix of possible bio-physical effects has been devised and is given in **Table V.3.1**. This summaries by category some of the more important impacts which could emerge as policy making or research issues in the consideration of the preliminary Regional Schemes at this pre-feasibility level.

The iterative planning requirements under modern EIA procedures necessitate a preliminary checklist determined through initial scoping and public participation. This leads to a first internal working document on likely key issues to be considered in the early phases of the planning,in the conceptualization and organization of the actual research. The preliminary checklist phase was carried out through coordination in mid-1991 which is used with FAP 16 and FAP 2 and 5. Each of these studies had been reviewing the likely boundaries of potential impacts and focused on likely key issues.

At the pre-feasibility level of assessment, only "rapid rural appraisal" modes of fieldwork, entailing "scoping", "bounding", and an absolute minimum of ecological data collection have been possible. Only after substantive fieldwork and additional research would it be possible to construct a credible revised matrix (and even then still mainly in qualitative terms). The NCR's environmental analysis has been constraint by the fact that little time was available to carry out site - specific and project - specific data for environmental impact analysis.

The field work concentrated on case study surveys in selected areas within the region. The context of public participation at the regional level has not yet been mobilised. For public participation to be successful a major mass media and public debate is required. Such an exercise was not part of the original TOR of the individual regional studies but is now being considered for future action by the FPCO.

Establishing impact boundaries is paramount in the systems analysis which underpins much of the approach to impact analysis and where the determination of inter-sectoral and inter-disciplinary linkages are crucial. The impact assessment has avoided representing impacts as being generalized (i.e., "scheme-wide") when spatially these impacts could have very different levels of impact in different areas.

For example, in providing flood protection and isolating a large region from riverine flooding a number of different scenarios are under consideration. One option requires embankments with concomitant increases in stream stage, velocity, and discharge. Other scenarios involved complete diversion of headwaters, or installation of regulators. In considering different issues, matrix categories, such as "water quality", or "wetlands impacts", often are insufficient unless specifically addressed to the correct geographical area. Impeded drainage and flushing within the protected area might result in reduced water quality inside but the water quality of the river itself could improve, with the increase in the dilution and removal of pollutants.

Similarly, certain regions landward on the unembanked opposite shore but outside the protected area of this particular scheme could be expected to experience increased flooding, because of the rise in stage and discharge. In this way some of the region's wetlands (not being generally embanked) would possibly be enhanced, as would rates of flushing and indices of overall water quality.

To design a matrix reflecting these actualities requires that the problem of boundaries is manifest. The different zones which have been examined for differential impact include the floodplains of protected areas; the river(s) to be subjected to hydrological changes; and the exterior collateral regions also serving as possible impact zones.

3.2 Matrix Assumptions

Each impact category has been sub-divided into three parts: Ef, Ei, and Ec. These refer, respectively to potential effects within the project area *floodplains* (Ef); the potential *instream* effects within the project area river net, including interior and peripheral waterways (Ei); and the potential *collateral* effects (Ec), which could arise or become manifest outside the project area. "Ec" may include riverine, as well as upland impacts. Collateral effects might occur adjacent to, either up-or-downbasin of the "improvement zone", or otherwise outboard of those waterways to be *directly* modified under the Regional Schemes.

Project interventions generally intended to "terrestrialize" the landscapes, would often result in minor-to-substantive negative impacts on the remaining natural systems. Thus, a presumptive value of -1 or lower is ascribed to all "Natural Environment" categories encompassing biodiversity, habitat, flora and fauna. The magnitude of environmental disbenefits borne by fish and wetlands are regarded even more significant, and ascribed - 2, or lower.

It is also presumed that the periodicity, the absolute area, and the water quality of bils, wetlands, and khals within the floodplains would all be negatively impacted by terrestrialization: both by direct or indirect "dewatering", following the overall reduction of inundation; and by the increased usage of agro-chemicals usually associated with the adoption of HYV cultivars.

It is of concern that while there indeed might be enough rain to recharge the groundwater table - regardless of the proposed alteration of riverine flood regimes - the possibilities of project-induced "droughtiness", as opposed to groundwater drawdown, warrant serious concern and is flagged as -2 also. Similarly, the highest consideration must be given to the possible depression of surface aquifers by channelization and dredging schemes which is also flagged as an issue.

TABLE V.3.1

Preliminary Subjective Environmental Impact Assessment Matrix

			RS2		RS3A	RS3B	RS4	RS6A	RS6B
			Baushi	Kauljani				No bridge	With Bridge
A) NATURAL ENVIRONMENT:									
Biodiversity/aquatic diversity									
Overall diversity		Ef	-1 ?	-2	-1	-2	-2	-1	-2
		Ei	-1 ?	-3	-1	-2	-2	-1	-2
		Ec	-1 ?	-2	+1	+1	-2	-1	-2
Endangered species		Ef	-1	-1	-1	-1	-2	-1	-2
		Ei	-1	-1	-3	-3	-3	-1	-2
		Ec	-1	-1	+1	+1	-1	-1	-2
Fauna (Overall)		Ef	-1	-1	-1	-1	-1	-1	-2
		Ei	-1	-1	-1	-1	-1	-1	-2
		Ec	-1	-1	+1	+1	-1	-1	-2
Fish									
	Fish Habitat	Ef	-2	-2	-2	-3	-2	-3	-3
		Ei	-2	-3	-2	-3	-3	-2	-3
		Ec	-2	-2	+2	+1	?	-3	-3
Fish Migration	Pathways	Ef	-3 (D)	-2	-3 (D)	-3	?	-3	-3
		Ei	-3	-2	-2 ?	-3	-3	-1	-2
		Ec	-3	-2	+2	2	?	-3	-3
	Timing	Ef	-1	-2	-2	-2	?	?	-1
		Ei	-1	-2	-2 (D)	-2	?	?	-1
		Ec	-1	-2	?	?	?	?	?
Fauna									
Birds:-	Resident	Ef	-1	-2	-2	-2	-1	-1	-2
		Ei	-1	-2	?	-1	-1 ?	-1	-2
		Ec	-1	-2	+1	+1	-1	-1	-2
	Migratory	Ef	-1	-2	-2	-2	-1	-1	-2
		Ei	-1	-2	?	?	-1 ?	-1	-2
		Ec	-1	-2	1	1	-1	-1	-2
Flora									
Exotic		Ef	-1	0	-1	-2	?	-2	-3
		Ei	-1	2	?	-1	1	0	-2
		Ec	-1	-1	+1	+1	?	?	?
Forests:-	Riparian	Ef	?	x	-1	?	?	-2	?
		Ei	?	x	x	x	x	x	x
		Ec	?	?	1	?	?	?	?
	Upland	Ef	?	X	?	?	?	?	?
		Ei	?	X	X	X	X	X	X
		Ec	?	?	?	?	?	?	?
	Homestead Trees	Ef	0	?	1	1	?	?	?
		Ei	X	X	X	X	X	X	X
		Ec	0	?	-1	-1	?	?	?
Wetland:-	Spatial (Areal)	Ef	-2	-2	-3	-3	-2	-3	-3
		Ei	-2	-2	-2	-3	-2	-3	-3
		Ec	-2	-2	2	2	-2	-3	-3
	Temporal (Period of Inundation)	Ef	-2	-2	-2	-3	-2	-3	-3
		Ei	-2	-2	?	?	-2	-3	-3
		Ec	-2	-2	1	1	-2	-3	-3
Water Quality									
Lentic (Bil & Wetlands)		Ef	-1	?	-2	-2	-2	-2	-3
		Ei	X	X	X	X	X	X	X
		Ec	-1	-2	1	1	-2	-2	-2
Lotic (River & Khals)		Ef	-1	-2	-1	-2	?	-2	-3
		Ei	-1	-2	0	?	?	0	-2
		Ec	?	?	+1	+1	?	-1 ?	-2
Groundwater		Ef	?	?	?	?	?	?	?
		Ei	X	X	X	X ?	?	?	?
		Ec	?	?	+1	+1	?	?	?

Ef = Flood plain effects, Ei = instream effects, Ec = collateral effects

TABLE V.3.1 (Cont'd)

Preliminary Subjective Environmental Impact Assessment Matrix

		RS2 Baushi	RS2 Kauljani	RS3A	RS3B	RS4	RS6A No bridge	RS6B With Bridge
B) HUMAN ENVIRONMENT								
Agriculture								
Cereal Production	Ef	3	3 ?	3	3	3	2	3
	Ei	X	X	X	X	X ?	X	X
	Ec	?	?	-1	-1	3	-1	?
Non-Cereal Production	Ef	?	?	?	-1	?	?	?
	Ei	X	X	X	X	X	X	X
	Ec	?	?	?	?	-1	?	?
Soil Fertility & Structure	Ef	0	-2 D	?	?	?	?	?
	Ei	X	X	X	X	X	X	?
	Ec	0	?	?	?	?	?	?
Induced Drought	Ef	-1	-2	-1 ?	-2	-2 ?	-2	-3
	Ei	X	X	X	X	X ?	X	-1
	Ec	-2	1	1	-2	-2	-3 ?	?
Pest-Predator Imbalance	Ef	-1	-2	-2	-2	-1	-1	-2
	Ei	-1	-2	?	-1	-1 ?	-1	-2
	Ec	-1	-2	+1	+1	-1	-1	-2
Public Health								
Sanitary & Sewage (Incl. Diarrohoea)	Ef	?	0	-1	-2	2	-2	-2
	Ei	X	X	X	X	?	?	?
	Ec	?	?	1	1	1	-1	?
Insect vectors	Ef	?	?	?	?	1	1	2
	Ei	?	?	X	-1	?	?	?
	Ec	?	?	?	1	1	?	?
Potable water supply	Ef	?	?	?	?	-1	?	?
	Ei	?	?	?	?	?	0	0
	Ec	?	?	?	?	-1	?	-1
Navigation	Ef	–	0	-2	-2	-1	-2	-3
	Ei	-2	+2 D	-1	-2 D	?	?	?
	Ec	–	+1 ?	1	1	-1	-2	-3
Land Transport	Ef	1	1	1	2	1	1	2
	Ei	X	X	X	X	X	X	X
	Ec	1	?	-1	-1	1	1	2
Risk & Hazards								
Flood Hazard	Ef		0	-2	2	0	-3	-3
	Ei		0	X	X	0	X	X
	Ec	1	0	X	-2	0	-2	-3
Overall Natural Hazard	Ef				-2			
	Ei				X			
	Ec				?			
Manmade Cuts	Ef	X	0	X	-2	X	-2	-3
	Ei	X	X D	X	X ?	X	X	X
	Ec	X ?	0	-2	-2	X	?	?
Geneal Equity Issues								
Benefit & Disbenefit Fisherman/Farmers	Ef	-2	-2	-2	-3	-2	-2	-3
	Ei	-2	-2	-2 ?	-3 D	-2	-2	-3
	Ec	-2 ?	-2	2	2	-2	-2	-3
Landless/Landowners (Non-Fisheries Related)	Ef	1	1	1	1	?	2	2
	Ei	X	-3	X	X	X	X	X
	Ec		?	?	?	?	?	?

Ef - Floodplain effects, Ei = instream effects, Ec - collateral effects.

D = Impacts dependant on desing and no assessment possible at this stage

X = Category not applicable

The other potentially negative impacts which it has not been possible to quantify include:

- The imbalance in draught power supply and demand patterns associated with the loss of grazing areas and green forage and feed.

- The change in livestock species composition and its implications for survival strategies and family financial viability.

- The potential changes in availability, use or loss of other wetland products and particularly, common property resources (e.g. livestock grazing, medicinal plants, craft and thatching materials, shellfish), for which there is little or no knowledge of the systems or their importance amongst minority groups or others in the NCR.

- The ecological damage inflicted in bils by construction excavation.

- The changes in floral and faunal composition and condition associated with the new hydrological/morphological patterns and pollution management system that FCD and intensive agriculture will result in, and the impacts which this may induce in the productivity of the aquatic eco-system.

On the positive side, the Regional Schemes were selected on the basis of maximally increased agricultural outputs, so +3 is ascribed to "cereal production" under every proposal. Likewise, it can be assumed that land transportation would be automatically facilitated by terrestrialization. Other areas where changes may lead to additional benefits which have not been quantified include:

- improved health conditions resulting from better water control, increased income and associated improvements in nutrition amongst certain groups.

- improved incomes and commercial status for contractors, agricultural processors and transporters

- transport benefits arising from the use of structures to facilitate traffic and movement in the wet and dry season or from the use of the main drains as navigation routes.

- improved possibility of culture fisheries

- secondary benefits deriving from stimulation to the regional, national or international economy from increased demand for FCD and agricultural inputs, or from the increase in land values and the local investment climate from the reduced flood risk.

The "hazards" category was subdivided into flood hazards, non-flood natural hazards, and man-made hazards. While somewhat arbitrary, it is assumed that while erection of embankments might indeed reduce risks of "ordinary" flood hazards, a psychologically over-confident or fiscally over-extended population might be made more vulnerable to disaster, if the embankments were to fail; either as a result of high-energy floods beyond the design capacity of the structures, as a result of seismically-induced collapse, or if the failure was due to intentional "public cuts", or perhaps as a consequence of inadequate O&M or quality control.

The "equity" issue was subdivided into fishermen versus farmers and landless versus land-owning. The assumption was made that the logic of agricultural intensification underlying all the Regional Schemes inherently favours farmers and landowners, as opposed to the landless and the fishermen - although the relative levels of disbenefits may be adjustable or mitigable. ("Fishermen" and "landless" are not mutually-exclusive terms.) A value of -3 would indicate a proposal of greater inequity to fishermen than would a value of -2. "Fishermen" refers here to both the professional and the subsistence fisheries; and that all fishery and fish protein-related equity issues are deemed to be encompassed within the first equity category, and excluded from the second.

While short-term benefits may well accrue to landless people engaged as labourers during project construction or maintenance, this is considered a non-sustainable flow, unlike the potential increased demand for part-time agricultural workers.

3.3 Fisheries Impact

Present knowledge is inadequate to allow any in-depth analysis about ecological aspects of Bangladesh's fisheries. The lack of an ecological appreciation of the role of fish as indicators of the eco-system on which man depends has often reduced the debate to a set of "rice versus fish" arguments whereas in fact increase of production of both is necessary.

The oversimplification of the rhythmic and cyclical connection and disconnection of the bils from the exterior major river system and the associated floodplains, as given in the earlier descriptions, has left out two other floodplain processes. Some bils are "recharged" only by local rainfall delivered through local drainage. Other bils ordinarily not connected to the river/floodplain complex may be recharged primarily by groundwater. Natural recruitment of fish populations to such bils depend on rare inundations by high floods. The successful species here would be those capable of breeding in-situ, rather those displaying migratory reproductive patterns. If such stocks were removed, through either overfishing or dewatering, restocking becomes altogether dependent upon the arrival of an unusually severe flood, or upon artificial means. These beels, not connected with the rivers, do have a high potential for culture fisheries.

The overall impacts on bil fisheries of interventions intended to protect against the infrequent high floods may be larger than expected, even if ordinary flooding is allowed to continue as before. Thus, in some places, knowledge of bil hydrology on a case-by-case basis may be pre-requisite to predicting effects, influencing planning and to designing mitigation measures.

It is widely accepted that around 80% of Bangladesh's consumption of animal protein is provided by fish; mostly from the fresh and estuarine open water capture fisheries. Much of the culture fishery is also still dependent on "wild-caught" fry. Assuming that similar proportions apply to the NCR, fish comprise the most significant component of the remaining native fauna. Available protein - from fish and from all other sources - is grossly inadequate. A 1991 survey by ICDDR suggested that 90% (or more) of Bangladesh children between six months and six years of age may now be subject to protein and/or vitamin deficiencies.

It is also being increasingly recognised that the issues of equitable distribution and access to resources are inextricably linked to the type of hydrological or development initiatives that impact the status of the capture fisheries, as it is the malnourished and the landless rural poor (who comprise almost half of the NCR's population) who depend on wild fish stocks for their protein, vitamin and animal oils. The nutritional significance of losses in this sector cannot be over-emphasized.

Although culture fisheries might be expanded to "replace" natural stocks extirpated by habitat reduction. However, engineered alterations of the regional water regime, which are intended to permit further intensification of agriculture, can directly (yet inadvertently) worsen the nutritional status of the poor. This can only be mitigated if such intensification results in sufficiently broad new demands for agricultural labour, or otherwise avails the poor with entitlements allowing their purchase of culture fishery outputs. This expectation would not seem to be realistic as the prime beneficiaries of agricultural intensification will continue to be the relatively successful, land-owning farmers with family members generally able to meet expanded labour requirements. Furthermore, there is some evidence that agricultural intensification also tends to reduce the production of non-fish proteins as farmers replace pulses or pasture land with HYV rice influenced by the less-risky environment created through flood control.

Species diversity is also not insignificant. Some 110 fish species may be found in the NCR; most of them acceptable for human consumption, but little understood ecologically. In this diversity of species lies the total gene pool for future generations. The present levels of research give us no indication of the potential utilitarian, medicinal, or economic value which lies unexplored in this resident gene pool. Any loss to this gene pool cannot be valued but certainly cannot be ignored by policy makers or politicians.

3.4 Pest and Predator Impact

Predator/pest relationships will prove to be one of the most significant ecological processes determining the future economic and nutritional status of the NCR. The regional landscape is already predominantly agricultural and the impacts of pest populations and the limiting influences of natural predators are pre-eminent elements of crop production systems. Imbalanced predator/pest interactions may render impossible the development of a truly sustainable agriculture systems.

The remaining foci of beneficial predator populations beneficial to agriculture and public health are possibly to be found within the homestead forests, waterbodies and waterways. There is little or no research substantiating these relationships, particularly as regards homestead habitats. Undoubtedly these groves of planted useful tree species provide important roosting sites for insectivorous birds. The relict bils and wetlands that have not yet been drained and put under boro rice provide a diversity of different aquatic rooted, submerged and floating flora and semi-aquatic margins that support a wide diversity of fauna which are particularly important in predation on mosquito larvae for instance.

Uninfluenced by agricultural inputs predator populations are generally very closely adjusted to prey populations. This is achieved through a series of feedback systems, whereby stability is achieved through the evolution of ecosystemic mechanisms tending towards self-regulation and dynamic equilibrium.

Agricultural intensification generally, and the multiple cropping of rice particularly, tends to increase plant vulnerability to pests and diseases. The reasons for this include:

- The elimination of fallow periods which provide unfavourable habitats to pest species; thus tending, formerly, to suppress pest recruitment and pest population density. Conversely, such fallow lands may have been excellent habitat or cover for predators.

- Indirect elimination of predators and other beneficial species by habitat destruction and land-use change (i.e., draining bils, khals, or wetlands in conjunction with cereal self-sufficiency schemes); or as a consequence of the discharge of toxic agrochemicals ordinarily associated with adoption of HYV cultivars.

- Direct removal of predators by extirpating them as pests or threats themselves (e.g. snakes, birds of prey, small mammals); or by over-harvesting them for food or for sale (e.g., insectivorous fish, mammals and reptiles for the skin trade, frogs for the frozen seafood export market).

Obviously, in none of these cases is the reduction of predator populations a reaction to declining prey population densities, as would be the case without human intervention. Accordingly, the equilibrium is thus tilted radically in favour of the prey species.

The response of the farmers facing an imbalance in favour of pest population ordinarily would be to increase the application of toxic biocides, exacerbating the impact of pollution on surviving beneficial predators. As these become even more marginalised, well-adapted or resistant pest populations rise all the more.

This is an example of a positive feedback system, where natural equilibrium-inducing mechanisms have been removed and replaced with artificial systems magnifying the disequilibrium further with each new input of energy and material.

The limitations of biocide-dependent agriculture have been becoming ever more apparent, and the search for alternative crop protection strategies has been underway for some time. "Integrated Pest Management" (IPM) is an emerging approach combining the following:

- "Biological and physical controls", i.e., predation-enhancing elements based upon the protection of existing predator species - or upon the introduction of exotic predators and specialized diseases of pest species. Also by physical adaptation and management of habitats to encourage predation species and activities.

- "Genetic engineering", i.e. developing crop strains that are resistant, toxic, distasteful to, or otherwise less attractive to pests.

- The accelerated development - and restrained application - of biocides that are as "environmentally benign" as possible: such materials may be extremely target-specific, speedily biodegradable; etc., etc.

International and Bangladesh development agencies now supporting IPM and at least in principle committed to its speedy adoption include inter alia the World Bank, IRRI, USAID, BARC and CARE. IPM research is now sufficiently well-advanced that the time frame of its potential broad acceptance in Bangladesh is roughly congruent with the time frame of the implementation phase of the Flood Action Program and should therefore be considered directly in each agricultural planning strategy and impact analysis for projects under FAP.

All the research of indigenous systems so far carried out in Bangladesh provides direct evidence that there is a enormous wealth of practical knowledge in integrated pest management and natural resource management. This has enabled the rural people to, not only control pests, but also to access to a wide diversity of medicinal plants in their environment. Detailed study of these systems in desperately needed given the current scale of natural resource degradation and loss of traditional knowledge which seems to pervade the rural systems under current development trends.

3.5 Biodiversity Impact

If the area were less radically transformed by man than it clearly already is, native wetland communities, which are closely coupled to natural hydrological conditions, would be severely disadvantaged by any "terrestrialization" of the landscape. While rice fields are a kind of wetland community, replacing broadcast aman with transplanted aman is quite different than replacing a natural marsh with a rice field.

Intuitively the deeper waters and unobstructed flows inundating lands, now limited to broadcast aman culture, probably support a more diverse aquatic flora and fauna than the shallower and more "manipulated" aquatic environment following project implementation, but field work has yet to confirm this. However, transplanted aman is more dependent upon agro-chemicals than broadcast aman. Since the chemical inputs ordinarily applied are not ecologically benign some incremental negative impact on fish and invertebrates can be assumed. In gross economic or nutritional terms the current valuation methods for the loss of natural flora and fauna at discounted market prices do undervalue the real long-term costs to the ecological processes and economy. In real terms losses of fish may outweigh the gain in rice. But the problem could well be much more complicated, depending upon contributions that the lost fish might be making to the protein needs of the poor. This is particularly a problem as the poor are also those who depend on the less marketable varieties of fish which emphasises the need for maintaining species diversity.

There are a number of other equity issues related to bio-diversity which so far have been more easily evaded than questions of obligations to humans without entitlements. It will be in this social light that international concern on endangered species will have direct relevance to the future status of sustainable development and government policy in Bangladesh.

Once proper and methodical field research examining these species issues is completed it is expected to confirm that an array of aquatic species which of are little interest currently to the fields of production fisheries may already be depleted or endangered by terrestrialization and cropping intensification. If it is unlikely that projects yielding short-term agricultural gains would be redesigned, set aside or even dismantled on grounds of damaging biodiversity the question which might be asked would be why bother investing in expensive research to determine their ecology? Conversely, if the protection of biodiversity is a real issue the time is already late to initiate credible zoological, botanical and limnological surveys in the NCR. This argument is even more strongly supported when one considers that the NCR floodplains are amongst the last which have so far not been embanked and thus may still support the last remaining operational eco-system where considerable aquatic biodiversity is still being maintained. The work recently started under FAP 17 will assist to some extent in clarifying the importance of these issues.

3.6 Water Supply Impact

Domestic water supplies are taken from a number of sources and, even when tube wells have been installed, surveys have found that families continue to use a variety of other surface supplies, either for drinking water supplies, but more commonly for other uses, such as bathing and washing. There are a number of impacts of drains and FCD which might affect homestead water supplies and would require a mitigation planning in the feasibility stage. There are important linkages between the farming and homesteading systems on high ground and the degree and seasonality of soil moisture available on the receding flood. The seasonal depth to the water table and the type of technology used to extract homestead water is also significant in assessing FCDI impacts. There are also important local (and possibly wider linkages) which maintain the recharge and water depths in the lower lying wetlands which can be affected by FCD and I. The details of these linkages cannot be differentiated between schemes at this pre-feasibility stage and will require more detailed analysis during the feasibility surveys.

3.7 Nutrition Impact

There are problems of self-sufficiency in food grains for Bangladesh which relate directly to the logic of the regional planning for the NCR. A minimum level of human nutrition requires inputs other than carbohydrates as is reflected in any food ration given out by the UNHCR and WFP. Major intensification of rice culture under the green revolution and FCDI projects has indeed augmented the production of cereals at a rate slightly ahead of population growth. Thus, per capita production of rice has unquestionably increased. However, the overall nutritional picture has worsened. This is, in part as a direct consequence of FCDI impacts and, includes issues which cannot be divorced from planning a regional approach to water resource management in the NCR for the next 40-50 years.

The international terms of trade for Bangladesh exports have markedly worsened in recent decades. Also, while the price of domestic rice rises with world prices, this is set in an economy which has a relatively stagnant labour market. The agricultural sector is unable to absorb more than a fraction of the vast new labour supply generated by present population growth. Similarly, there is an absence of a vibrant industrial sector which could otherwise employ surplus labour. As a result the value of labour has drastically fallen relative to the price of food. For the part of the rural population that own enough land to feed itself this is not a problem. Bigger farmers who use hired labour have found their labour inputs cheaper, but for the increasing numbers of landless it is a disaster, particularly as their numbers now almost form the majority of the rural population.

In effect, the surplus of labour has become so undervalued that even regularly employed unskilled workers cannot now afford to buy an adequate supply of food. In other words, while the rice may be there, the "entitlement" to it is not.

However, the primary element of the present nutritional crisis is arguably the extreme reduction in the intake of proteins and lipids. This decline seems to be coincident with the growth in activity to achieve food grain self-sufficiency. Increasing evidence from research and ex-post evaluations indicates that the construction of FCD or FCDI schemes leads to a whole new series of cause and effect linkages which affect access to resources, entitlements and resource depletion as new resource use and management patterns arise in their operation and maintenance. Since these lessons are learned from the limited perspective of previous planning decades they should not be perpetuated into the next generation of projects.

Sometimes the results are unexpected. While overall caloric intakes may indeed be rising, protein deficiencies may be rising even faster, as the production of proteins and vitamins from fishes (or pulses) formerly harvested there declines out of proportion to the enhanced yields of rice. In some cases, a portion of those people who were physically or economically displaced by the project will have lost their previous access to "entitlement", and thus become unable to purchase food, regardless of local production increases.

For social equity and resource tenure, these new chains of causality tend to alter the situations of landless, professional or incidental fishermen. In some instances they are recorded as having been made generally worse-off by FCD and FCDI projects as their previous open access to a common property resources has been foreclosed. Meanwhile, the situation of some farmers and other absentee land owners is usually bettered, especially those whose present land holdings are further augmented by the acquisition (*de jure* or *de facto*) of the khas lands underlying former bils.

3.8 Public Health Impact

The primary and interactive elements influencing the general state of public health within the NCR are nutrition and disease. Underpinning the hydraulic intervention options are assumptions about altered inundation regimes resulting in augmented cereal grain production and their implications for the demise of inland capture fisheries - commercial and subsistence - and how protein availability may have been negated.

Major manipulations of regional (or local) hydrology can be expected to have significant epidemiological effects - both negative and positive, depending upon the nature of the alteration and the etiology of the disease. Not all diseases prevalent in Bangladesh are directly connected to the state of the aquatic environment, but those which can be so linked include cholera, which is completely waterborne, as well as those transmitted by mosquito vectors, which require aquatic habitats for egg-laying and larval development; including Japanese encephalitis, filariasis, malaria, and dengue fever.

Cholera

There exist two biotypes of the cholera-causing bacterium *Vibrio cholera*, the "el tor" strain, which generally prevails in regions of Bangladesh north of Dhaka, and "classic cholera" which seems to be limited to estuarine zones south of Dhaka. Characteristic of both strains is that while the *V. cholera* organisms seem to be generally present in the aquatic environment throughout the entire year, the disease itself is very rarely reported during the months of the monsoon. This alone suggest that ecological factors may be determinate in its appearance and etiology. It should also be noted that unlike the case with many other highly pathological organisms (e.g., the malaria parasite), the ecology of *V. cholera* itself does not appear to be particularly dependant upon the presence of a human population, nor upon human-related transmission or reproduction pathways.

More significant to the relative environmental concentration of *V. cholera* is the presence of various copepods - crustacean zooplankters - which themselves feed on algae and other phytoplankton. Thus, there exists considerable interest in the food-web ecology of cholera, and several hypotheses have been offered as to why, particularly in Bangladesh, the disease itself is effectively suppressed by monsoonal conditions. Here are two:

i) The characteristic high turbidity of overbank river flooding limits algal photosynthesis - with a resultant decline in phytoplanktonic density - and an ensuing drop in those populations of grazing copepods which appear to be primary reservoirs of activated and pathogenic *V. cholera* bacteria.

ii) Since some low-turbidity inundated areas likewise, display reduced copepod populations during the monsoon, the possibility exists that predation may also be a limiting factor. Larvae, fry, and juveniles of many species of floodplain fish are presumably heavy copepod predators.

These two factors have led to informed speculation that the construction of major new embankments - which tend to reduce the turbidity of floodwater and to impede the reproduction, transport, and recruitment of floodplain fishes - may lead to a worsening cholera situation. This hypothesis assumes that the primary controls on copepod populations during the monsoon are algal photosynthesis and fish predation.

A protocol has now been devised by ICDDR entitled "Influence of embankments on childhood mortality and morbidity"; funding, staff, and instrumentation have recently been secured, and data collection is now underway in the Matlab area (just outside the NCR), where embankments were constructed under the Meghna-Dhongoda scheme, and where unembanked control districts have also been subjected to long-term epidemiological and nutritional studies. Preliminary results should be available by mid-1992.

Another approach to the ecology of *V. cholera* is less concerned with embankments. This hypothesis holds that the "green revolution" is largely responsible for rising cholera levels - a "rise" which it is difficult to confirm, given the present defective data base. According to this theory, anthropogenic eutrophication, induced by the use of chemical fertilizers essentials to HYV rice culture, results in greatly augmented production of phytoplankton; followed in turn, by a bloom in cholera-carrying copepods.

Malaria

The NCR is a nexus of one form of malaria, *Plasmodium vivax*, which is characterized both by the parasite's persistence in the human host - symptoms may reappear over the course of years, while the host remains an active reservoir of transmission - and by its marked lack of pathogenicity: *P. vivax* is very rarely fatal or severely debilitating. Its relative prevalence in the NCR tends to obscured in public health surveys, since its appearance can be categorized under the vague term "fevers".

It was widely accepted, in earlier times, that embankment construction and land reclamation in West Bengal was directly responsible for the arrival and spread of malaria there in the early 20th Century. Following the development during World War II of cheap and long-lived chlorinated hydrocarbon insecticides (e.g., DDE and DDT), ambitious and well-managed "malaria eradication" schemes were implemented throughout the Indian subcontinent by the World Health Organization.

As with the other forms of malaria - the most dangerous among them being *Plasmodium falciparum*, which is presently limited to the Chittagong Hill tracts - the insect vector is an anopheline mosquito. The "eradication" of such mosquitos was probably never practicably attainable, and it remains even less so today, with Anopheles having succeeded in evolving considerable resistance to pesticides; especially now that "official" massive application of chlorinated hydrocarbons would generally be constrained on environmental grounds and that the GOB has now finally officially banned its use (Feb. 1992).

The other mosquito vector diseases evidenced in the NCR also remain comparatively minor public health problems: the strain of dengue found here is again, relatively non-pathogenic (compared to strains in Thailand and Burma), and while Japanese encephalitis can be fatal, it is generally not. In any case, it appears to be relatively uncommon. Again, as with vivax malaria, the actual levels of infection with both dengue and encephalitis may be statistically masked by their inclusion within unspecified categories of "fevers" in the existing rural health databases.

Present proposals under FAP-3 might alter the prevalence of mosquito vector borne diseases in the NCR in several ways: if embankments worsened local problems of drainage and stagnation and reduced the effects of riverine flushing, the prevalence of vector species of mosquitoes might well increase, conversely better drainage should improve the situation. Possibly, the issue of fish migration and/or recruitment also arises, if fish predation is a significant aspect of natural mosquito control, and if the fish species involved are negatively impacted by the proposed projects. Mechanical flushing by overbank floodflows may also play some role in mosquito ecology.

Intense public debate has recently been reported in the Dhaka press over the obstruction of urban drainage pathways by the inadequately planned and executed flood embankments built under the previous regime; and over the "unbearable" levels of mosquitos then evident in the city. Conversely, "mosquito control" has always been one of the primary justifications for drainage improvements everywhere, and as terrestrialization is advanced in the NCR, mosquitoes, along with other aquatic organisms, are necessarily suppressed.

As is the case with cholera ecology, there is insufficient knowledge of mosquito vector ecology and these issues should be addressed much more substantively in subsequent, feasibility-level studies.

"Water-washed" diseases may be another category of environmentally-influenced diseases of possible concern to NCR project planners; the most important of which is bacillary dysentery caused by *Shigella spp.*, a highly invasive bacterium. *Shigellosis*, probably the primary cause, now, of diarrhoeal deaths of young children in Bangladesh, is spread directly between human, without any intermediate aquatic phase. Treatment requires intensive use of antibiotics, and unlike the situation with cholera, oral rehydration therapy is only marginally helpful. In this case, the sanitation issue is the availability of water for washing, rather than its quality.

3.9 Navigation Impact

Discussions with BIWTA indicated their concern regarding possible construction of embankments and regulators along the Pungli, Dhaleswari and Kaliganga rivers which they believe may adversely effect launches and mechanized boats. There is also concern for the secondary waterways and khals between Aricha and Harirampur.

The pre-feasibility phase of planning has attempted to include the requirements for boat passage as far as is possible. In practice the provision of locks and passage through control structures can only be theoretical, until detailed local research is carried out. This is primarily because there is considerable use of the floodplains by a whole category of boats smaller than that which is being considered at present. This must be an important component of any feasibility study TOR.

Even if major navigation routes are maintained, closure of minor passages by embankments, drains or by reduced water levels is likely to have a significant effect on poorer people who depend on these routes. There is a basic contradiction between terrestrialization and the requirements of the country boat sector. Many of the proposals would either change the available landscape of water over which small boats could ply or else change the timing of the floods so that important seasonal marketing and social needs would be disrupted.

The main drains being considered could provide new seasonal navigation opportunities. Access to these from the hinterland streams along their routes would need detailed planning to provide for adequate landing stages and locks. Details on minimum navigation standards for channel and locks design will need to be obtained from BIWTA for future planning purposes.

Major areas will inevitably remain inaccessible during the monsoon. Changing flow regimes will affect the sedimentation patterns. The water which remains will be critical for the movement of people and goods. The modelling tools cannot answer these basic questions. Changes in the technology of country boats may also be affecting the erosion and sedimentation patterns. This would also have to become a design factor which might require changes to the vegetation management on embankments. This has social implications and stresses the need for public participation in these designs and their management. Such approaches are increasingly commonplace in the designs and management for waterways throughout Europe.

Catchment management and land use planning in the Madhupur Tract will also require careful consideration if the proposed drainage lines along the Bangshi and Bangshi Turag are followed through and if they are to be sustainable. Terracing and proper vegetation management may be an essential pre-requisite for these drainage schemes.

How much navigation by mechanized country boats could be benefitted or disadvantaged is difficult to appraise without more field research and better data. Dredging schemes to straighten and deepen an interior waterway to improve drainage, rather than navigation, might result in a higher velocity and more efficient river (to remove floods) but, could result in a drying of the channel earlier in the season than would otherwise be the case. The same drain as part of an overall water control and management system could be operated to maintain water levels later into the dry season and thus advantage navigation. If the channel were deepened sufficiently to lower the regional water table so that the mainstem ran all the year round, this could result in the tributaries, bils, and khals drying out altogether earlier in the dry season. This would result in mixed effects on navigability.

These types of operating criteria have not been examined at this level of study. They are clearly a very real set of actual problems and trade-offs which must be addressed at the feasibility stage.

CHAPTER 4
IMPACT ANALYSIS OF FCD STRATEGIES

4.1 The Options

There are two primary mechanisms to accomplish "terrestrialization" of the semi-aquatic landscape of deltaic Bangladesh: the first is to improve drainage, so that waters previously standing on the land are conveyed downbasin faster or sooner than before. The second is to prevent the advance across the floodplain of rising river waters by erecting embankments parallel to the stream along one or both of its banks.

Understanding of the flood control and water management in Bangladesh is complicated by several important factors:

- The local rainfall, runoff, and drainage patterns are usually not significant elements determining the discharge regime of the three major rivers of the Padma, Jamuna and Meghna. This is because their combined watersheds are an order of magnitude larger than local catchments in Bangladesh. Nonetheless, important interior waterways do convey large volumes of water from time to time which greatly affect local drainage capacities.

- Many of the inland waterways in the NCR do not fit into the normal river pattern, as they lack discrete watersheds, defined sub-drainages and a topographic gradient. They function sometimes as distributaries, and sometimes as cross-channels which interconnect mainstems of different rivers, and/or interconnect distributaries or the same river. The very direction of their flow may reverse according to the hydraulic difference between the two ends.

Considerable modifications of the region's hydrological system has already taken place because of the construction of road and rail networks. Since these were not designed specifically for flood control or management, their influence on the hydrologic and drainage network is not necessarily rational for effective management of floods, drainage, irrigation, crop production and integrated resource use. These aspects need to be clarified further at feasibility level of study.

4.2 General Ranking of FCD Intervention Types ("RIT")

In general terms, the various options for physical infrastructure which might appear under prospective scenarios of the NCR's FAP could be ranked from their lowest to highest level of environmental impact. This is another way of appraising and listing not based on any evaluation of the site-specific impacts of particular schemes or scenarios. It is, like the present matrix, only a very preliminary assessment device, which remains largely unsubstantiated either by credible data or by new research. It is intended mostly to assist in the organization and conceptual analysis of more substantive EIA studies to follow at the feasibility-level of investigation. A RIT ranking categorisation is given as follows:

No Hydraulic Structures, No Change to Surface-water Regime

I. "floodproofing", including non-structural and relatively-minor structural interventions that provide localized elements of protection, such as flood shelters and elevated housing sites (based on stilts or on fillpads), involving no substantive hydraulic structures and no appreciable manipulation of local or regional hydrology.

No Hydraulic Structures, Drainage Improvements Only

II. Local drainage improvements based on removal, realignment, or "perforation" of existing artifical impediments or obstructions; e.g., poorly sited embankments, unculverted roadways, etc.

III. Minor stream channel improvements that follow existing channel alignments, with appreciable conservation of riparian and wetland vegetation, where it exists.

IV. Significant stream improvements based on maintaining existing channels in their semi-natural condition, but with construction of alternate, parallel floodways to handle peak discharge events. (May require hydraulic structures).

V. Major channel improvements involving significant re-sectioning, and excavation and deposition of voluminous dredged spoils. This involves substantive removal of biota.

VI. Complete realignment and re-shaping of the previous streamcourse, involving numerous meander cutoffs, total removal of existing vegetation, and establishment of a new channel section optimized solely towards hydraulic efficiency.

Depending on the design depth of the excavated improved channel and on the local conditions of surface and subsurface hydrology, drainage improvements of the above-described types could result in, either contraction, or expansion of the period during which waters, either lentic or lotic, would be maintained in the channel. Thus, this could result in either improvement to, or worsening of conditions of navigability and of fish and wildlife habitats.

Also, the volume of dredged spoils generated, and the manner and site of their disposal may result in varying environmental impacts of otherwise similar drainage schemes. The bankside disposal of dredged materials by aligning spoils into *de facto* embankments is possibly the highest-impact variant of any stream drainage improvement scheme.

Controlled or Semi-controlled Hydraulic Structures: No Significant Embankments

VII. Stream regulation schemes incorporating hydraulic devices allowing ordinary flows to pass normally (as in the "no-project situation"), but limiting or diverting peak flows only.

VIII. Stream regulation schemes incorporating hydraulic devices that permitted passage of flows only under certain discharge or stage conditions.

Setback Embankments: No Hydraulic Structures

IX. Substantive embankments of interior and secondary rivers, with considerable setback from active channel. Most outlets left open and unregulated. Minor reduction only of local inundation regime.

Major Embankments: Controlled or Semi-controlled Hydraulic Structures in Project Design:

X. Substantive streamside embankment schemes for interior and secondary rivers with many openings retained for offtakes and tributaries/distributaries, regulated either by fully controlled or semi controlled hydraulic structures across outlets and mainstem. Minor or intermediate degree of flow reduction throughout floodplain.

XI. Substantive setback embankment schemes for primary "exterior" rivers with many openings retained for offtakes and tributaries/distributaries, regulated either by fully controlled or semi controlled hydraulic structures across intakes and outlets. Intermediate degree of flow reduction throughout floodplain. Little change of mainstem stage under ordinary monsoonal conditions.

XII. Substantive embankment schemes adjacent to active channels of primary "exterior" rivers with many openings retained for offtakes and tributaries/distributaries, regulated either by fully controlled or semi-controlled hydraulic structures across intakes and outlets. Intermediate to large degree of flow reduction throughout floodplain. Possible significant change of mainstem stage under ordinary monsoonal conditions.

XIII. Substantive embankment schemes adjacent to active channels of primary "exterior" rivers with offtakes and tributaries/distributaries mostly closed. Very significant reduction of overbank or distributary flows entering the floodplain. Major increase of mainstem stage under ordinary monsoonal conditions. Maximum alteration of pre-project inundation regime, spatially, temporally, and volumetrically; and maximum floodplain "release".

4.3 Drainage

Activities taken under this category might range from the deployment and operation of mechanical pumps (although no pumps have been included in the plan); to the dredging of a silted river bed or bar-obstructed confluence point to re-establish a channel cross-section or a hydraulic connection. The objective is to reduce the depth and areal extent of floodwaters, and/or the overall period of inundation, by facilitating and accelerating their rate of downbasin conveyance.

Intermediate actions could include excavating entirely new drainage pathways or "re-sectioning" the geometry of existing riverbeds. This may be either by reducing the flow-impeding effects of turbulence and friction by eliminating bottom irregularities and bankside vegetation; or by increasing their depth/width ratio; or by short-circuiting sinuous meander loops with new cutoff channels which will shorten and steepen the streamcourse and thereby result in increased discharge velocity.

In general, changes to drainage systems cannot be pre-supposed to bring environmental improvements. Within the streamcourses themselves, bottom irregularities, shallow sloping banks, and densely-vegetated riparian corridors may be absolutely essential to provide a wide range of ecological niches, offering various habitats to flora and fauna; usually maximizing species diversity, and often maximizing productivity as well. These may have a multitude of economic, social and physical advantages which should be considered in the planning process.

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Furthermore, drainage modifications to augment stream velocity may result in the resident fish and invertebrate fauna simply being swept away, while the excavations may unthinkingly remove vegetation. Neither of these scenarios need result if careful planning and design take these factors into account. Some species are well-adapted to withstand high-velocity transient events, maintaining their position and territoriality; other are not. Conversely, some waterways may become so clogged seasonally by an accumulation of exotic aquatic vegetation (e.g., *Eichornia crassipes)* that eutrophication (if it is already far advanced) may be removed by induced high-velocity discharges.

Across the floodplain, one community's "drainage improvement scheme" may be another community's ecological catastrophe; particularly if the project is intended to convert naturally productive and species-rich wetlands or swamp communities to agro-chemical dependant crop monocultures. On the other hand, aspects of certain drainage improvement schemes might well be ecologically benign, or even actively beneficial. The main benefits might come from the habitat alterations which would remove problems of water-related disease or allow for improved sanitation and water quality or provide improved habitats for some species of flora and fauna.

These issues again raise the question of what is environmentally sound, as is discussed further in **Chapters 1 & 6**. Such questions are essentially *normative*, having to do with values, goals, aesthetics, ethics, social objectives, and the like. The answers to normative questions must necessarily vary with cultural, economic, and geographic circumstances. Insofar as an EIA claims to be "empirical and scientific", it cannot legitimately address normative questions.

The excavation of a drain necessarily produces spoil. To minimise haulage costs this spoil is not carried out of the floodplains or spread on the land. It is heaped alongside the drain route thus creating an embankment. Thus, a drain is as much an embankment as an embankment requires borrow areas which could be drains. In practice contiguous borrow areas are not a design feature in Bangladesh and thus they do not operate as drains. The experience in many parts of Bangladesh is that drainage schemes block a natural floodplain flow routes behind them and create localized undesirable ponding. The cumulative effects of ill-coordinated and poorly-engineered embanked roadways have included blockage of migratory fishes. This sometime has had severe effects on important local fisheries. These obstructions of surface drainage pathways, result in disruptions to agriculture, and heightened social strife between those who perceive themselves benefitted from such embankments, and those who do not.

There is certainly a strong case to be made for a major option which would either remove altogether many road embankments, or substantially re-design the drainage structure and the community means of operating and managing these. While these options could possibly have a temporary negative impact upon transportation the evidence again suggests that so many FFW feeder roads are repeatedly breached by "public cuts" that the actual effects might be relative minor. Thus, a substantive "drainage improvement scheme" devoted to removal of embanked roadways would almost certainly be environmentally beneficial.

Another question seldom addressed properly is whether drainage-improvement schemes might not be "zero sum games". Any agreement on this would have dramatic results on how to approach the project and regional planning in the FAP. If one area is protected from inundation, the discrete volume of water previous stored there now has to be stored elsewhere in the floodplain because there is only a finite flow capacity of the whole system out into the Bay of Bengal. With sea levels potentially in a phase of rising, rather than falling, can it be said that any protection for one area will inevitably worsen drainage problems elsewhere?

4.4 Embankments

4.4.1 Overview

As indicated by several of the NCR's regional options offered for analysis at the pre-feasibility level, embankment and drainage are often devised to be complementary elements of the same overall project. Certainly, in an area subject to nearly 1-2m of monsoonal rainfall, deploying full embankments does not automatically prevent flooding, nor obviate any need for drainage improvements. Experience in the NCR has repeatedly indicated that construction of embankments often worsens the drainage situation, even if the embankments themselves succeed perfectly well in restricting rivers to their active channels outboard of the protected zone.

Obviously, wherever local precipitation is quite substantial, and where absorption and/or percolation capacity of the landscape is limited (either by high water tables; by rainfalls of great intensity; or by soils or substrata of poor permeability), rainwater will accrue and pond if normal overland flow downbasin into stream channels is obstructed by erection of flood control embankments.

The problem of obstructed drainage landward of embankments is sometimes severely compounded in urban areas, where the overall infiltration capacity tends to be substantively reduced by structures and pavements, and where large volumes of domestic and industrial wastewaters are added to the interior effluent stream.

Thus, serious quality-of-life and public health problems can result from flood-protection schemes even when the stage and areal extent of ponded waters are themselves unexceptional. A significant equity issue arises here also. Squatter settlements and bustees are dis-proportionately concentrated in the lowest-lying areas of cities; the first to be inundated by the slightest rise of stage of backed-up sewage canals.

Approaches to the problem of internal ponding include :

- mechanical pumps to lift standing waters over the embankment, regardless of river stage.

- one way gates or "flap valves", which allow interior waters to drain outward through the embankment when the stage of the exterior stream has fallen sufficient to permit gravity flow; and

- controlled sluices to accomplish much the same, with the added capability of allowing regulated amounts of river water to enter the protected zone to provide for fisheries, agriculture, pollutant flushing, and vector control.

- temporary storage below the general grade of the interior area, either in remnants of the pre-existing natural drainage system (i.e., khals, bils, etc.); in excavated ponds or tanks; or in topographic depressions where flooding is managed.

While the generalised flooding of cities is inconvenient and unhealthy, particularly for those at the bottom (socially and topographically) such flooding may also yield some benefits commonly associated with wetland processes: e.g., recharging aquifers; flushing accumulated wastes from stagnant interior waterbodies; restocking urban fisheries (which are relatively unstudied and may be of greater importance than generally realized). Growing urban conurbations are particularly vulnerable economically and socially to floodborne disruption; even when direct flood damage to irreplaceable capital improvements remains insignificant.

Accordingly, the disbenefits from urban flooding can be expected to far outweigh the benefits. If the technical and institutional constraints upon implementing a rational internal drainage system can be overcome, flood control embankments around cities are probably desirable.

Rural flooding may not be so similar. It was notable but, not necessarily typical, that farmers have requested to be spared in their neighborhood of any more embankments or flood protection schemes. Many farmers in the NCR are convinced that the fertility of their fields is assured by the unobstructed passage of floodwaters. Questions of whether much the same fertilization would be provided by blue-green algae growing in standing rainwater isolated from any connection with the exterior river are not yet answerable by present research.

As landlessness becomes more prevalent in the NCR, cultural adaptations to monsoonal inundation that characterized Bengali civilization become less and less applicable; the landless or dispossessed having no elevated baris to go to, nor boats in which to ride out the floods. There is also the obvious inability of traditional "floating rice" cultivars to meet the country's food requirements, and the need, in the short-term, to absorb millions of "surplus" rural people in a vastly expanded industrial urban economy.

4.4.2 Full Flood Protection

The fluvial geomorphological trends of the last several centuries have left none of the NCR's major cities today closely adjacent to the primary rivers themselves, or to the larger secondary streams and distributaries. The exception would be Narayanganj on the Lakhya. The NCR's urban districts are well-removed from the enormous difficulties and expenses entailed in building secure embankments close to the active channels of the main rivers. Accordingly, full flood protection of the NCR's urban areas (including drainage needs) is probably both technically feasible and economically justifiable. Whatever environmental benefits might be lost in "fully-protecting" the NCR's cities from river flooding are probably subject to mitigation although this faces major institutional and cultural constraints.

FAP-8 (the Metro Dhaka Flood Protection and Drainage Plan) provides for a 1,850 km^2 protected zone; some 11% of which would be the minimal area required for storing rainwater, urban runoff, and sewage effluent. This amounts to some 90 km^2 of presently unoccupied or sparsely settled lowlands and floodplains which must be kept completely open and perpetually undeveloped. Thus, they might be relegated to urban fisheries while also serving as recharge and retention basins. Without this secure and permanent storage, the drainage plan would not work, and sooner or later, Dhaka would once more be routinely polluted.

Yet, given the skyrocketing value of any real estate close to the city, and given the irresistible pressures to squat and develop urban wetlands whether spontaneously by the poor or by "quasi-legal" commercial developers, it is unlikely that these lands can be maintained as functional storage ponds. **Appendix I** provides some background of an analogous situation.

The rural situation is quite different. Large segments of the NCR front upon the unstable channels of major active rivers in their traversing an active deltaic landscape comprised of unconsolidated particles of low cohesiveness. Relatively secure embankments (i.e., structures that were armoured, reinforced or cased in concrete) close to the riverfront would probably be uneconomic, even for protecting minor cities, and much less so for protecting agricultural regions. Riverside earthen embankments may be justified when situated further shoreward of the active channel. However, the further landward these embankments are placed, the less the area that would be protected with a concomitant reduction in benefits.

More significantly, given the high density of population, embankments constructed well inland of existing channels would inevitably result in vast numbers of people being situated outboard of the newly protected zones. This raises the contradictions of public cuts and thus makes dubious the economic assessment and engineering assumptions predicated on the belief that the cuts would not take place. People living outboard would quite probably have to live with peak discharges of higher stage and greater velocity.

The hydraulic changes indicated on 10 day modelling might show changes to be insignificant. However, if modelled over a hourly, or daily or weekly basis the peak event may temporarily be far more significant. Whatever the case, the floodplain dwellers could be expected to do two things: first, they would probably press for a new embankment project right along the channel. This option might not be chosen for good technical and economic reasons. Second, if the setback embankment was eventually built, the risk of it being breached by "public cuts" rises proportionately with the size of the population remaining riverward of the structures.

4.4.3 Controlled Flooding

Complete flood protection" (or "full flood control") was a concept proposed in pre-FAP reconnaissance studies. This initially meant the total exclusion of overbank floodflows accomplished by continuous and "impermeable" embankments. Except for abrogation to particular urban areas, such a one-dimensional approach was subsequently discarded within FAP and the NCR because it does not take into account rainfall flooding and because of the inherent great disbenefits to fisheries, navigation, and possible adverse impacts on groundwater recharge and soil fertility.

The full flood control concept is thus not recommended in the NCR plan, but the concept of controlled flooding is recommended in certain places. This includes for two main variations;

> The present definition of "fully-controlled hydraulic structures" describe devices allowing passage of waters through a permeable embankment. These can employ adjustable or moveable gates, locks, valves, sluices and possibly pumps. Here "controlled" actually means "controllable", so that discharge through the control structure is subject to regulation or closure and is variable mechanically.
>
> By contrast, "semi-controlled hydraulic structures" achieve their effect by establishing a specified cross section, allowing limited bi-directional passage of all waters exceeding a particular stage. This approach includes fixed weirs, culverts, sills, submersible embankments, and flapgates, which do not incorporate adjustable mechanisms (flap gates, which permit one-directional movement only, are an exception). Maximum discharge through the structure would be restricted by its dimensions and elevation.

Thus "semi-controlled" refers to a water management strategy deploying a class of devices which are actually uncontrollable, but which effectuate - in conjunction with the embankments themselves - a predetermined alteration of flood hydrology, either inboard, and/or outboard of the levees. Such alterations may be "temporal", i.e. they change the timing or periodicity of the floodplain inundation regime. Or they may be "volumetric", with the stage and discharge being changed. They may also create both types of change.

The NCR plan thus includes for two *tactical* methodologies toward implementing a single *strategic* preference: "controlled flooding" as opposed to the now-abandoned strategy of "complete flood protection". (Note that a given flood management scheme might well deploy both types of control structures).

The advantage of fully-controlled hydraulic structures is that they allow maximum flexibility of response to a particular hydrological situation, permitting decisions on where the water should be routed, and how much, and when. Such decisions might be made on the basis of specific local requirements for aquifer recharge, soil moisture demands, fertilization mechanisms, migratory fish pathways or flood storage; this in accordance with specific local capacities for flood storage, or in response to flood crisis situations up or downbasin.

A flood management system based on fully-controlled structures could be either low-tech (crank telephones and manual closure devices) or high-tech (satellite monitoring downlinked to automatic gate actuators). Optimality throughout the technological spectrum requires reliable communications, command, and control. Another basic requirement, even of the lowest tech applications, is that O & M be reasonably satisfactory.

Such technologies require careful control as in the context of the NCR constraining factors include:

- financial inadequacies, leading to unmanned control structures; to poor or non-existent maintenance procedures; or to reallocation or misappropriation of critical system components; the removal of which would not be otherwise much noticed, e.g. primary or ancillary closure mechanisms, or emergency backup devices which may only be infrequently called into operation.

An example of this type of system failure occurred when a severe crop loss was recently sustained in the Muhuri project: the emergency generators provided in the scheme to raise the electrically-operated floodgates in case of power cuts were unavailable or inoperable when the need arose.

- institutional and social weaknesses, where operators of the various control structures may choose or be compelled to regulate water flow according to purely local and/or private considerations (or to serve the needs of a single sector only), irrespective of regional or basin-wide management strategies.

- infrastructure limitations with insecure or marginal telephone and electrical systems most likely to fail at the very time that the command, control and communications requirements for power and communications are most critical.

FAP-12 and 13 have addressed problems such as these in relatively general terms. It is indeed conceivable that great improvements could be implemented in the near-term. Nevertheless, present realities should imply great caution against water control schemes for the NCR that are dependent on fully controlled hydraulic structures being properly and systematically coordinated and deployed.

Such wariness seems particularly necessary wherever environmental management or mitigation plans intended to protect ecological processes would be absolutely contingent upon high calibre performance throughout the life of the project. Unlike ordinary engineering or implementation failures - which can often be easily rectified or rebuilt - a dysfunctional fishway "or energy/nutrient pass" may well result in irretrievable damage to genetic diversity or to other unrecoverable ecological losses.

Once having been built, semi-controlled hydraulic structures generally achieve their hydraulic or hydrological objectives without further interventions. The temporal and volumetric characteristics of structure "throughput" have been fixed in the design stage and additional adjustments are generally not possible. This leads to a number of distinct advantages over fully controllable devices and also to a number of disadvantages:

The principal advantages are that:

- O & M requirements are generally modest and relate largely to the intermittant removal of sedimentation and the clearing of debris, rather than to the regular maintenance of mechanical components of greater or lesser complexity; and,

- Many of the institutional and fiscal contraints that weaken the quality and reliability of "operations" are avoided in that there is no operator.

The disadvantages are more numerous, and potentially quite serious, particularly if environmental management or ecological mitigation is involved, with all of the associated uncertainties. These are as follows:

- If the design of the structure was based on erroneous or inadequate knowledge (i.e. poor topographic data), it can make the overall situation worse, with no recourse offered by adjustment of the operating regime, and no feedback of information or data. There is no operator, nor is there an operating regime.

- If the structure itself is a critical element of an environmental management scheme, monitoring will be all the more difficult; since ordinarily, nobody is posted to a semi-controlled structure, seeing what is *actually* happening: i.e., if migrating fish are supposed to pass through the structure, are they, in fact, doing so? Are fish overly vulnerable at such a constriction to improper harvest? Who will enforce fishing regulations intended to protect spawning adults at an unmanned choke point?

- Security may or may not be worse than with a manned facility, in terms of vulnerability to public cuts. Semi-controlled hydraulic structures were the most opportune targets of the Jamalpur char-dwellers, who perceived themselves to be victimized by the previous Jamuna left-bank flood protection scheme.

- While some retention may be provided by a semi-controlled hydraulic structure, opportunities for storage of floodwaters are limited; depending upon its siting, and upon the elevation of the established cross-section, relative to flood or stream stage on the both sides of the device.

4.4.4 Compartmentalisation

Much of the NCR (excepting the Madhupur uplands) is already in effect divided by existing FCDI components partly by embanked transportation routes (railway, main roads, and feeder roads), by paddy field dikes, by village paths and by the terraced/levelled fields. This represents the aggregate product of thousands of planning (but not necessarily rationally interconnected) decisions already taken at the macro, intermediate, and micro levels.

This present hydrological network does not, amount to an optimal, or even a rational system. The grandest macro projects have frequently been undertaken with insufficient knowledge of local realities - social and/or hydrophysical; while food for work (FFW) schemes have been generally driven by nutritional and equity objectives, rather than objectives representing sound engineering responses to clearly perceived infrastructural or hydraulic deficiencies.

At the micro scale, farmers have erected embankments which have been entirely predicated upon their own perceived short-term needs. This has sometimes been in coordination with the perceived needs of other farmers in their immediate proximity, and sometimes not. But rarely have up-or-downbasin consequences entered their consideration (except when compelled by hydraulic realities that could not be ignored).

Institutional and organizational difficulties and failures abound. It is difficult to obtain a useable map indicating even those projects completed in a particular region by a single agency, much less a map indicating the cumulative locations of all public projects implemented there by government at all levels, and by the major and minor NGO's. Even less available is a knowledge of the local micro-scale works and their influence on the hydraulic system at different times of the year.

Characterizing the majority of existing elements is the narrowest possible conceptual outlook. Previous projects designed to accomplish intersectoral objectives and to provide intersectoral benefits have been even rarer than projects properly addressing intersectoral disbenefits, and attempting to mitigate them.

FAP's concern about the benefits of FCD schemes need further consideration particularly as FCD scheme are devoted primarily to wet-season hydrological manipulations. Aside from rice, many other dry-season crops require structural mechanisms for careful retention and redirection of available surface water supplies. As water control and water management are important in the local situation it is important that the effect of major embankment and drains are considered in terms of the year-round water management, and this is to be considered at feasibility study level.

4.4.5 Without Project Scenarios

The "without" project scenario used in the economic analysis is a simplistic comparative base for measuring the increased level of costs and benefits associated with the NCR options for FCD. It assumes essentially a static situation in real terms, except for irrigated agriculture and for yield increases as the base case includes the very good yields of the last two years. Under this scenario there is obviously no impact assessment which can be applied and it does not appear in the matrix (**Table 3.1**).

The "no-project" alternative is not necessarily the environmentally preferable option: given the intense human pressures on the landscape everywhere in the NCR, it cannot be assumed that any ecologically-significant element can be sustained. Accordingly, major development schemes that included formal mitigation measures to conservation and environmental management species/habitat components might actually have a more positive impact than the "no-project, no-mitigation" scenario. This outcome is predicated on such improvements being technically well-conceived, adequately implemented, and then maintained and properly operated ad infinitum.

4.5 Impact Analysis of the Regional Scheme Scenarios

RS1 - Jamalpur Priority Project

The Jamalpur Priority Project is being studied at feasibility level by the FAP 3.1 study team. An EIA for the area is currently under preparation and a matrix assessment can be found in the Final Report (JPPS 1992).

RS2 - Structural improvements along the southern and southeastern periphery of the Jamalpur Priority Area.

Objective: to reduce Jamuna overspill flow entering into PU's 2 and 4, an area subject to monsoonal inundation resulting mostly from ponding rainwater and local runoff. (RIT categories VII, VIII.)

The embankment sub-components to RS2 are either already in place or are due to be completed soon under non-FAP projects. Thus these RS2 elements do not induce further environmental change. Similarly, of the three proposed new fully controlled hydraulic structures, two already exist as semi-controlled structures: at minor overflow or spill channel offtakes allowing some portion of Jamuna peak discharge into the Fatikjani and the Jhenai (West) Rivers.

The design and proposed operating regimes will be prepared at the feasibility study stage and thus at present it is only clear that some incremental reduction of riverine waters entering PU's 2 and 4 is intended. The most significant new structural element under RS2 would be a fully-controlled hydraulic structure across the existing opening beneath Baushi Bridge. This presently allows a part of the combined Jhenai/Chatal flow to pass through the rail embankment and enter PU's 2 and 4. Present estimated peak flows through the existing uncontrolled opening reach 350 cumecs. The proposed gated structure at Baushi Bridge would reduce this amount to a maximum of 50 cumecs. The design of this facility is not yet established, so it cannot be said whether all ordinary discharges exiting at Baushi would be unchanged beneath the 50 cumec threshold, or whether some other low-flow regime would be established. It is not known whether this structure would have effects on fisheries or other elements of the fauna and flora, beyond the effects resulting from the generalized terrestrialization of PU's 2 and 4, which is, of course, the objective of RS2.

It is also unknown whether flows through this part of the Jhenai contribute appreciably - if at all - to floodplain fish stocks or what effect - if any - the hydrological alterations resulting from the Baushi structure would have on the augmented Jhenai/Chatal, and upon the upper Jhenai, near Jamalpur (a channel presently subject to severe water quality problems during the dry season). The ecological significance of a changed ratio of riverwater to rainwater in the modified flood inundation regime of PU's 2 and 4 - in terms of soil condition or of more general nutrient deliveries - is also unknown.

Major Impacts:

Possible significant effects on instream and floodplain fish habitat; possible wetlands impacts, resulting from generalized reduction inundation in PU's 2 and 4. Increased crop production.

RS3A; Dhaleswari/Kaliganga Left Bank Embankment Scheme (W/O Jamuna Bridge).

Objective: to ameliorate or reduce deep and persistent flooding of PU's 6a and 7, resulting from Jamuna overspill entering the floodplain via the Dhaleswari/Kaligana (RIT categories X, XI, and primarily XII.)

The primary element of RS3A is a continuous streamside hydraulic embankment (with structures) to run along the left bank of the Dhaleswari and the Kaliganga from the Dhaleswari northern offtake to the Bangshi confluence at Kalatia. (The Dhaleswari/Kaliganga system is a cross-channel carrying a segment of the Jamuna's discharge directly to the Meghna, rather than to the Meghna via the Padma. Present estimates of the relative portion of overall Jamuna flow diverted through this route vary by one order of magnitude, between 1.5% and 15%.) Apparently, pursuant to present conditions, the general direction of surficial drainage of PU 6a is reversible, so that the left-bank distributaries under one set of hydraulic conditions become tributaries under the other set. (A segment of the upper Dhaleswari left bank embankment is already in place, but its present effectiveness is unknown, as are its existing impacts on fish migration and floodplain ecology).

The proposed embankment scheme would incorporate twelve new semi-controlled hydraulic structures. These would allow some flow to continue through the principal existing left bank outfalls (or intakes, depending upon the season).

It should be particularly noted that under RS3A, the deeply flooded regions along the Dhaleswari/Kaliganga right bank, in PU's 6b and 7 - which were not regarded as offering much opportunity for "release" under any embankment scheme for the Dhaleswari/Kalinganga - would probably be subjected to somewhat-worsened flooding. Accordingly, "floodproofing" elements for the right bank regions would be necessitated. Also, since terrestrialization of PU 6b and 7 under existing de facto compartments would probably be reversed, in part, the RS3A option would have conceivable positive effects on fish recruitment, wetland habitats, etc.

It must be stressed that the Dhaleswari/Kaliganga is one of the major waterways of Bangladesh still generally devoid of continuous embankments. Accordingly, insofar as the NCR remains the FAP region with floodplain fisheries least impacted by direct obstruction of migratory pathways, the embankment of even one side of the Dhaleswari/Kalinga could be regarded as having a potential impact on floodplain fisheries of national significance. The actual contribution of the Dhaleswari/Kaliganga migratory pathway to overall fish production is unknown, but important spawn and egg collection sites remain active along much of that river system. The proportion of spawn and eggs actually collected, relative to the overall amount produced, and the effects, if any, of this upon natural recruitment also remains unknown. Furthermore, the middle Kaliganga appears to be prime habitat for "shishu' (*Platanistes gangeticus*). The population level (and trajectory), and the overall status of Gangetic dolphins remains unknown, but this piscivorous species is now generally considered to be rare - if not actually endangered.

Major Impacts:

Potential significant disruption of riverine and floodplain capture fisheries (inside and outside the project area); loss of natural stock for culture fisheries; direct and indirect damage to endangered species habitat and aquatic food webs. Possible substantive improvement in cereal production (shift from b. aman to t. aman), accompanied by increased aquatic discharges of agrochemicals.

RS3B; Dhaleswari/Kaliganga left bank embankment scheme (with Jamuna Bridge).

Objective: to ameliorate or reduce deep and persistent flooding of PU's 6a and 7, resulting from Jamuna overspill entering floodplains there via the Dhaleswari/Kaligana. (RIT categories X, XI, XII, and XIII.)

The characteristics of this scheme are generally similar to those of RS3A, with the primary difference being the complete closure of the existing Dhaleswari northern offtake. (Project may also entail possible construction of a major "guide embankment" downstream of the bridge site, along the Jamuna left bank 20 km southwards to the site of the present Dhaleswari southern offtake).

Major Impacts:

RS3B would probably result in comparatively greater instream (Ei) effects than would RS3A, both on river hydraulics and morphology, on a considerable increase in land area brought into T.Aman from B.Aman and on fisheries and aquatic ecology. While the cutoff upper Dhaleswari channel would remain partially filled, due to backwater effects, local sedimentation may be accelerated, with eventual blockage of much of the northern arm. In addition, the northern regions of PU 6a would be isolated from direct overbank spillage of the Jamuna, and would probably be substantively terrestrialized, with some incremental local losses to instream and floodplain fisheries.

If the reproductive cues and recruitment mechanisms of important fish species here are sensitive even to minor alterations in direction and velocity of mainstem river currents, the cutoff of the Dhaleswari northern offtake may have disproportionately greater consequences on the fisheries of the entire Dhaleswari/Kaliganga system than would seem to be implied by the elimination of the northernmost arm alone.

RS4; Major drainage improvements in the Middle Bangshi, the Bangshi-Turag, and Old Bangshi, between Kauljani and Kalatia.

RS4; 1 - Kauljani (Middle Bangshi) sub-component

Objective: to increase the hydraulic efficiency of the primary downbasin pathway draining PU's 2 and 4, an area subject to monsoonal inundation resulting mostly from ponding rainwater and local runoff. (RIT categories II through VI, but dependent on design criteria not yet established.)

Virtually the entire reach of the Bangshi between Kauljani and Mirzapur is characterized by meanders of high frequency and moderate amplitude, probably at least doubling the length of the river here, compared to the straight line distance.

The Bangshi drains the western slope of the Madhupur Tract, as well as much of the region west of the river, including Ghopalpur and Ghatail; the area under PU's 2 and 4. While the dominant landform here is the "young Jamuna floodplain", water from the Jamuna itself is a relatively minor component of the local inundation regime; overland movement of Jamuna spillage has been largely limited by the existing railway embankment of the Jamalpur/Jagannathganj line, and by segments of the existing Jamuna left bank embankment.

The major perceived problem here is impeded local drainage of ponding rainwaters. Overall cropping intensity in PU's 2 and 4 is already high at 218% so the principal limitation of agricultural productivity is the present unacceptable riskiness of converting from b. aman to t. aman. The assumption is that if downbasin flows were accelerated through the Bangshi's inefficient, meandering reach below Kauljani by means of channel improvements there, substantive areas presently flooded by rainwater would be "released" to t. aman. Such improvement could include cutting off or straightening meanders, as well as dredging the existing Bangshi channel, reshaping the banks, etc.

While the Kauljani reach probably transited an outstanding wetland a generation or so ago, at present the landscape is entirely manmade. (Some herbaceous natural wetland vegetation probably reappears temporarily during the rainy season). The last segments of high-quality *sal* forest on the Madhupur slope just adjacent to the Bangshi east bank were cut only within the last few years, despite the strident protests of local resident and local NGO's.

The Kauljani reach of the Bangshi still contains some water at the height of the dry season - continuing to serve then as a local navigation route for non-mechanized country boats - and subsistence fishing is carried out year-round, although yields are not high. Interestingly, this area is a nexus of "Bedeh" settlement: the Bedeh being a boat-dwelling Bengali Muslim subculture - sometimes called "water gypsies" - who traditionally monopolized the freshwater pearl and mussel gathering industries in deltaic Bengal. (The mussel shell is used for mother-of-pearl, or is burnt for the high-quality lime paste chewed ordinarily with areca and betel.) Some 100 Bedeh families live on their boats, concentrated at the apexes of several meanders in the central part of this reach, and presumably, river mussels are still found in sufficient numbers here to attract them.

It should be noted that a partial embankment scheme for the Bangshi left bank has been undertaken in the lower portions of this reach (probably under FFW). Farmers shoreward of these structures complain that the elimination of annual flooding here has severely reduced their crop yields.

Major Impacts:

Channel improvements to the Kauljani reach of the Bangshi could be devised and implemented with considerable ecological sensitivity - as would seem to be warranted by continued local dependence there upon aquatic biodiversity (and evidently, upon floodborne fertilization as well), or they might be predicated on hydraulic objectives only.

Based on present FCD practices,it would not be unusual for the spoil material excavated from a channel improvement initiative here to be deposited along both shores of the Bangshi as a de facto embankment, droughtiness may also turn out to be a problem in this scenario

The interests of the Bedeh community will require special protection, as their social status is not high.

RS4.2; Mirzapur/Kalatia subcomponent (Bangshi/Turag, Old Bangshi, and Lower Bangshi reaches)

Objective:

To improve overall drainage of PU's 6a and 7, allowing "release" from inundation of large areas in lands there now too deeply flooded to permit widespread adoption there of HYV t. aman technologies. (RIT categories IV-VI, and VII-VIII, depending on final project design; although the embankment proposals under RS3 and RS6 - required to make RS4 practicable - themselves fall under RIT categories XI and XII.)

To facilitate the drainage improvements in the upstream Kauljani reach (see RS4.1 above).

The "conjunctive" implementation of RS4 presumes that effective terrestrialization of PU's 6a and 7 requires, first that overbank floodflows arriving either directly from the Jamuna or arriving indirectly, via the Dhaleswari be eliminated or much-reduced by the embankment components of RS3 or RS6. Then, the portion of standing waters still remaining - now derived mostly from rainfall and local runoff - can be readily conveyed downbasin along the eastern margin of the release area. Thus, the present reversible flow of surface drainage throughout the release area would be made more mono-directional (i.e., from west to east).

RS4 would require emplacement of two fully-controlled hydraulic structures at Kaliakoir, across offtakes from the Turag, and two more situated downstream at Kalatia. These would regulate the relative shares of interior drainage flows now distributed between generally-parallel and repeatedly interconnected Bangshi and Turag/Buriganga channel systems. It should be emphasized that the details of channel improvements now being proposed under RS4 would have to be modified at feasibility level, taking into account ongoing activities on the Dhaka periphery that could significantly alter the present hydraulic characteristics of the Turag/Buriganga pathway. (See **Appendix I**).

Major Impacts

The successful "release" to t. aman of sufficient lands within PU's 6a and 7 to justify investments in the requisite hydraulic works implies very significant reductions in floodplain and riverine fisheries; marked alteration of the present spatial and temporal characteristics of remaining wetlands and bils; substantive changes to existing navigation routes (which may include both positive and negative effects); and probable reduction of biodiversity. On the positive side, cereal production should be made to rise appreciably, with the usual caveats about uncertain sustainability, and the further discharge of HYV-linked agrochemicals into local and regional waterways. Wet-season land transport may be improved, but not necessarily to a degree which adequately compensates for possible losses to internal navigation. Induced droughtiness is also an issue of possible concern, as the effects of hydrological manipulations at this scale upon ground and surface waters during the dry season cannot be dismissed.

RS6A/B; The Dhaleswari/Jamuna/Padma Left Bank Scheme: Bhuapur-Aricha-Harirampur Embankment (with and without the Jamuna Bridge)

Objective: To significantly reduce overbank spillage from the mainstem Jamuna and the combined Jamuna/Padma in PU's 6a, 6b, 7, 10, and 13; areas which include some of the most deeply and persistently inundated regions in the NCR - if not Bangladesh - as a whole. (RIT categories VII and XI, but predominantly XII.)

This is the most ambitious regional scheme considered under FAP-3 and it is only included as a possible element of the long term plan. Implementation cost would be very high, with substantial continuous embankments being (over 5m in several places) required. Construction would have to meet very stringent engineering standards, since the consequences of sudden, massive failure could be catastrophic. These could be similar to those of a cyclone, rather than the kinds of casualties and damages ordinarily associated with even extreme monsoonal flood events in the interior of Bangladesh. Hazard analysis should therefore be rigorously applied.

The primary embankment would run along the Dhaleswari left bank, from the Northern offtake (which would be regulated with control structure, as would be the southern offtake) but South of Dhula another embankment would follow the Jamuna and Padma. Other project elements would include additional semi-controlled structures along the Jamuna and Padma reaches, allowing restricted flows into offtakes of several lesser, interior cross channels, including the Ghior Nadi, and the Ichimati.

Accordingly, the benefit stream of the conversion from low-yield longstem native cultivars to HYV rice culture systems, as well as the reclamation of some regions too deeply inundated for practicable kharif agriculture, would also have to be proportionately substantial. This would require very significant degrees of terrestrialization accompanied, presumably, by very large adverse impacts on aquatic communities, both in the major rivers and in floodplain waterways. There would also be a range of less-certain ecological effects within some 300,000 ha of semi-aquatic landscape lying between the Padma and the Bangshi. Unless some extremely effective fisheries mitigation plan was devised, implementation of RS6 would represent, possibly, the single largest possible blow to Bangladesh's remaining inland fish stocks.

Major Impacts:

Extremely significant effects on riverine and floodplain fisheries and presumed similar effects on overall aquatic and terrestrial biodiversity. Maximal alteration of the present spatial and temporal characteristics of remaining wetlands and bils; substantive changes to existing navigation routes (in which negative impacts will probably outweigh positive benefits). Induced droughtiness is also an issue of possible concern, as the effects of hydrological manipulations at this scale upon ground and surface waters during the dry season cannot be dismissed.

On the positive side, there might be a very major increase in cereal grain production, and vast regions in which human habitation is presently somewhat limited by deep inundation may become available living space. Embankments of the scale and solidity required to achieve the goals of RS6 may be relatively resistant to public cuts, but they will not necessarily withstand a severe seismic event. Thus, the risk entailed by natural hazards may be substantively reduced when speaking of monsoonal floods, but very much exacerbated, in terms of vulnerability to embankment failures induced, either by fluvial process, by seismic events, or by a combination of the two.

The scope, and the potential environmental and social impact, of Regional Scheme 6 is so large that the relative difference between the "with" and "without" Jamuna Bridge scenarios can probably be overlooked at the present coarse level of investigation.

CHAPTER 5
RISKS AND HAZARD ANALYSIS

5.1 Introduction

Risk is inherent in the planning and operation of embankments. There are a number of features where specific risk and hazard assessment should become a standard part of the project analysis to enable policy makers to have a complete picture of the long term strategy that embankments entail. The decision to embank can only be justified when conventional analysis based on the available hydrological data base is supplemented by rigorous risk and hazard analysis.

Risk and uncertainty are largely inextricable. Risk usually refers to probabilities and to chance events; some of which may have predictable recurrence intervals. Uncertainty here shall refer to the lack of relevant scientific data (or the surfeit of flawed or fraudulent data); the absence of technical specifications of prospective structural or hydraulic interventions; the dearth of environmental modelling or simulation tools with sufficient predictive capabilities; and the rudimentary understanding of complex ecological processes.

If an impact assessment is judged on the basis of its providing quantitative guidance to decision-makers, the present study will be found wanting. Yet, the level of uncertainty inherent in a pre-feasibility level investigation severely limits the ability to provide defensible numeric outputs.

These risks and hazards fall under the headings of physical, socio-economic and human.

5.2 Physical Risks and Hazards

The primary planning is carried out on an assumed relevant range of data and time series analysis. In practise this may not adequately represent the actual range of events which may occur in the lifetime of the project.

Three conditions of climate have to be noted:

- Above average events which exceed the design criteria, but do not lead to structural damage.

- Extreme and catastrophic events that will need emergency measures and consideration of both structural and non-structural contingency plans.

- Changing global climate patterns that will affect the base conditions of the existing situation on which the design criteria for projects have been designed.

These and coincident events which exceed the design criteria will compromise the sustainability of the engineering structures and lead to damage within and outside of the protected areas. This would significantly increase the costs for maintenance and rehabilitation beyond those assumed in standard project analysis.
Historic data indicate a phase of global warming and suggests that rising sea levels could be expected. The effects

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of sea level rises of one and a half metres would create backwater and morphological effects at the confluence of the Ganges and the Brahmaputra. Unless these events were to happen in a much shorter time span than is currently being forecast it seems unlikely that provisions have to be made in the feasibility planning stage of the current round of projects in the NCR. The full FAP and the projects in the south of the country on the other hand are unlikely to be able to ignore these questions.

Other changes which might be associated with changing climate might involve variations in the seasonal pattern of precipitation and snow melt in the Himalayas which would affect the seasonal hydrology and morphology. These effects have not been modelled directly at this stage.

Siting embankments is another exercise in risk assessment. There are a number of major problems of the design standards and building materials and sustainability of structures and embankments given the dynamics of the physical and hydro-morphological systems they intervene in. High rainfall events behind or upstream of embankments can lead to their demise. Operations across the borders can lead to peak flooding which is unrelated to the natural hydrographs which the designers work from. Changing river courses mean their real costs increase above those estimated at the time of original design. If they are built close to existing mainstem channels, they are subject to being swept away by a high recurrence-interval flood. If this occurred early in the embankment's life the whole initial costs would have to be written off.

There are a number of hazards where analysis of their implications should take place. None are easy to evaluate mathematically. Earthquakes, for example, may or may not be predictably distributable on a recurrence interval scale. Their intensity of destruction may also be related more to their coincidence with other events such as coincidence with the monsoon and flood peaks, coincidence with high rainfall years or coincidence with mass wasting events and other morphological threshold events either upstream or within the delta.

The secondary effects have already been witnessed after the major quake in Assam in the 1950's which rapidly aggraded the bed of Brahmaputra by several meters. This was probably responsible for the sequence of peak flood events in 1954, 1955 and 1956 (which led to the setting up of the IECO studies in the 1960s) and for the severe deterioration of navigability in the Jamuna.

The probability and intensity of seismic events declines moving across the Delta from Northeast to Southwest. The NCR lies mostly in the area of medium risk of presumed seismic vulnerability. Nevertheless, Dhaka city was very severely damaged by a major earthquake in the late-19th Century.

Local embankment materials are at particular risk to liquefaction as evidenced by the geological surveys of the FAP 3.1 study. These largely unconsolidated, sandy-silt materials of low cohesive strength would result in widespread slumping failures in the next high-energy seismic event. Even if such an event occurred during the dry season, the direct effects of embankment failures might only be minor, but the integrity of the system would have failed for the following season unless a widespread programme of immediate rehabilitation could be mounted. If the rivers were high, the outcome could be catastrophic with considerable loss of life and property over and above that which would have occurred without the embankments.

Earthquakes could also result in the breaching of manmade or natural reservoirs in the upstream catchment in India and the Himalayan states. This could create major sudden increases in stream discharge that could conceivably overtop or destroy downbasin embankments that had withstood the direct seismic shock. Flood wave analysis on any of the existing or proposed dams is not available to assess these implications and stresses the need for a catchment and international cooperation in dealing with the issues of hazard assessment.

A proper safety analysis of hazards should be a minimum requirement for any donor financed scheme with implications of the scale which might well be involved. The major embankments act, in many respects, as dams and international standards for such analyses on any dam are usually very stringent internationally particularly where loss of life can be expected. These factors must be considered at the feasibility level investigations.

5.3 Socio-economic Risks and Hazards

FAP-3's Regional Schemes are specifically intended to alter the cropping pattern of conservative farmers whose planting strategies have traditionally been "risk-averting". Given the chance of ordinary floods damaging crops in their lower-lying fields, farmers customarily avoid the substantive investments necessary to raise HYV cultivars, hoping against experience for a bumper crop. Knowing that the odds for this are not good, they instead sow traditional, low-yielding cultivars that may or may not reach fruition: if the planting survives the floods and produces a modest harvest, so much the better. But if it doesn't, the investment was small enough that the loss is bearable.

The basic rationale for the proposed interventions is that the likelihood of crop survival in marginal zones can be raised sufficiently by the projects, that even a cautious and risk-averting farmer will consider that the odds have sufficiently changed in his favour, so that HYV inputs are now justified.

Most of the quantifiable benefits hinge exactly upon this "contingency". The gamble being taken is an engineered reduction of agricultural risks which will induce farmers to upgrade production modes. Contingency elements imply risk-taking. The current assessment of the probability of farmers actually shifting to HYV indicates that enough will shift production strategies to recommend that the higher-ranked projects be considered for feasibility-level studies. This argument can only be sustained if it can be established that those living outside the embankments will not find conditions worsened and thus that public cuts become inevitable and not possible to mitigate.

The "human-factor" hazards primarily concern the issue of public cuts which have been shown in certain circumstances to totally undermine the logic of any standard project analysis. Other factors may also have some strategic value and would involve analysis of the situations of warfare and political violence.

CHAPTER 6
ENVIRONMENTAL MANAGEMENT PLANNING

6.1 Future Approach

Given that the level of project designs are only to pre-feasibility level, no specific management plan can be put forward at this stage. The criteria for including a range of natural resource and multi-sectorial objectives into the planning framework have been highlighted. This will only become possible once serious attention is given to proper field research, monitoring and follow up. A minimum database of even one years research, covering the succession of seasons does not exist for water quality and a range of important ecological and public health processes. This research needs to be given high priority and initiated at an early stage. Without this data base the feasibility studies will also suffer from the same deficiencies on environmental assessment faced by this and other FAP studies.

There is no question that the future implementation and funding of the Jamuna Bridge are critical to the future of the NCR planning. Many issues such as who will fund the mitigation proposals and cover, institutionally, the adverse effects have yet to be clearly resolved. The Jamuna Bridge project has not yet indicated any plan for funding, operating and maintaining any mitigation components that should be expected as a consequence of their proposed construction. The environmental impacts and the management necessary to deal with these will directly affect the future of planning for the NCR and, unless they are dealt with, could also threaten the integrity and credibility of the scheme itself.

The following discusses some of the other requirements for environmental management planning based on the pervading limitations within the system and the basic principles for a future direction.

6.2 The Need for Better Policy Initiatives

Where negative environmental effects foreseen by the impact assessment cannot be adequately eliminated at the design and operational levels, "mitigation" measures are sometimes devised, whereby other interventions would be incorporated into the overall development program. Such elements do not necessarily rectify new environmental problems flowing from the project itself, but rather attempt to create a "no net loss" situation in overall environmental quality.

Science may be good at describing the current status of the environment of Bangladesh. It might also be getting better at predicting where it is going. However, scientific empiricism does not impart any particular ability to prescribe what ought to be the future status of Bangladesh environment. Ex-post evaluation of previous FCD and FCDI projects show that public participation has not been a feature of previous FCD(I) planning to elicit local priorities on these issues. It is the explicit decision not to delete these elements from the FAP and EIA planning process, which has disturbed many "no-nonsense" project proponents, who seek quick planning decisions, and on purely empirical basis.

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Worldwide many engineering schemes have been redesigned or sometimes stopped on grounds of their impact. Sometimes the issue may be largely technical when an external interlinkage is identified that would make the project fiscally irrational. An example would be where prospective losses to another economically-valuable resource sector. In other cases, decisions relate to such issues as the effect on social equity, aesthetic consequences or its impact on the habitat of an endangered species.

In Bangladesh impact analysis is very recent. While considerable sums of money have been spent on capital improvement schemes (of which about half were water management interventions, only one project has been stopped on environmental grounds and that was not stopped until after the damage was done. It is vital that credible policies and standards for environmental assessment and management are set.

Whether these policies and standards should be less stringent than elsewhere implies that a number of important issues require immediate and explicit consideration. Should these allow for "critical" projects to be delayed on grounds other than economic optimality? Should major investments be made into "uneconomic" environmental improvements? Are requirements for post-project mitigation, amelioration, or monitoring practicable in the existing institutional context? Are "quality of life" issues to be taken seriously in the face of irresistible demographic pressures? : all these are among larger questions of environmental management. While the preparations for an environmental policy have been underway for over a decade, this has yet to be fully clarified.

6.3 Strategic Issues

The TOR and resources of FAP-3 have not allowed for full consideration, design and costing of non-structural (or semi-structural) interventions to reduce impacts of flooding; however these have been taken forward as strong recommendations for inclusion in the feasibility study phase. While this logic may ensure that the future safeguards are installed in the planning process it is regrettable that genuinely alternative solutions to larger water management problems were not addressed immediately apart from hydraulic infrastructures to prevent flood damage. It may well be that the chance to provide a holistic focus upon regional resources development may have been lost as the only future planning scheduled for the NCR will be at a project and not at a regional level.

Evaluations of existing FCDI compiled from studies under FAP 2, 5, 12, 13 and 16 have noted over 100 impacts. Of these about 40% were potentially major impacts over a range of particular scheme and locality situations. That this number might apply to specific projects in the NCR would be misleading as, in some cases impacts which appear adverse in one project can be found to be beneficial in another. Nevertheless, the range in itself, highlights the complex nature of FCD(I) inter-actions and outcomes, as well as the problems to be faced in planning and appraising floodplain development through flood control, drainage and irrigation.

These analyses show that FCDI interventions sometimes contribute to environmental instability. Some have serious social and economic impacts which questions whether the historic FCDI approach is at all sustainable. If these conclusions are relevant future strategies must be re-designed with the advantages of hindsight and learning from the lessons of the past to maximise the benefits to the nation from future funds.

Previous FCD projects have not substantively addressed either social, ecological or inter-sectorial objectives. Therefore, many of the adverse impacts that have been found relate to these objectives limited to agriculture and FCD. Improved planning and more sustainable development can only be achieved if the most important impact areas, such as navigation, public health, pollution and natural resource management are integrated into the earliest stages of planning. This study has tried to present the strategic reasoning and limited evidence to highlight why this must be given priority in the future studies.

High on the list of actual resource management crises in Bangladesh are the general absence of urban sanitation - with predictable consequences to public health, and the rising levels of clinical malnutrition related to shortages of animal protein (due to a decrease of fish in the diet).

Pursuant to both the present FAP-3 TOR, and to the "Eleven Guiding Principles", it is not alternate strategies of water development that are being prepared and evaluated, but rather, it is only alternate tactics - most of them falling under the same general strategy of hydrological manipulations to be accomplished predominantly by engineering works, although locally organised initiatives involving such activities as improved water management induce non engineering changes through public participation and institutional agreements.

The National Environmental Policy and Management Action Plan (NEMAP) has specifically allocated the survey and planning for the nation's major floodplain wetlands to the FAP. This should affect the whole approach to coordinating national policy and resources in the fields of conservation and the identification of Protected Areas.

6.4 Monitoring

Monitoring is required to ensure that adequate baseline studies are carried out prior to the feasibility phase, and before any final decisions on implementation. In the absence of an adequate institutional capacity at present in the DOE this work will need to be carried out under specific contracts which can feed on into the DOE as its establishment is refined and better resourced. This monitoring would establish a quantified database with a capacity to detect change and assess its implications. The results should allow advice and action on an on-going basis to mitigate any adverse consequences arising from projects. In the NCR this will require the GOB and donors to immediately establish a basis for carrying out this work. Some indications on what this will require are given in section 6.6.

The first suggestions on the location for future water quality monitoring stations are given in **Figure V.2.6.**

6.5 Planning Framework

The approach to the next phase of planning should enable studies to be in a situation to assess how the maintenance of the resource base for future generations of users can be achieved. The approach must either avoid or effectively mitigate the worst impacts of future interventions and identify the complementary programmes which address key social and environmental objectives.

The FAP studies have already clearly identified that FAP schemes would be only one amongst many other activities affecting the quality of life and environment in the region. Yet, the FAP schemes, intervening in water and flood flows will directly impact these other activities. Proper resource management can only come about through close coordination with other FCD (I) water related-projects and other sectors. The coordination of the former has started under FPCO which has no mandate past the planning phase. The coordination of the latter needs to be part of an integrated planning approach within the feasibility studies and established institutionally in the operational phases.

The national environmental policy and management action plan (NEMAP) lays out the need for such an integrated approach. The growing acceptance for the need to promote public participation will mean that a radically different form of planning will have to be instituted to allow the planners adequate time and facilities to ensure that this is carried out. Improved environmental management will also require policy, legislative and fiscal measures to act as incentives and dis-incentives. Investment in resources and training to create a cadre of committed staff is also required. This has been started under ADB support. It will also require the active involvement of the media, the NGOs and local people if it were to have any chance of success. The shifts in emphasis of national policy with the NCS and NEMAP, together with ratified environmental policy, would require any future water sector planning to take full account of these.

6.6 Future Work and Resources

The future work will need to address the deficiencies in data and subject matter specialists that have limited the IEE and the progress of any future environmental planning. In view of the limited development of the reliable laboratory services in Bangladesh, it may also be necessary to consider the logistic of using international facilities, or else the direct improvement of local facilities in the DOE prior to the next phase of data collection. This problem particularly relates to the water quality sampling and the ability to conduct analysis for a range of pollution issues.

The surveys should be established so as to conform with the EIA and public participation Guidelines. This will require studies to deal with the pre-construction impacts, the construction impacts and the post-construction operation and maintenance impacts. In addition specific data and analysis will be required to allow proper hazard and risk analysis.

The timing of inputs into the follow up or feasibility studies is important. Initial baseline surveys should be started well in advance to allow a full year of data collection in the biological subjects. If the EIA is to be completed properly and feed smoothly into the feasibility analysis and planning logic the specific needs of the impact coordination have to provided for.

Inputs are required to set up, coordinate and carry out the baseline surveys and preliminary analysis. This if followed by an inter-disciplinary input to feed key issues into the mid-planning stages of the agricultural and engineering alternatives. Finally after the final project options and their designs are complete the economic and impact analysis can be completed.

TOR for feasibility studies have been prepared by the NCRS and are under consideration by FPCO.

Supporting Report V

Environment

Appendices

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REFERENCES

BDG	1975	Bangladesh District Gazetters, Dhaka 1975. Mymensingh 1978.
Cross	1992	"Synchronicity, Energetics, and the Stability of the Floodplain Fisheries." Proc. Eighth Nat. Zool. Conf. Bangladesh. Rajshahi, 1992.
Cross	1991	Annex V, Dhaleswari Mitigation Plan, GHK/MRM International, Dhaka, Bangladesh, Cross D, 1991.
Harvey	1990	"Birds in Bangladesh." UPL, Dhaka, Harvey WG, 1990.
Khan	1989	"The Freshwater Fish of Bangladesh." UPL, Dhaka, Khan A.R., 1989
MOEF	1991	"Draft National Conservation Strategy" Dhaka, July 1991, MOEF/IUCN 1991.
NCRS	1991	North Central Regional Study - Phase I: Reconnaissance, R.S.I Land use map based on SPOT imagery.
Rashid	1978	"Geography of Bangladesh", Rashid, Haroun-Fr, 1978.
Sarker	1990	"Environmental Aspects of Surface Water Development in Bangladesh." Eds Rahman, A.A., Huq, S., & Conway,G.R.,Article by Sarker M.D. & Husain, K.Z., 1990.
WRI	1990	Draft Report on "Bangladesh environment and natural resource assessment", Centre for International Development and Environment. Washington D.C., World Resources Institute 1990.

APPENDIX V.I
RARE AND ENDANGERED WILDLIFE SPECIES IN BANGLADESH

Key to Status: 1 = Very Common, 2 = Fairly Common, 3 = Common
4 = Uncertain   5 = Threatened   6 = Endangered
**** = Present in NCR**

Category/Name	Past Status (@ 1940)	Present Status
MAMMALS		
Slow Loris *Nycticebus coucang*	2	6
Capped Lengure *Presbytis peliata* **	2	6
Crab Eating Macaque *Macaca fascicularis* **	2	5
Hoolock Gibbon *Hylobates hoolock*	3	6
Large Civet *Viverra zibethina* **	3	6
Fishing Cat *Felis viverrina* **	2	6
Jungle Cat *Felis chaus*	2	5
Tiger *Panthera tigris*	2	6
Leopard *Pantheris pardus*	3	5
Clouded Leopard *Neofelis nebulosa*	2	6
Asiatic Elephant *Elephas maximus*	3	6
Barking Deer *Muntiacus muntjak*	3	5
Sambar *Cervus unicornis*	3	5
Serow *Capricornis sumatraensis*	2	6
Hispid Hare *Caprolagus hispidus* **	3	6
REPTILES		
Estuarine Crocodile *Crocodylus porosus*	3	6
Gharial *Gavialis gangeticus* **	3	6
Olive Ridley Turtle *Lepidochelys olivacea*	3	6
Green Turtle *Chelonia mydas*	3	6
Hawksaw Bill Turtle *Eretmochelys imbricata*	3	6
Loggerhead Turtle *Coratta coratta*	3	6
Leatherback Turtle *Dermochelys coriacea*	3	6
Batagur Turtle *Batagur baska*	3	6
Bostami Turtle *Trionyx nigricans*	3	6
Land Tortoise *Geochelone emys* **	3	6
Grey Lizard *Varanus bengalensis* **	3	5
Monitor/Ring Lizard *Varannus salvator*	1	5
Yellow Lizard *Varanus flaviscens* **	3	5
Clouded/Black Lizard *Varanus nebulosa*	3	5
Rock Python *Python molurus* **	2	6
King Cobra *Ophiophagus hannah* **	2	6
Dog-faced Water Snake *Cerberus rhynchops*	3	5
Hook-nosed Sea Snake *Hydrophis cyanocintus*	1	5
Banded Sea Snake *Hydrophis fasciatus*	4	5
Estuarine Sea Snake *Hydrophis obscurus*	3	5
Common Narrow-headed Sea Snake *Microcephalophis gracilis*	3	5
Cantor's Narrow-headed Sea Snake *Microcephalophis cantoris*	3	5

RARE AND ENDANGERED WILDLIFE SPECIES IN BANGLADESH (Cont)

Key to Status: 1 = Very Common, 2 = Fairly Common, 3 = Common
4 = Uncertain 5 = Threatened 6 = Endangered

Category/Name	Past Status (@ 1940)	Preset Status
Amphibians		
Bull Frog *Rana tigrina* **	1	5
Green Frog *Rana hexadactyla* **	4	5
BIRDS		
Little Grebe *Podiceps ruficollis* **	1	5
Darter *Anhinga rufa* **	2	5
Purple Heron *Ardea purpurea* **	2	6
Grey Heron *Ardea cinerea* **	3	5
Openbill Stork *Anastomus oscitans* **	3	6
Lesser Adjunct *Leptoptilus javanicus* **	2	6
Whitenecked Stork *Ciconia episcopus* **	2	6
Glossy Ibis *Plegadis falcinellus* **	2	6
Spoonbill *Platalea leucorodia* **	2	6
Greater Whistling Teal *Dendrocygna bicolor* **	3	6
White Winged Wood Duck *Cairna scutulata*	2	6
Comb Duck *Sarkidiornis melanotos* **	2	6
Black Winged Kite *Elanus caeruleus*	3	6
White Bellied Sea Eagle *Haliaeetus leucogaster*	3	6
Pallas's Fishing Eagle *Haliaeetus leucoryphus* **	2	6
Greyheaded Fishing Eagle *Ichthyophaga ichthyatus* **	3	5
White Backed Vulture *Gyps bengalensis* **	1	5
Assam Black Partridge *Francolinus francolinus* **	2	6
Rain Quail *Coturnix coromendelica*	3	6
Common Peafowl *Pavo cristatus* **	2	6
Pheasant-tailed Jacana *Hydrophasianus chirurgus* **	2	5
Painted Snipe *Rostratula bengalensis* **	2	5
Brown Fish Owl *Bubo Zeylonensis*	2	6
Great Hornbill *Buceros bicornis*	3	6
Hill Myna *Gracula religosa*	3	5
Paradise Flycatcher *Terpsiphone paradisi*	2	5

Source: MOEF, Draft National Conservation Strategy, July 1991.

APPENDIX V.II
THREATENED FLORA - TENTATIVE LIST

PTERIDOPHYTA	DISTRIBUTION
Psilotum triquetrum	Khulna
Tectaria chattagramica	Barisal
ANGIOSPERMS	
Aglaonema clarkei	(endemic) Chittagong
Aldrovanda vesiculosa	Bandarban
Aquillaria agallocha **	Dhaka, Rajshahi
Cirrhopetalum roxburghii	Sylhet
Cymbopogon osmastonii	(endemic) Sunderban
Debregeasia dentata **	Bogra, Dhaka
Elaeocarpus lucidus	Chittagong
Hippocratea macrantha	Chittagong
Homalium schichtii	Chittagong
Justica oreophila	Chittagong
Knema bengalensis	Chittagong
Limnophila cana	(endemic) Cox's Bazar
Mantisa spathulata **	(endemic) Jamalpur, Pabna, Dhaka
Marsdenia thyrsiflora	(endemic) Chittagong, Sylhet
Ophiorrhiza villosas **	Central Regions
Phrynium imbricatum	Chittagong
Quercus acuminata	Chittagong
Rotala simpliciuscula	Chittagong
Semecarpus subpanduriformis	(endemic) Chittagong, Sylhet
Sonneratia griffithii	Chakaria, Sunderbans
Spatholobus listeri	(endemic) Chittagong
Toournefortia roxburghii	Chittagong, Rangamati
Typhonium listeri	Chittagong
Vatica scaphula	(endemic) Chittagong
Vernonia thomsonit	Chittagong

** = Present in NCR

Source: MOEF, Draft National Conservation Strategy, July 1991.

APPENDIX V.III
AMPHIBIANS AND WETLAND REPTILES

** indicates species present in NCR.

Name	Status
AMPHIBIANS 19 total species known and include:	
Bull Frog *Rana Tigrina* **	Threatened
Green Frog *Rana hexadactyla*	Threatened
Skipper Frog *Rana cyanophyctis* **	Very Common
Cricket Frog *Rana limnocharis* **	Common
??? Frog *Rana temporalis* **	Rare
??? Frog *Rana tyleria* **	Rare
Tree Frog *Rhacophorus maximus* **	Common
Tree Frog *Rhacophorus bimaculatus* **	Common
Balloon Frog *Uperodon globulosus*	Rare
Toad *Bufo melanostictus* **	Fairly Common
REPTILES 150 total species known, aquatics include:	
Lizards and Skinks 18 total species, aquatics include:	
Large Land Lizard *Varanus bengalensis* **	Threatened
Ring Lizard *Varanus salvator*	Threatened
Yellow Water Lizard *Varanus flaviscens* **	Threatened
Wall Lizard *Hemidactylus flaviviridis* **	Common
House Lizard *Hemidactylus brooki* **	Fairly Common
Wall Gecko *Gekko gecko* **	Common
Garden Lizard *Calotes versicolor* **	Fairly Common
Common Skink *Mabuya carinata* **	Common
Striped Skink *Mabuya dissimilis* **	Common
Crocodiles known total species are:	
Salt Water Crocodile *Crocodilus porosus*	Endangered
Fresh Water Crocodile *Crocodilus palustris*	Extinct
Ghorial *Gavialis gangenticus*	Endangered
Turtles and Tortoises 31 total species known, of which 3 terrestrial and 24 freshwater, 4 marine include:	
Spotted Flap Shell Turtle *Lissemys punctata* **	Fairly Common
Coast Soft Shelled Turtle *Pelochelys bibroni*	Rare
Soft Shelled Turtle *Chitra indica*	Rare
Ganges Soft Shelled Turtle *Trionys gangeticus* **	Fairly Common
Bostami *Trionys nigricans*	Endangered
Pezcock Soft Shelled Turtle *Trionys hurum*	Common
Leatherback Turtle *Dermochelys coriacea*	Endangered
Common Roofed Turtle *Kachuga tectum* **	Common
Sylhet Roofed Turtle *Kachuga sylthensis*	Uncommon
Smithi Roofed Turtle *Morenia petersii*	Fairly Common
Common Batagur Turtle *Batagur baska* **	Endangered
Loggerhead Turtle *Coratta coratta*	Endangered
Green Sea Turtle *Chelonia mydas*	Endangered
Olive Ridley Sea Turtle *Lepidochelys olivacea*	Endangered
Hawksbill Sea Turtle *Eretmochelys imbricata*	Endangered

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Name	Status
Loggerghead Sea Turtle *Caretta caretta*	Rare
Burmes Tortoise *Geochelone elongata*	Rare
Freshwater Tortoise *Cyclemys dentata* **	Rare
Three Keeled Tortoise *Melanochelys triciarinatz* **	Rare
Pond Tortoise *Melenochelys triguga* **	Rare
River Turtle *Hardella thurji* **	Fairly Common
Snakes 78 total species known, floodplain and aquatics include:	
N.B. Data on snakes for NCR are very incomplete.	
Cobra *Naja naja* **	Common
King Cobra *Ophiophagus hannah* **	Endangered
Russells Viper *Vipera russellii* **	Rare
Rock Python *Python molurua* **	Endangered
Common Royal Python *Python reticulatus*	Uncommon
Slender Worm Snake *Typhlina porrectus*	Common
Common Worm Snake *Typhlina braminus*	Common
Large Worm Snake *Typhlina cliardi*	Common
Common Wolf Snake *Lycodon aulicus*	Common
Banded Wolf Snake *Lycodon fasciatus*	Common
Yellow Spectacle Wolf Snake *Lycodon jara*	Rare
Banded Kukri Snake *Oligodn arnensis*	Rare
Striped Keelbacked Snake *Amphiesma stolata*	Fairly Common
Rednecked Keelbacked Snake *Rhabdophis subminiata*	Very Rare
Rat Snake *Phyar mucosur*	Fairly Common
Common Trinket Snake *Elapha helena*	Rare
Copperheaded Trinket Snake *Elapha radiata*	Rare
Flying Snake *Chrysopelea ornata*	Rare
Bronzeback Tree Snake *Dendrelaphis tristis*	Common
Painted Bronzebacked Tree Snake *Dendrelaphis pictus*	Rare
Vine Snake *Ahitulla nasutus*	Common
Common Cat Snake *Boiga trigonata*	Common
Common Krait *Bangarus caeruleus*	Rare
Banded Krait *Bangarus fasciatus*	Common
Common Water Snake *Enhydris enhydris* **	Fairly Common
Checkered Keelbacked Water Snake *Xenochrophis piscator* **	Very Common
Darkbellied March Snake *Xenochrophis cerasogaster*	Rare
Olive Keelbacked Water Snake *Afretium schistoeum*	Fairly Common
Dogfaced Water Snake *Cerberus rhynchops*	Threatened
Hooknosed Sea Snake *Enhydrina schistosa*	Threatened
Estuarine Sea Snake *Hydrophis obscurs*	Threatened
Annulated Sea Snake *Hydrophis cyanocinctus*	Fairly Common
Banded Sea Snake *Hydrophis fasciatus*	Threatened
Blackbanded Sea Snake *Hydrophis nigrocincta*	Rare
Common Narrowheaded Sea Snake *Hydrophis gracilis*	Threatened
Cantor's Narrowheaded Sea Snake *Hydrophis cantoris*	Threatened
Yellowbellied Sea Snake *Pelamis platurus*	Rare

Sources: MOEF, Draft National Conservation Strategy, July 1991 and Sarker, M.D. & Husain, K.Z. appearing in Environmental Aspects of Surface Water Development in Bangladesh. Eds Rahman, A.A., Huq, S., & Conway,G.R. 1990 and limited field research.

APPENDIX V.IV
LIST OF BIRDS RECORDED IN THE NORTH CENTRAL REGION

No.	Name	Habitat	Status
1	Great Cormorant	Wetlands	Former ? resident
2	Great Bittern	On haors	Uncommon winter visitor
3	Indian Shag	Wetlands	Scarce ? resident
4	Little Cormorant	Throughout wetlands	Local breeding resident
5	Dalmatian Pelican	Wetlands	Former visitor
6	Little Bittern	Wetlands	Former resident
7	Yellow Bittern	Wetland	Local Resident
8	Yellow Bittern	Wetlands	Local breeding resident
9	Cinnamon Bittern	Near ponds/paddy fields	Common breeding resident
10	Indian Pond Heron	Wetlands	Abundant breeding resident
11	Little Egret	Wetlands	Locally common breeding resident
12	Intermediate Egret	Wetlands	Locally common breeding resident
13	Great Egret	Wetlands	Locally common resident
14	Cattle Egret	Agricultural land. Usually associated with livestock	Local breeding resident
15	Grey Heron *	Wetlands	Local breeding resident
16	Purple Heron	Wetland	Local breedingresident
17	White Stork	Wetland	Rare winter visitor
18	Asian Open Bill	Wetlands	Local wondering resident
19	White Spoonbill *	Near River	Rare winter visitor
20	Fulvus Whistling Duck	Wetland	Local winter visitor
21	Greater Flamingo	Wetlands	Former rare visitor
22	Fulvous Whistling Duck	Wetlands	Local winter visitor
23	Lesser Whistling Duck	Wetlands	Common winter visitor and local breeding resident
24	Grey Leg goose	Wetland	Local winter visitor
25	Bar-headed Goose	Wetlands	Local winter visitor
26	Cotton Pygery Goose	Near lakes	Local breeding resident
27	Gadwall	Wetlands	Scarce winter visitor
28	Common Teal	Wetlands	Locally common winter visitor
29	Comb Duck	Wetland	Rare breeding resident
30	Spot-billed Duck	Wetlands	Rare winter visitor
31	Mallard	Wetland	Rare winter visitor
32	Garganey	Wetlands	Common winter visitor
33	Red-crested Pochard	Wetlands	Winter vagrant Pochard
34	Northern Pintail	Wetland mainly inland	Common winter visitor
35	Northern Shovelar	Wetland	Scarce winter visitor
36	Ferruginous Pochard	Wetlands	Locally common winter visitor
37	Tufted Duck	Wetlands	Locally common winter visitor, sometimes over summering
38	Baer's Pochard	On lake	Rare winter visitor
39	Greater Scaup	Wetlands	Rare winter visitor
40	Ferruginous Pochard	On wetland	Locally common winter visitor
41	Black Shouldered Kite *	Open country	Local breeding resident
42	Pariah Kite	Open country and urban areas	Common breeding resident
43	Pallas's Fish Eagle *	Wetlands and large rivers	Rare breeding resident formerly more common

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No.	Name	Habitat	Status
44	Brahmini Kite	Open country particularly near water	Common breeding resident
45	Grey-headed Fish Eagle *	Wetlands/fish farms	Local breeding resident
46	Egyption Vulture	Open country	Rare visitor
47	Long-billed Vulture	Open & wooded country	Scarce ? winter visitor
48	Red-headed Vulture	Open country	Rare breeding
49	White-rumped Vulture	Open country	Locally common breeding resident
50	Western Marsh Harrier	Near water	Common winter visitor
51	Pied Harrier	Open country	Scarce winter visitor
52	White-eyed Buzzard	Open woodland	Local breeding resident
53	Long-legged Buzzard	Near river	Rare winter visitor
54	Lesser Spotted Eagle	Open country near water	Scarce winter visitor
55	Greater Spotted Eagle	Open country near water	Scarce winter visitor
56	Black Eagle	Central woodland	Rare breeding resident
57	Towny Eagle	Open country	Rare visitor
58	Ospray	Wetland	Scarce winter visitor
59	Amur Falcon	Wooded areas with palms	Scarce passage migrant
60	Indian Pea Fowl	Wood land	Rare resident
61	Common Crane	Near river	Former winter resident
62	Imperial Eagle	Open country	Rare winter visitor
63	Booted Hawk-Eagle	Open country	Scarce winter visitor
64	Red Necked falcon	Open wooded areas	Local breeding resident
65	Black Francolin	Open country	? Former resident
66	Common Quail	Grassland and cultivation	Local breeding recident
67	Small Buttonquail	Open country	? Former resident
68	Baillon Crake	Wetlands	? Former resident
69	Brown Crake	Wetlands	? Former resident
70	White-Breasted Waterhen	Wetlands	Local breedingresident
71	Common Moor Hen	Wetlands	Local breeding resident
72	Purple Swamp Hen	Wetlands	Scarce breeding resident
73	Water Cock	Large wetlands	Local breeding resident
74	Eurasian Coot	Wetlands	Scarce breeding resident
75	Sarus Crane	Wetlands	?Former resident now extinct
76	Pheasant-tailed Jacana *	Wetlands	Scarce breeding resident
77	Bronze-winged Jacana	Wetlands	Local breeding resident
78	Small Pratincole	Near rivers	Local breeding resident
79	Oriental Pratincole	Open country	Local breding resident
80	River Lapwing	Near rivers	rare? resident
81	Red-wattled Lapwing	Throughout open country	Local breeding resident
82	Rufous-necked Stint	Wetlands	Scarce winter visitor
83	Little Stint	Near rivers	Local winter visitor
84	Pied Avocet	On river	Scarce winter visitor
85	Black-bellied Tern	On river	Very local breeding resident
86	Temmincks Stint	Wetlands	Scarce winter visitor
87	Jack Snipe	Wetlands	?Former winter visitor
88	Pintail Snipe	Wetlands	Common winter visitor
89	Solitary Snipe	Wetlands	Rare winter visitor
90	Eurasian Curlew	Near rivers	Locally common winter visitor
91	Marsh Sandpiper	Wetlands	Scarce winter visitor
92	Black- bellied Tern	Near river	Very local breeding resident
93	White-winged Term	Wetlands	Rare passage migrant
94	Indian Skimmer	Near river	Local winter visitor
95	Rock Dove	Open country & urban areas	Abundant breeding resident

No.	Name	Habitat	Status
96	Spotted Dove	Woodland	Local bredding resident
97	Orange-breasted Pigeon	Forest & wood lands	Local breeding resident
98	Thick-billed Pigion	Woodland	Local breeding resident
99	Yellow-footed Pigeon	Wooded areas	Common breeding resident
100	Rose ringed Parakeet	Woodland	Local breeding resident
101	Red breasted Parakeet	Woodland	Common breeding resident
102	Blossom-headed Parakeet	Wooded areas	local breeding resident
103	Plaintive Cuckoo	Open wooded areas	Common breeding resident
104	Chestnut-winged Cuckoo	Foresh and woodland	Local breeding resident
105	Common Cuckoo	Forest woodland	Scarce migrant
106	Sirkeet Malkoha	Open woodland	? rare resident
107	Brown Fish-Owl	Wooded areas near water	local breeding resident
108	Collared Owl	Well wooded areas	Scarce resident
109	Brown Boobook	Well wooded areas	Local breeding resident
110	White-throated Kingfisher	Wetlands with trees	Common breeding resident
111	Stork-billed Kingfisher	Throughout woodland	Local breeding resident
112	Common Kingfisher	Throughout country site near water	Local breeding resident
113	Pied Kingfisher	Throughout wetland	Local breeding resident
114	Green Bee-eater	Open country	Common breeding resident
115	Common Grey Hornbill	Wooded areas	? former resident
116	Chestnut-headed Bee-eater	Open land	Local breeding resident
117	Indian Rollar	Open field	Local breeding resident
118	Hoopoe	Open Country	Local breeding resident
119	Cropper Smith Barbet	Wooden Area	Common breeding resident
120	Streak Throated Woodpecker	Woodland particularly Sal	Local breeding resident
121	Yellow-Crowned Woodpecker	?	? Former resident
122	Indian Sandlark	Sandy rivers	Local breeding resident
123	Finchlark	Sandy rivers	Local breeding resident
124	Plain Martin	large rivers	Local breeding resident
125	Blyths Pipit	Open country	Large passage migrant
126	long -billed Pipit	Open country	? Former resident
127	Brown Tree Pipit	Open country	Rare winter visitor
128	Common wooded-Shrike	Wooded areas	Common breeding resident
129	Common Iora	Wooded areas	Common breeding resident
130	Plumbeous Redstart	Near water	Rare passage migrant
131	Blue Fronted Redstart	Open woodland	Rare winter visitor
132	Indian Chat	Open country & fields	? Former resident]
133	Ashy Prinia	Scrub woodland	local breeding resident
134	Jungle Prinia	Scrub and grassland	? Former resident
135	Swamp Prinia	Swamp grass	? Former resident
136	large Grass-Warbler	Swamp grass	? Former resident
137	Blunt-winged Warbler	Wetlands	Rare winter visitor
138	Brownish Warbler	Woodland	Rare winter visitor
139	White Spectacled Warbler	Woodland	Scarce winter visitor
140	Greenish Warbler	Throughout in trees	Abundant winter visitor
141	Large-Billed Leaf-Warbler	Trees	Scarce winter visitor
142	Grey-headed Flycatcher	Forest and woodland	Locally common breeding resident
143	Tawny-Bellied Babbler	Grassland, scrub and forest	? Former resident
144	Chestnut-Capped Babbler	Scrub	local breeding resident
145	Common Babbler	?	? Former resident
146	Jungle Babbler	Wooded country & scrub	Commn breeding resident
147	Great Grey Shrike	Open country	Rare winter visitor
148	Purple Sun Bird	Woodland	Localy common

No.	Name	Habitat	Status
149	Little Spider Hanter	Forest and wooland	Local breeding resident
150	Scarlet-backed flower peaker	Forest and wooland	Localy common breeding resident
151	Red Vented Bulbul	Open field bushy area	Localy breeding resident throughout Bangladesh
152	Green Magpie	In Forest	Rare winter visitor
153	Rofous Tree Pie	Wooded country and town	Local breeding resident
154	Mag Pie Robin	Bushy area	Local breeding resident
155	House Crow	Settled areas	Abundant breeding resident
156	Brahminy Starling	Open country	local breeding resident
157	Asian Pied Starling	Open Country	Abundant breeding resident
158	House Sparrow	Throughout Near human setlement	Abundant breeding resident
159	Red Avadavat	Open country with grass	Rare breeding resident
160	Scaly-Breasted Munia	Open country	Common breeding resident
161	Chestnut-Eared Bunting	Open country	? Former winter visitor

Note : 1 * Probably internationally significant populations occur in Bangladesh

Source : Harvey, WG Birds in Bangladesh UPL 1990

SUMMARY OF SPECIES BY HABITAT TYPE

Habitat	No of Species	Comment
1 Rivers, beels and sandy rivers	17	Habitat would be affected if project intervention led to chnges in river regime
2 Wetlands, swamps	61	Habitat changes most likely to occur due to project intervention
3 Open country, grassland, dryland	40	Some changes in habitat likely to occur due to extension of agricultural land as a result of project intervention
4 Forest, shrub and woodland	45	Some changes in habitat likely to occur due to extension of agricultural land as a result of project intervention
Total :	**163**	

Note: Some species have been counted in more than one habitat

APPENDIX V.V
AQUATIC AND FLOODPLAIN MAMMALS

Name	Present Status In Bangladesh
Floodplains and Rivers	
Rhesus monkey *Macaca mulatta* **	Common
Leopard *Panthera pardus*	Threatened
Leopard Cat *Felix bengalensis*	Uncommon?
Fishing Cat *Felix viverrina* **	Endangered
Bengal Fox *Vulpes bengalensis*	Common
Common Mongoose *Herpestes edwardsi* **	Common
Small Mongoose *Herpestes auropunctatus* **	Common?
Wild Boar *Sus scrofa*	Rare
Common Otter *Lutra lutra* **	Uncommon
Smooth Coated Otter *Lutra parspicillata*	Fairly Common
Lesser Bandicot Rat *Bandicota bengalensis* **	Common
Gangetic Dolphin *Platanista gangetica* **	Rare

There are many species of rodents not listed here

Name	Present Status In Bangladesh
Marine and Estuarine	
Common Dolphin *Delphinus delphis*	Fairly Common
Malay Dolphin *Stenella malayana*	Rare
Melon Headed *Dolphin Peponocephala*	Fairly Common
Frawaddy Dolphin *Orcaella breavirostris*	Rare
Rough Toothed Dolphin *Steno bredanensis*	Uncommon
Plumbeous Dolphin *Sotalia plumbea*	Uncommon
Pilot Whale *Globicephala macrorhyncha*	Uncommon
Little Piked Whale *Belenoptera acutorostrata*	Uncommon
Great Blue Whale *Belenoptera musculus*	Fairly Common
Fin Backed Whale *Belenoptera physalus*	Uncommon
Black Finless Porpoise *Neomeris phocaenoides*	Rare

Source:Sarker, M.D. & Husain, K.Z. 1990, Rashid, Haroun-Er. Geography of Bangladesh, 1978.

APPENDIX V.VI
TENTATIVE LIST OF FISH FAUNA IN NCR

Scientific Name	English Common/ Bangali Name	Indications
F = Family G = Genus		
F-Synagnathidae		
G-*Doryichthys Kaup*	Kumirer Khil	Common in River Padma
Doryichthys cancalus		
F-Synagnathidae		
G-*Doryichthys Kaup*		
Doryichthys chokderi	Kumirer Khil	Common in River Padma
F-Anguillidae		
G-*Anguilla Shan*		
Anguilla bengalensis	Elongate eel/Banehara	Fairly common
F-Synbranchidae		
G-*Monopterrus lacepede*		
Monopterus cuchia	Mud eel/Kuchia	Fairly common in muddy holes of lowlands and ponds.
F-Tetraodonidae		
G-*Tetraodonidae Linn*		
Tetraodon cutcutia	Puffer Fish/Potca	Common in ponds beels canals and rivers.
F-Belonidae		
G-*Xenontodon Regan*		
Xenontodon cancila	Gar/Kakila	Very common in ponds smaller rivers, beels & canals.
F-Hemirhamphidae		
G-*Hyporhamphus Gill*		
Hydporhamphus gimardi	Gar/Ekthota	River fairly common
F-Cyprinodontidae		
G-*Aplochelus Mcciellan*		
Aplocheilus panchax	Top minnow\ Techoukka	Commom in river, beels, canals, streams and other water areasof the river.
F-Channidae		
G-*Channa Scopoli*		
Channa starius	Snake-headed fish/shol	Threatened species due to recent Epozotic Ulceratic Disease (EUD)
F-Channidae		
G-*Channa Scopoli*		
Channa marulius	Snake headed Fish/Gajar	Threatened species may be due to EUD.

Scientific Name	English Common/ Bangali Name	Indications
F-Channidae G-*Channa Scopoli* *Channa barca*	Snake headed fish/Tilashol	Fairly common in beels of Mymensingh area.
F-Channidae G-*Channa Scopoli* *Channa punctatus*	Snake headed fish/Taki	Threatened species mainly found in ditches
F-Channidae G-*Channa Scopoli* *Channa orientalis*	Snake headed fish/Cheng	Common mainly found in beels, ditches rivers.
F-Psilorhynchidae G-*Psilorhynchus Mccielan* *Psilorhynchus balitora*	?? /Balitora	Fairly common in Dewanganj
F-Psilorhynchidae G-*Psilorhynchus Mccielan* *Psilorhynchus gracilis*	?? /Balitora	Fairly common in Brahmaputra river.
F-Cyprinidae G-*Oxygaster Van* Hasselt *Oxygaster gora*	?? /Ghora chela	Common in Mymensingh area.
F-Cyprinidae G-*Salmostoma Swainson* *Salmostpma argentea*	?? /chela	Common in the river Padma
F-Cyprinidae G-*Salmostoma Swainson* *Salmostoma phulo*	?? /Fulchela	All over NCR and also in Bangladesh.
Salmostoma bacaila	?? /Katari	Common in NCR and also through Bangladesh.
F-Cyprinidae G-*Esomus Swainson* *Esomus danricus*	?? /Darkina	Common in NCR.
F-Cyprinidae G-*Chela Hamilton* *Chela cachius*	?? /Chepchela	Rare
F-Cyprinidae G-*Chela Hamilton* *Chela laubu*	?? /Chepchela	Fairly common in NCR.

Scientific Name	English Common/ Bangali Name	Indications
F-Cyprinidae		
G-*Aspidoparia Heckel*		
Aspidoparia jaya	?? /Jaya	Mainly in the Brahmaputra. Fairly common.
F-Cyprinidae		
G-*Rasbora Bleeker*	?? /Leuzza dackina	Fairly common in NCR.
F-Cyprinidae		
G-*Rasbora Bleeker*		
Rasbora daniconius	?? /Darkina	Common in river beels, ponds and flood plains.
F-Cyprinidae		
G-*Barilius Hamilton*		
Barilius bola	?? /Bola	Rarely found in the hillyarea of Mymensingh.
F-Cyprinidae		
G-*Barilius Hamilton*		
Barilius tilco	?? /Tila Koksha,	Fairly common in NCR.
F-Cyprinidae	Patharchata	
G-*Barilius Hamilton*		
Barilius bendelisis Var.Chedra	??/Chedra coksa	Fairly common in NCR.
F-Cyprinidae		
G-*Danio Hamilton*		
Danio acquipinnatus	?? /chebli	Rare. Also in Dinajpur and Rangpur.
F-Cyprinidae		
G-*Amblyopharyngodon Bleeker*		
Amblyopharyngodon mola	?? /Mola Mach, Moya.	Common.
F-Cyprinidae		
G-*Rohtee Sykes*		
Rohtee cotio	?? /Keti, Dipali.	Rare. Also in Bangladesh.
F-Cyprinidae		
G-*Chagunius Smith*		
Chagunius chagun	Barbfish/Jarua, Utti	Fairly common in streams of NCR.
F-Cyprinidae		
G-*Labeo Cuvier*		
Labeo gonius	Carp/Goni, Karchi	Rare in NCR.
F-Cyprinidae		
G-*Labeo Cuvier*		
Labeo calbasu	Carp/Kalibaus	Most common in the river Brahmaputra.

Scientific Name	English Common/ Bangali Name	Indications
F-Cyprinidae G-*Labeo Cuvier* *Labeo rohita*	Carp/Rohu, rui	Most common in rivers.
F-Cyprinidae G-*Labeo Cuvier* *Labeo bata*	Carp/Bata	Fairly common in rainy season
F-Cyprinidae G-*Labeo Cuvier* *Labeo boga*	Carp/Bhagonbata	Fairly common.
F-Cyprinidae G-*Labeo Cuvier* *Labeo dero*	Carp/Kursha	Rare in NCR
F-Cyprinidae G-*Cirhinus (oken) Cuvier* *Cirrhinus reba*	Carp/Raik	Common.
F-Cyprinidae G-*Cirhinus (oken) Cuvier* *Cirrhinus mrigala*	Carp/Mrigal	Common in NCR. Also throughout Bangladesh.
F-Cyprinidae G-*Puntius Hamilton* *Puntius sarana*	Barp/Sarpunti	Rare in NCR and Bangladesh.
F-Cyprinidae G-*Puntius Hamilton* *Puntius sophore*	Barb/Jatpunti	Common.
F-Cyprinidae G-*Puntius Hamilton* *Puntius terio*	Barb/Teri Punti	Common throughout Bangladesh, bil, river, khal canal, and floodplains.
F-Cyprinidae G-*Puntius Hamilton* *Puntius guganio*	Barb/Mola punti	Common in river, canal, beels and flood plains
F-Cyprinidae G-*Puntius Hamilton* *Puntius phutunio*	Barb/Phutunipunti	Common in Bangladesh in river floodlands, beels rivers, flood plains beels

Scientific Name	English Common/ Bangali Name	Indications
F-Cyprinidae G-*Puntius Hamilton* *Puntius conchonius*	Barb/kanchon punti	Common in Bangladesh in
F-Cyprinidae G-*Puntius Hamilton* *Puntius ticto*	Barb/tit punti	Common in small steams, beels ponds, ditches, and inundated fields throughout Bangladesgh
F-Cyprinidae G-*Puntius Hamilton* *Puntius jelius*	Barb/jeli punti	Abundant throughout Bangladesh
F-Cyprinidae G-*Puntius Hamilton* *Puntius terio*	Barb/teri punti	Common in river, canals, ditches, and inundated field throughout Bangladesh
F-Cyprinidae G-*Tor Gray* *Tor tor*	Mahaseer/mohashol	No longer found in NCR.
F-Cyprinidae G-*Tor Gray* *Tor putitora*	Mahaseer/mohashol	No longer found in NCR
F-Cyprinidae *Catla Valenciennes* *Catla catla*	Cesp/catla	Very common in ponds and fairly common in rivers.
F-Cobitidae G-*Nemachilus Van Hasselt* *Nemachilus botio*	Loach/Balichata	Common in NCR
F-Cyprinidae G-*Nemachilus Van Hasselt* *Nemachilas corica*	Loache/korica	Fairly common clear water hill streams
F-Cobitidae G-*Nemachilus Van Hasselt* *Nemachilus savorna*	eoache/saron koricka	Fairly common river streams
F-Cobitidae G-*Nemachilus Van Hasselt* *Nemachilus savorna*	Loache/saron koricka	Abundant in the streams of Mymenshingh
F-Cobitidae G-*Botia Gray* *Botia dario*	Loache/ Rani	Abundant in the streams of Mymensingh.

Scientific Name	English Common/ Bangali Name	Indications
F-Cyprinidae G-*Botia Gray* *Botia lohachata*	Loache/Beti	Family common in NCR.
F-Cyprinidae G-*Lepidocephalus Bleeker* *Lepidocephalus guntea*	Loache/Gutun	Common in the streams of Mymensingh
F-Heteropneustidae G-*Heterpneustes Muller* *Hetropneuestes fossilis*	Catfish/shinghi	Common in NCR
F-Claridae G-*Clarius Scopoil* *Clarius batrachus*	Catfish/Magar	Common in NCR
F-Siluridae G-*Wallago Bleeker* *Wallago attu*	Fish water shark/Boal	Most common in rivers and beels.
F-Siluridae G-*Ompok Lacepede* *Ompok bimaculatus*	?? /Pabda	Rare in rivers and streams.
F-Siluridae G-*Ompok Lacepede* *Ompok pabo*	?? /Pabda	Rare in NCR.
F-Siluridae G-*Ompok Lacepede* *Ompok Pabda*	??/Madhu pabda	Rare in rivers, beels and floodplains.
F-Chacidae G-*Chaca Gray* *Chaca chaca*	Squarehead fish/Gangania	Fairly common in rivers, flood lands in winter
F-Schilbeidae G-*Pungasius valeciennes* *Pangasius pangasius*	??/Pangas	Common in River Padma.
F-Schilbeidae G-*Ailia Gray* *Ailia coila*	??/Kajuli	Common in river beels and floodplains.
F-Schilbeidae G-*Pseadeutropis Bleeker* *Pseudeutropius atherinoides*	??/Batasi	Common in NCR.

Scientific Name	English Common/ Bangali Name	Indications
F-Schilbeidae G-*Electropiichthys Blekker* *Eutropiicthys vacha*	??/Bacha	Fairly common.
F-Schilbeidae G-*Clupisoma Swainson* *Clupisoma murius*	??/Muri bacha	Fairly common
F-Schilbeidae G-*Clupisoma Swainson* *Clupisoma garua*	?? /Gharua	Fairly common
F-Bagridae G-*Rita Bleeker* *Rita rita*	Bagrid cat fish/Rita	Common in rivers in NCR.
F-Bagridae G-*Chandramara Jayaram* *Chandramara chandramara*	Bagrid cat fish/Tengra	Common in beels, rivers and streams.
F-Bagridae G-*Batasio Blyth* *Batasio batasio*	Bagrid cat fish/Tengra	Common in beels rivers, flood plains.
F-Bagridae G-*Mystus Scopoli* *Mystus aor*	Cat fish/Ayre	Common in rivers beels, flood plains, streams.
F-Bagridae G-*Mystus Scopoli* *Mystus singhala*	Cat fish/Guizzi Air	Uncommon in NCR.
F-Bagridae G-*Mystus Scopoli* *Mystus menoda*	Cat fish/Gulsha tengra	Common in NCR in rivers, beels, streams.
F-Bagridae G-*Mystus Scopoli* *Mystus cabasius*	Cat fish/cabashi Tengra	Common in river canals beels and ponds
F-Bagridae G-*Mystus Scopoli* *Mystus bleekeri*	Cat fish/Gulsha Tengra	Common is rivers, canals, khals, and beels.
F-Bagridae G-*Mystus Scopoli* *Mystus gulio*	Cat fish/Guillya	Common in the river Padma.

Scientific Name	English Common/ Bangali Name	Indications
F-Sisoridae G-*Conta Hora* *Conta conta*	Cat fish/konta	Uncommon river beels and streams.
F-Sisoridae G-*Gagata Bleeker* *Gagata nangra*	Catfish Gangtengra	Common in river Padma
F-Sisoridae G-*Gagata Bleeker* *Gagata sp.*	Cat fish/Gangtengra	Fairly common in Padma.
F-Sisoridae G-*Bagarius Bleeker* *Bagarius bagarius*	Catfish/Bagha air	Fairly common in river and flood lands.
F-Sisoridae G-*Hara Blyth* *Hara hara*	Catfish/kuta kanti	Common.
F-Notopteridae G-*Notopterus Lacepede* *Notopterus chitala*	??/Chitol	Common in rivers beels and streams.
F-Notopteridae G-*Notopterus Lacepede* *Notopterus notopterus*	??/foli	Fairly common in beels kahal, rivers.
F-Angraulidae G-*Setipinna Swainson* *Setipinna phasa.*	??/Fasa	Common in rivers.
F-Clupeidae G-*Gudisia* *Gudisia chapra*	Shad/Chapila	Abundant in beels, rivers, streams, ditches inundated fields.
F-Clupeidae G-*Ctenualosa* *Ctenualosa ilisha*	Shad/Ilish	Padma rivers. common.
F-Clupeidae G-*Ctenolosa* *Ctenolosa toli*	Shad/Chandana	Found in Padma and Jamuna.
F-Clupeidae G-*Corica Ham* *Corica saborna*	Shad/Kachki	Common in rivers, beels

Scientific Name	English Common/ Bangali Name	Indications
F-Clupeidae G-*Ilisha (Gray) Richardson* *Ilisha motius*	Shad/Choakka	In Padma in rainly season.
F-Mastacembelidae G-*Mastacembelus Scopoli* *Mastacembelus armatus*	Spiny eel/Bain	Common in river beels and flood plains.
F-Mastacembelidae G-*Mastacembelus Scopoli* *Mastacembelus puncalus*	Spinyed/Turibain	Common in NCR. River beels and flood plains.
F-Mastacembelidae G-*Macrognathus Lacepede* *Macrognathus aculeatus*	Spiny ell/Turibain	Common in NCR river beels, ponds and flood plains.
F-Mugilidae G-*Rhinomugils Gill* *Rhinomugil corsula*	Mullet/Khorsula	Fairly common in rivers.
F-Mugilidae G-*Mugil Linn* *Mugil cascasia*	Mullet/Khorsula	Common in river Brahmaputra.
F-Anabantidae G-*Colisa Cuvier* *Colisa sota*	Goramy/khoilsha	Common in the beels, ditches and canal throughout Bangladesh.
F-Anabantidae G-*Colisa Cuvier* *Colisa fasciatus*	Gorama/khoilsha	Common in river beels and flood lands.
F-Anabantidae G-*Colisa Cuvier* *Colisa lalius*	Goramy/Lalkhoilsha	Common in beels, river and canals.
F-Anabantidae G-*Ctenops Mcclelland* *Ctenops unobilis*	Goramy/Napitani	Common in rivers, beels, ponds,
F-Anabantidae G-*Anabas Cuvier* *Anabas testudineus*	Climbing perch/koi	Common in River, beels,khals, ditches throughout Bangladesh.
F-Pristolapidae G-*Badis Bleeder* *Badis badis*	?? /Napitakoi	Throughout Bangladesh in rivers, beels, floodlands.

Scientific Name	English Common/ Bangali Name	Indications
F-Gobiidae G-*Glossogobius Gill* *Glossogobius giuris*	??/Bele	Common in Rivers, beels, khal and streams.
F-Gobiidae G-*Gobiopterus Gill* *Gobiopterus chuno*	Gobifish/Bele	Fairly common in padma.
F-Taenioididae G-*Odontamblyopus Bleeker* *Odontamblyopus rubicundus*	Gobi/Lalchewa	Fairly in Padma.
F-Nandidae G-*Nandas Cuvier* *Nandas Nanda*	Mudperch/Meni	Rare in NCR.
F-Centropomidae G-*Chanda Hamilton* *Chanda nama*	Glassperch/Chanda	Common in River, beels, and streams throughout Bangladesh
F-Centropomidae G-*Chanda Hamilton* *Chanda ranga*	Glassperch.chanda	Throughout the country in beels, river streams.
F-Centropomidae G-*chanda Hamilton* *Chanda beculis*	Glass perch/Chanda	Common in rivers throughout Bangladesh.

APPENDIX VI.VII
LIST OF IMPORTANT PLANT RESOURCES IN VILLAGE GROVES

Botanical Names	Local Names	Ordinary Uses	Wild Life Value
Albizia lebbeck (L) Benth	Sirish	Fuel, timber	Nesting roosting & cover
A.Lucida Benth	Silkoroi	Fuel, timber, Medicinal	Nesting roosting & cover
A.Procera Benth	Silkoroi Sadakoroi	Medicinal, timber	Nesting roosting & cover
Aphananixis polystachya (Wall) R.N.Park	Pitraj, Royna	Fuel, timber, Medicinal	Nesting roosting & cover
Areca catechu L.	Siqxui	Fruit Edible, timber used in furnitures	Nesting roosting & cover
Artocarpus heterophyllus Lamk.	Kathal	Fruit Provide cotton Timber used in match stick production	Nesting roosting & cover
Bombax ceiba L.	Shinmul	Fruit Edible, timber Wood	Nesting roosting & cover
Barassus flabellifer L.	Td	Fruit used for tanning of nets	Fruit used roosting, cover
Cocos nucifera L.	Narikel, Dab	Fuel Medicinal	Fruit used nesting roosting cover
Diospyros peregrina (Gacrtn.) Gurke	Gab, Deshi gab	Timber, Fuel Latex used in Medicine	Nesting roosting & cover
Erythrina variegata L.	Mawkku	Timber wood religious value for Hindus latex used in medicine.	Nesting roosting & cover
Ficus benghalensis L.	Bot, Jhuri bot	Medicine timber	Fruit used nesting roosting & cover
F.religiosa L.	Assawath Pan bot	Fruit edible, timber wood	Fruit used nesting roosting & cover
Lannca coromandclica (Houtt.) Mett.	Jika, Bhadi, Kafila	Fuel Fruit edible	Nesting roosting & cover
Mangifera indica l.	A.n		Fruit eaten nesting roosting & cover
Phonex sylvestries (L) Roxb.	Khajur		Fruit eaten nesting roosting support
Samanca sanan (Jacq.) Merr	Raindi		Roosting cover
Tamarindus indica L.	Tetul		Nesting roosting cover
Trewia polycarpa benth	Lattu, Petari, Pitali		

APPENDIX V.VIII
ARCHAEOLOGY SITES

District	Locality	Short Note
1. Dhaka	Lalbagh Fort	
2. Dhaka	Tomb of Bibi Pari	
3. Dhaka	Mosque within Lalbag Fort	
4. Dhaka	Darbar and Hammaam Khana in interior of Lalbag Fort	
5. Dhaka	South east gate of Lalbag Fort	
6. Dhaka	Satgumbad Mosque	
7. Dhaka	Khan Md. Mridha Mosque	
8. Dhaka	Mosque of Tomb Haji Khwaza Shahbaz	
9. Dhaka	Unknown Tomb near Satgumbad Mosque	
10. Dhaka	Old Idgah	
11. Dhaka	Bara Katra	
12. Dhaka	Chotta Katra	
13. Dhaka	Rose garden	
14. Dhaka	Ruplal House	
15. Dhaka	North Brook hall	
16. Dhaka	Sankhamidi House	
17. Dhaka	Rada Krishna Mondir	
18. Dhaka	Sutrapur Zaminder House	
19. Dhaka	Vaja Hari Lodge	
20. Dhaka	Raja Haris Chandra Buroj	
21. Dhaka	Raja Haris Chandra Prashad	A group of 5 mounds, known as Rajasan, was excavated in 1926 by the department of Archaeology. This yielded terra cotta plaques stamped with the image of Buddhist divinities besides coins and other fragmentary inscription being to 7th & 8th century AD. The legendary King Haris Chandra is identified.
22. Naryanganj	Hajigonj fort	Hajigong fort (Pentagon plan) is sited to overlook & the western bank of the Sitalakhya.
23. Narayanganj	Tomb of Bibi Maryam	This highly dilapidated tomb of one of the supposed daughters of Nawab Shaista Khan 17th century A.D has a Central Square Chamber covered with a fall dome covered with a tall dome. It contains a masonry cenotaph of Bibi Maryam and surrounded by vaulted verandah & on all four sides.
24. Narayanganj	Sonakanda Fort	This oblong fort with battlemented defence wall and a huge drum for mounting large calibre cannon similar to Idrakpur Fort was built by the Mughal Governor in 17th Century A.D. as rive out Post of waid off recurring raids of the Magh and Portuguese pirates.
25. Naryanganj	Khandaker Mosque	
26. Naryanganj	Haji Baba Shah	Stone grave of Haji Baba Salah erected during sultan Alauddin Hussain Shah (1493-1519 A.D) is now stripped off its original building which covered it.
27. Naryanganj	Tomb of Giasuddin Azam Shah	

28. Naryanganj	Goaldi Mosque	The single-domed highly dilapidated Mosque was built by Mulla Hizabar Akbar Khan in 1519 A.D during the reign of sultan Alauddin Hussain Shah. It is the earliest existing Mosque in the region and beautifully ornamented with carved arabesque on stone mihrabs and Terra Cotta of walls.
29. Naryanganj	Panam Bridge	
30. Rupgang	Murapara Prashad	On the bank of the Lak shya just opposite to Rupgong bazzer there are the fine brick built residences of Zamindars of Murapara. The founder of this family was one Ram Ratan Banerjee.
31. Munshiganj	Sonarong Temples	Two highly ornate siva and Kali Navaratna Temples with lofty spires built on same Platform in 1843 A.D. by Zamindar Rupchandra.
32. Munshiganj	Drakpur Fort	Probably built by Mirjumla in 1660 AD on river Ichamati as an outpost to ward off the recurring incursions of the mag and Portuguese pirates who infested the lower waters of Bengal with their main strong hold at Chittagong. Now heavily encroached by the sub-jail and the residence.
33. Munshiganj	Baba Adamis Mosque	The mosque is locally known after a famous saint Baba Adam whose simple grave is close by,but nothing his-torical is known about him, except the popular late of his fight with Ballal Sen. According to the inscrip-tion on the Mosque. This six domeds mosque was built by the great Malik Kafur during the reign of Sultan Jalaluddin Fatah Shah date 1483 A.D.
34. Munshigang	Mirkadim Bridge	
35. Munshiganj	Tank of Harish Chandra	Large number of stone images and other antiquarian objects of 11th/12th Century A.D. Primarily of Hindu Region was dug up an kept in the Dhaka Museum.
36. Manikganj	Baliati Prashad	The seat of a well-known Zaminder family members who were great patrons of learning. A member of the family established the Jagangath college in Dhaka.
37. Tangail	Atiya Mosque	Construction in 1609 AD by Sayyid Khan Pani, son of Bayzid Khan Pani measures 69'x 40' with 1/1/2 thick walls and consists of a single domed square prayer chamber with a verandah covered by 3 domes. Cornice deeply curved and wall surface relieved with terracotta ornamental panels and presents a combination of Mughal elements with pre-Mughal feature.
38. Tangail	Khadim Hamdani Mosque	
39. Mymensing	Shashi lodqe	"Shasi lodqe" a 10 acre palace of ex-Zaminder of Muktagacha in Mymensing town.
40. Khishangang	Shah Muhammad Mosque	A Mosque built during Moghal period after the name of the builder, But the inscription tablet is missing and the exact date of construction is not known, The style suggests about AD 1680.

Source: - Bangladesh District Gazeteers Dhaka 1975. Mymenshing 1978.

APPENDIX V.IX
CASE STUDIES

IX.1 Case Study 1 - Arial Bil

Overview

Arial Bil provides a good example of an area already impacted by dewatering, inequitable transfers of access to resources and poor planning of a drainage scheme to encourage agricultural intensification, in spite of a fisheries mitigation component, see Figure V-I.1.

Arial Bil is the largest bil in the North Central Region and, until a decade or two ago, was well known as a site both of a particularly productive year-round fishery, and as a resting area for migratory waterfowl, particularly during the rabi (dry) season (when the bil formerly retained considerable areas of relatively deep, permanent, open water). The present situation is quite different, as indicated by conversations with local fishermen and boatmen, and by review of available maps and aerial photographs.

The 1972 and 1979 1:50,000 maps of the Survey of Bangladesh show the region of Arial Bil as comprised mostly of wetland or marsh, interspersed with a small number of artificial rectangular fill sites. By contrast, the 1990 sheet shows a much reduced permanent wetland area, and a far greater proportion of raised fills and beams. The older fills seem to be generally rectangular while the newer fills are as likely to be "lineal". The 1984 SPARRSO "land use" photomap shows Arial Bil as nearly completely under boro rice cultivation, as does the later and more detailed SPOT imagery of February and March 1989 (NCRS 1991).

During the kharif (rainy) season Arial Bil continues to be deeply flooded and is intensively exploited by professional and part-time fishermen, apart from the growing proportion of discontinuous artificial uplands now occupying the bil depression. It remains a seasonally important habitat for resident piscivorous birds, such as Brahminy kite, marsh harrier, and black cormorant; all of which were observed there in considerable numbers.

During the monsoon season, a relatively small proportion of the man-made upland fills appear under cultivation for food crops, fodder, or fuel. During the rabi, when the entire unfilled portion of the bil is boro rice field, the raised sites seem generally to be under pulses and winter vegetables.

The waters of Arial Bil seem low in turbidity. During a medium-altitude flyover by light plane, observers could clearly see in outline a network of submerged paddy field dikes and what appeared to be submerged young rice plants covering virtually all of the floor of the bil. Areas of floating macrophytes (e.g., water hyacinth) appeared relatively sparse, and occupied only segments of the bil's periphery. Thus, from the air, the greater, hyacinth-free portion of the bil looked like "open water."

The view of the bil's surface from the ground was quite different. What appeared to be "open water" from an aircraft was actually a thick mat of rooted, submerged macrophytes (mostly hydrilla) which a mechanized country boat could penetrate only with some difficulty. The hydrilla is what looked like "rice plants" from the air. Engine boat routes across the bil were restricted to several deeper channels less densely colonized by hydrilla.

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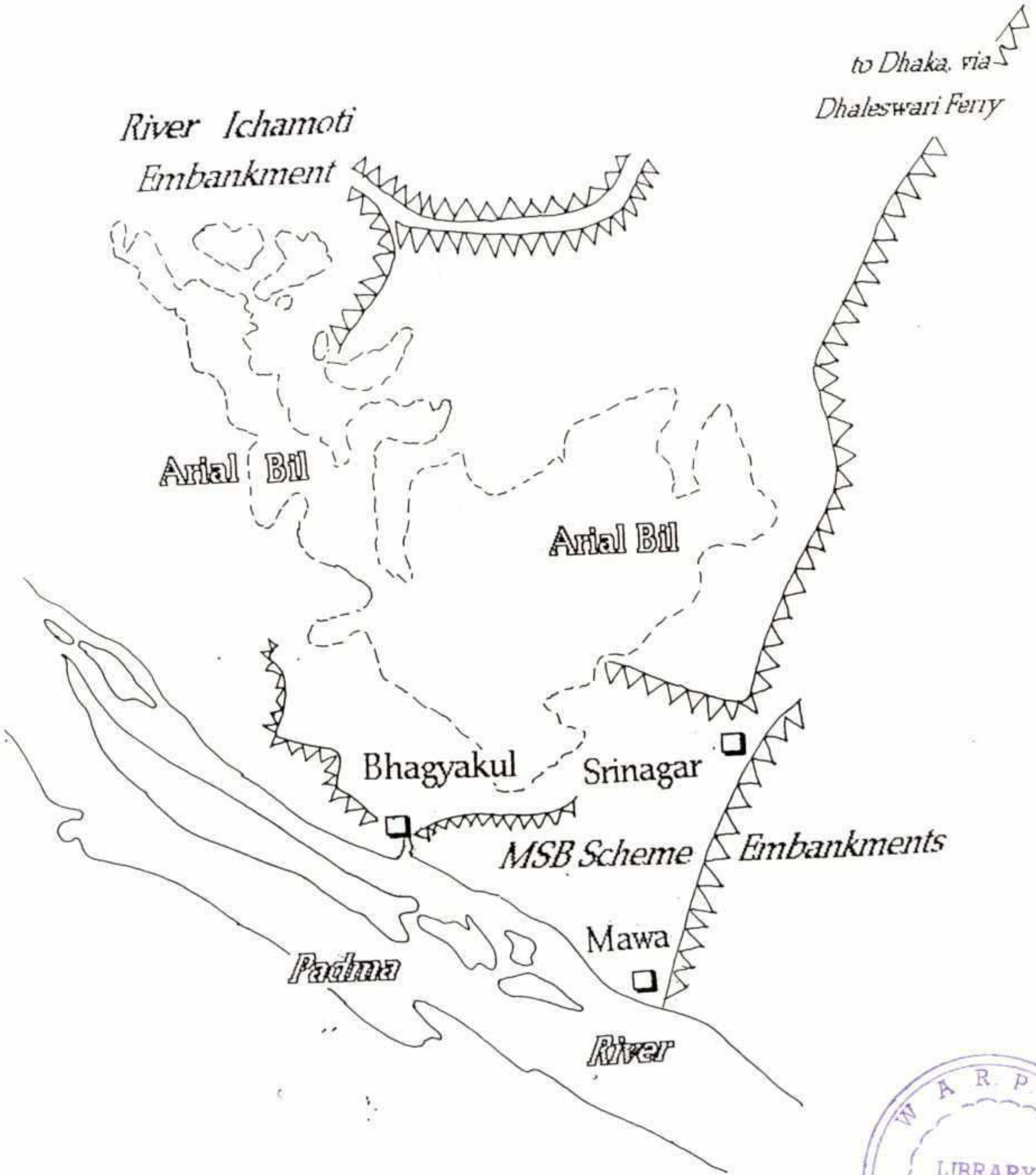
"Reclamation" and Isolation of Arial Bil
(Showing Major Projects Since 1972)



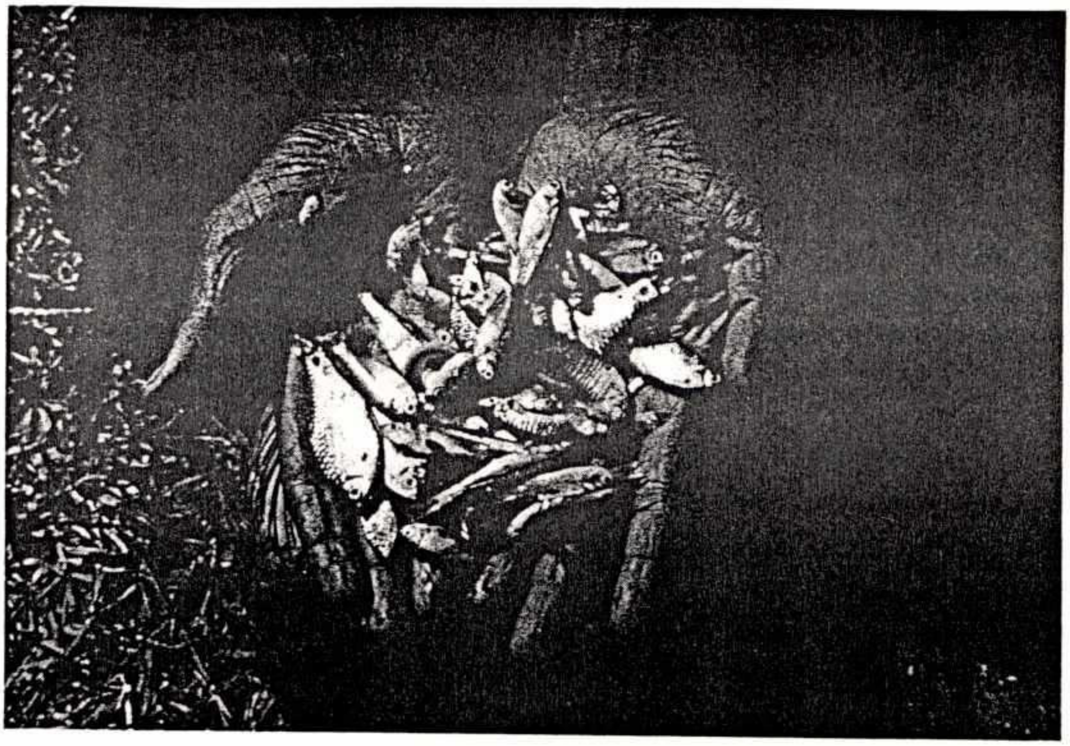


Plate V.1 "Typical Throw Net Catch of Small Fish Species".

These fish rarely enter the cash economy and are probably under-appreciated in any formal evaluation of fishery "disbenefits" and yet comprise (insofar as stocks still remain) the basic protein supply of the rural poor. Species seen here include: *Pontius stigma*(to 10-12 cm), *Mylopharynogodon mola* (to 7-8 cm), *Colish chota* (2-3 cm), and *Chandra ranga* (23 cm).

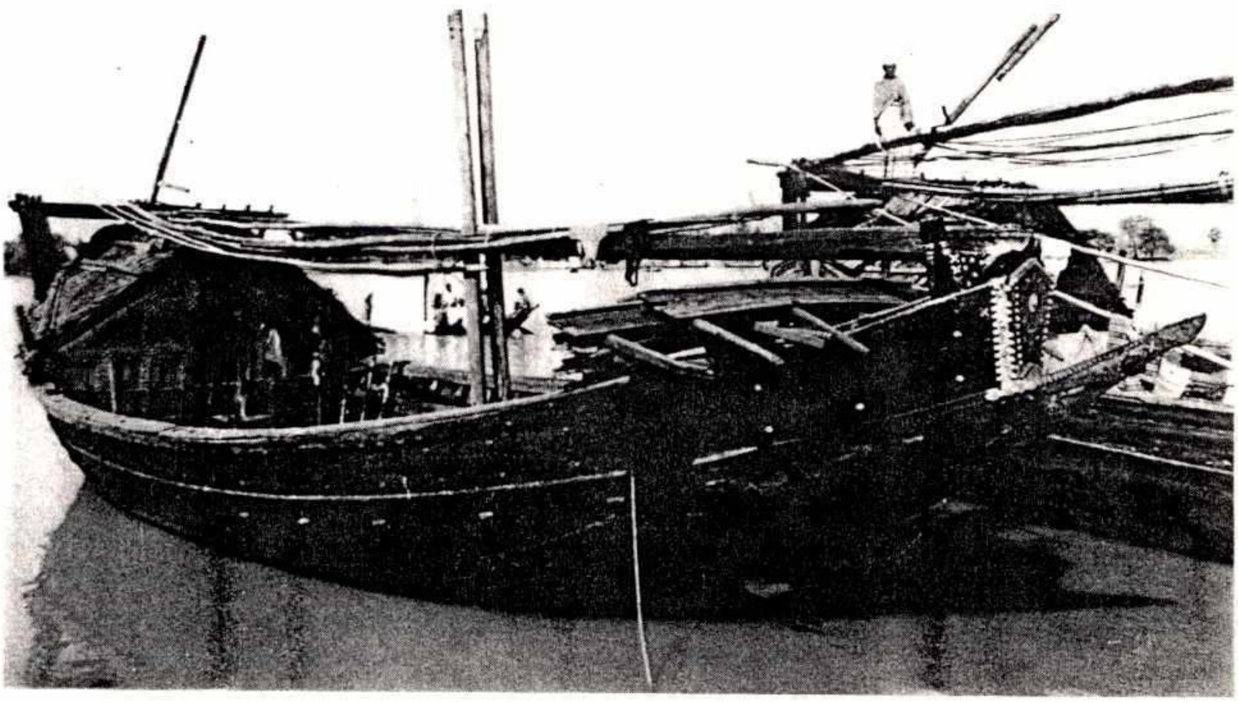


Plate V.2 "Non-mechanized Country Boats".

The boats are preparing to load sal *(Shorea robusta)* timbers from Madhupur N.P., at Kapasia in the NCR. A "bazra" (or budgerow), probably hailing from the Barisal area, is a type of vessel traditionally used to carry "Sundari" from the Sundarbans to Dhaka.

Fisheries

Arial Bil continues to be very intensively fished during the monsoon season, and production there still remains reasonably high. Fixed and moveable gears were everywhere, as were fishermen with and without boats.

In about an hour, one large dip net landed approximately 2 kg of fish of mixed species and size. The net's operators reported that this was a small fraction of what they would have taken in an hour there fifteen years ago. A major cause of the depletion of the bil's fishery was the unrestricted entry of many additional fishermen since then — mostly Muslims — who were compelled to take up fishing by landlessness and lack of economic alternatives. This conforms with a known pattern reported everywhere in Bangladesh.

The bil is heavily stocked with mrigal fingerlings by the Fisheries Department, accompanied unusually by relatively stringent local enforcement of regulations against the taking of undersized fish. The bil's many unmanned dip nets would become active only after sunset, when illegal fish could be caught with impunity, and then exported for sale outside the enforcement zone. These devices cost about 12,000 Tk. per unit to erect, an investment far exceeding the capabilities of ordinary fishermen. Accordingly, these highly efficient fish traps are typically capitalized by local businessmen. They may have no other connection to the fishery or to the region. The trap is then turned over to a working fisherman on a share-cropping basis with one-third of the fish yield going to the operator and two-thirds retained by the investor.

Typically, given the present condition of the Arial Bil fishery, such a trap will generate about Tk.150 per day representing roughly 6 kg of fish, of which the investor's share will be Tk.100. In micro-economic terms, the trap can be expected to return a considerable profit well before the end of the first year, assuming a seven or eight-month fishing season. During the rabi period, when Arial Bil is dry, the traps are disassembled and removed for use in harvesting fishponds and tanks, for which the owner presumably receives some additional rent.

Conclusions for Planning

At this stage it is clear that a significant loss of heritage and access rights has already occured with artificial fisheries having taken over. Even if there were a good case to be made for the restoration of Arial Bil as part of a regional environmental management plan there would be considerable opposition by those parties who have now gained access to its resources. This indicates the serious need for a clearer assesssment of the costs and benefits of such projects at the feasibility stage.

X.2 Case Study 2 - Bosillar Bil

Introduction

Bosillar Bil provides a good example of uncoordinated development policies concerning urban development, management of urban waterways and specifically conflict between donor investments in drainage improvements and local activities which will exacerbate the drainage problem and could overwhelm the original project objectives and expected benefits, see Figure V-I.2.

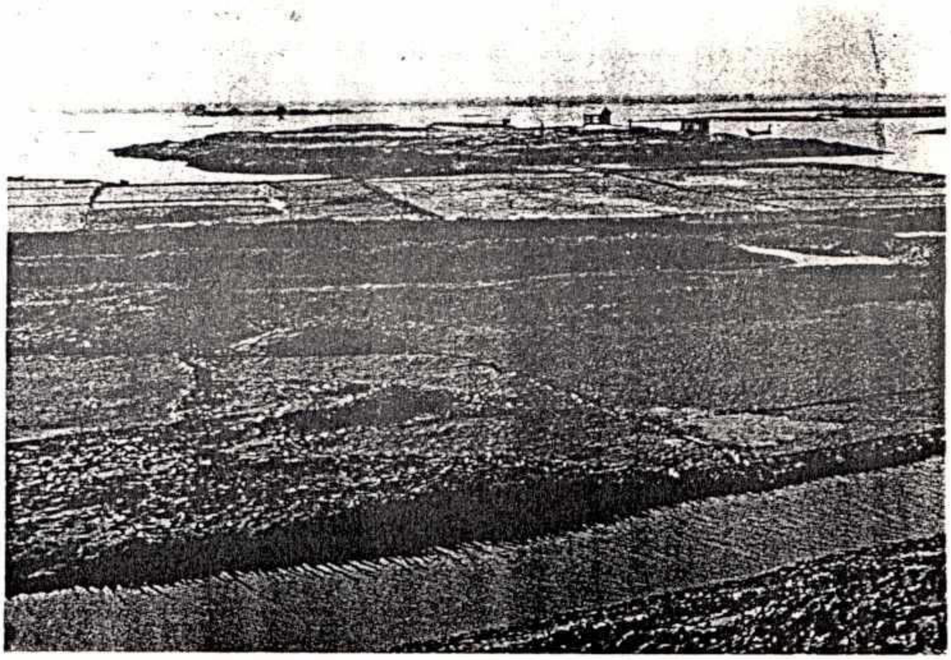


Plate V. 3 "Landfill in the active Buriganga Floodplain, at Bosillar Bil, Dhaka".

This activity is creating new residential real estate for the urban middle class outside of the existing Dhaka City Flood Protection Embankment, and outside of the embankment configurations under FAP-8.

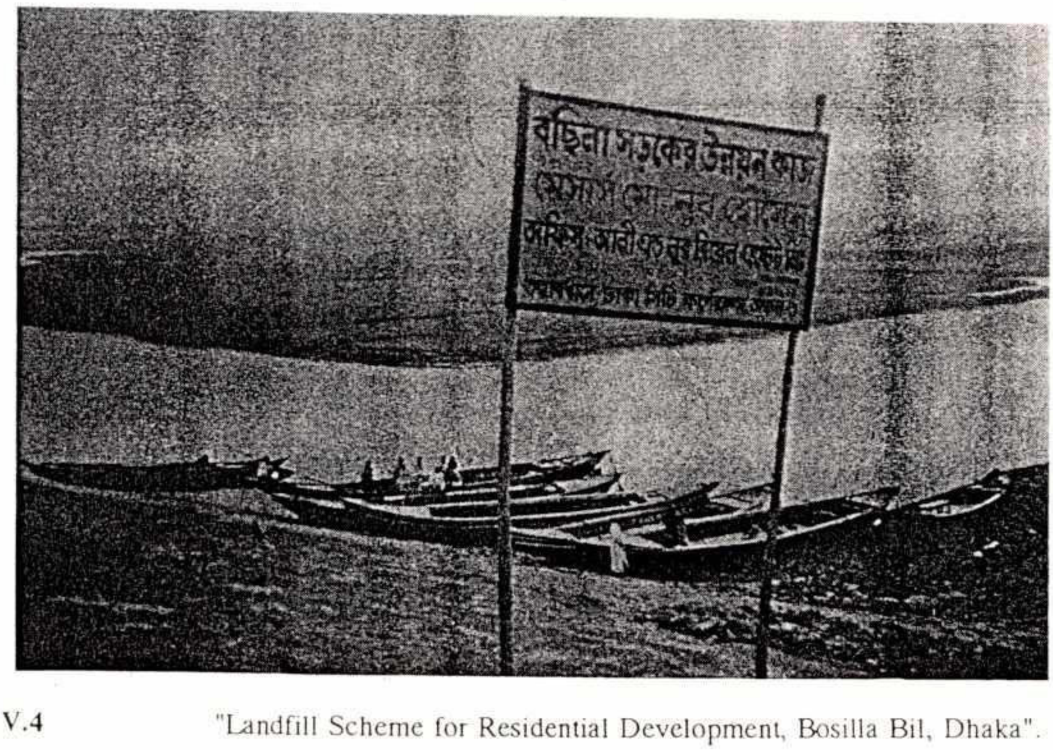
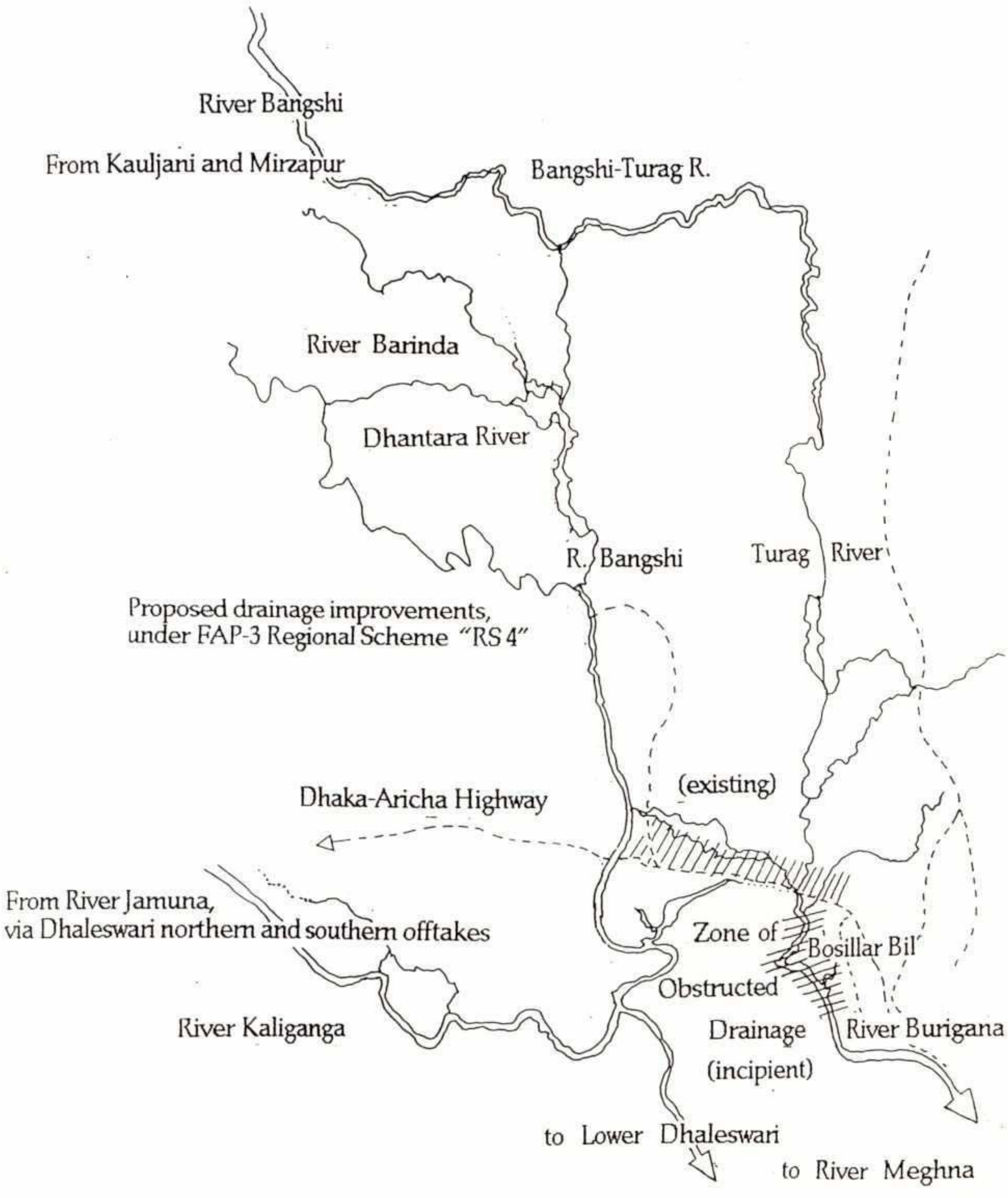


Plate V.4 "Landfill Scheme for Residential Development, Bosilla Bil, Dhaka".

As observed for Plate V.3 above. The area is subdivided into 5-decimals parcels (c.250m^2), each to be sold for Tk. 3 Lac (c.US $8,000). Bangla sign reads: "Improvement work for Bosilla Road, C/o. Noor Hossain Office: Ali and Noor Real Estate, Authorized by Dhaka City Corporation".

Parallel Drainage Pathways
Dhaleswari/Bangshi, and Turag/Buriganga systems



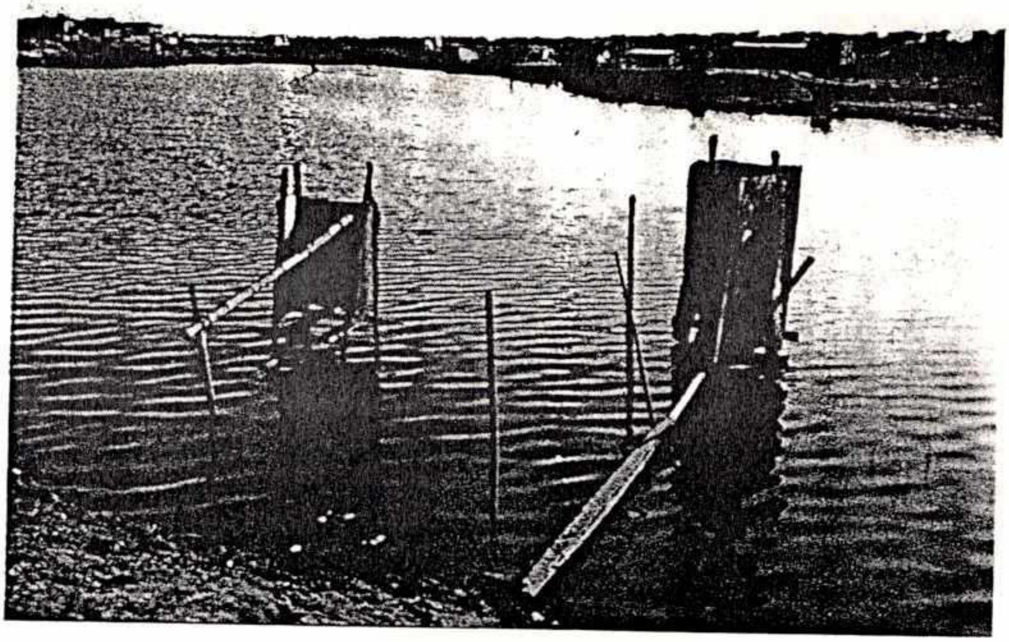


Plate V.5 "Open Privies, behind Shat Masjid, Dhaka".

The present population of the squatter *Bustee* now occupying this 2 lineal km reach of the 20m. wide Dhaka City Flood Protection Scheme Embankment is about 8,000. When rural sanitation technologies are transferred to sites of urban population density, and where the receiving waters are no longer regularly flushed, the effects on public health are predictable: estimated childhood mortality rates(up till age four) in Dhaka's bustees are 25%.

Plate V.6 "Reclaimed Area of Bosillar Bil, West of Shat Masjid"

Until the Dhaka Flood Protection Embankment was built in 1989, Shat Masjid a fine example of 17th Century Moghul religious architecture (visible at top centre of photograph) stood majestically at the water's edge. No effort was made to protect the integrity of what had been one of Dhaka's most splendid elements of "cultural patrimony"

The existing West Dhaka flood protection embankment was built between 1989 and 1991. It is the line of demarcation between the area of responsibility of FAP-3 and that of FAP-8. Shat Masjid ghat, in Mohammedpur, Dhaka, is a site that demonstrates the stream of environmental consequences likely to flow from the construction of major flood-control embankments in close proximity to urban areas. Some of these effects would also appear anywhere in Bangladesh containing a surplus of displaced and/or landless rural people.

Shat Gumbad Masjid was erected in the mid-seventeenth century and maintained for some 300 years in near original condition. It is a small, but exquisite, Moghul mosque at the foot of a large waterfront garden in an area of Dhaka that had been at the far periphery of the old city. The site had apparently occupied a portion of natural levee adjacent to the active Buriganga floodplain.

During the rainy season, the main Mohammedpur ghat directly abutted the rear of Shat Masjid, which stood as a promontory at water's edge. During dry season, the ghat was displaced several hundred meters riverward toward the net of active khals. These drain an area of some 400 hectares contained within an arc formed by a large meander of the Turag/Buriganga. Excepting the system of permanent khals (which remained "khas lands"), most of this well-defined segment of bottomland was privately owned and was generally under boro rice during the winter rabi season. During the kharif the water depth ordinarily exceeded three meters.

A considerable part of the stormwater, and sewage drainage systems of west-central Dhaka was discharged by gravity into the Buriganga close by Shat Masjid. This includes the untreated waste streams from the complex of tanneries at Hazaribagh. Urban and industrial wastes concentrated in the khal channels during the rabi.

By around 1985, several brickyards had been established adjacent to Shat Masjid ghat. The site became a marshalling and distribution point for bricks and sand transported by large country boats. By 1988, *de facto* land reclamation was already well under way. Employment breaking bricks became increasingly available for the. With the city's burgeoning population becoming proportionately poorer, the low-lying floodlands shoreward of and thus, semi-protected by these random brickwaste landfills, were converted into bustees. Some sites were also used for new pukka constructions.

The hydrological and sanitary problems resulting from the increasing obstruction of west central Dhaka's drainage were also increasingly apparent near Shat Masjid, and the brunt of the ensuing disease and squalor was borne, as is usual, by the bustee dwellers. But, at least during kharif, Shat Masjid still stood at the water's edge and still remained one of Dhaka most splendid aesthetic and archaeological treasures.

Unplanned Land Development

In late September 1991, while much of the Buriganga floodplain was still beneath 2-3 m. of water, an intensive landfill and reclamation scheme was launched by the owner of a 4 ha. parcel situated adjacent to, and outside of, the existing Dhaka City flood control embankment. The project site is at far eastern edge of a low-lying region of around 400 ha., generally known as "Bosillar Bil", and demarcated by a large meander of River Turag.
Under this proposal, some 10,000 cubic m. of dry earthen fill would be required to raise the site to approximately 4 m. above existing level. The reclaimed land was intended to be subdivided into some 100 individual allotments, each of 5 decimals (about 75 sq. m.) in area, for subsequent construction projects to be individually financed by the allottees. These would all probably involve low-rise detached housing.

Plate V.7 "Dhaka, Shat Masjid Ghat"

Authorised, semi-authorised, and unauthorized structures shoreward of the Dhaka Flood Control Embankment. This area is mapped as devoted to stormwater storage in the FAP Dhaka Drainage Master Plan. Bangla sign translates as:- Greater Dhaka Protection Embankment.

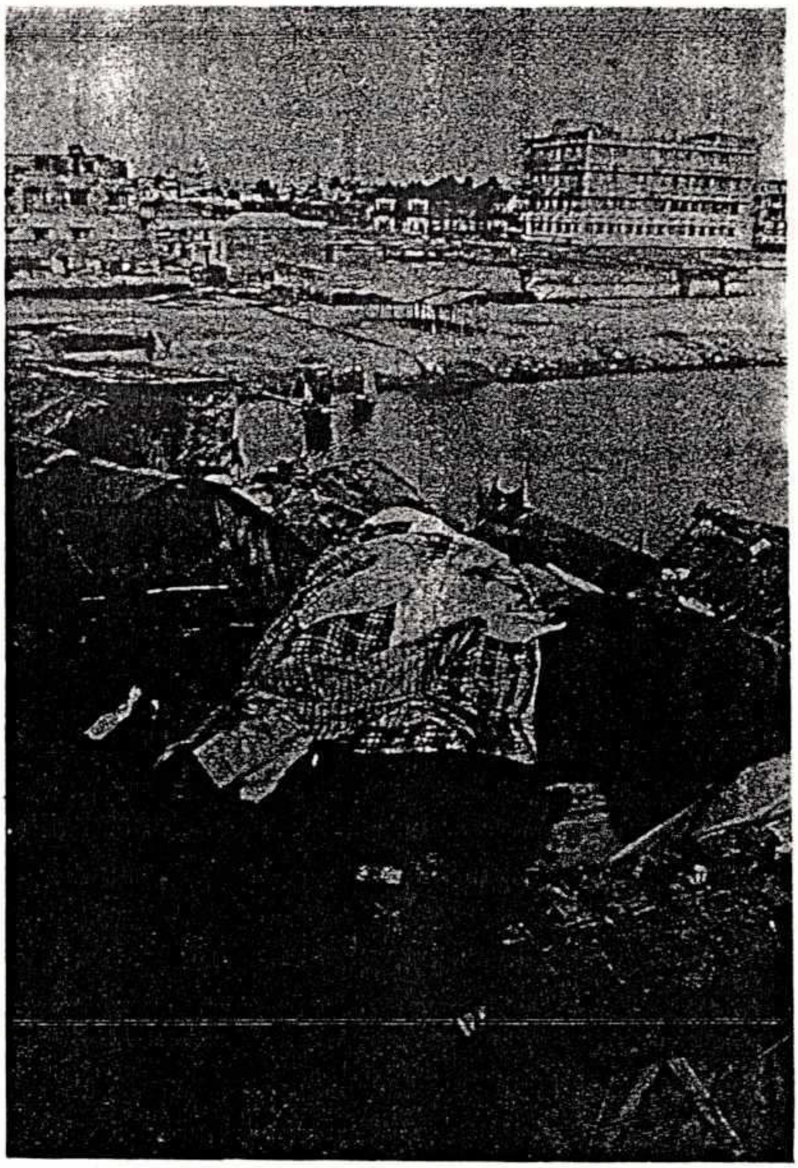


Plate V.8 "Intensity of Squatter Settlements on the Dhaka Flood Protection Embankments".

Landless people displaced from the countryside try to eke out a living however & wherever they can. Experience indicates that major embankments will be speedily covered with marginal dwellings, with the levee backslopes soon unofficially "terraced" to provide flat housing sites. If this is inevitable - as it seems to be - can such embankments be better engineered to accommodate such habitation, without being subjected to higher risk of human induced structural failure, as may now be the case ?

The prospective residential estate was specifically intended to be a profit-making enterprise by the proponent — a well-known and highly-respected Bangladesh NGO — which receives considerable international support, and which had purchased the land in 1986.

In rough figures, each five-decimal parcel would be sold for around TK 3 lakh (about $US 8,300), of which TK 1.2 lakh alone would have been the pro-rated cost of filling the undivided site. The developer's profit margin would been the sale price, minus the fill cost, minus the original land cost, including taxes and overhead. It was the profits generated by the housing estate scheme that were to be applied to charitable purposes elsewhere.

According to the developer's project officer, virtually all the allotments were sold long in advance of the land reclamation work actually being undertaken. The total selling price of the subdivided fill site was to be approximately TK 3 crore (around $US 830,000) with a fair portion already paid to the developer. With sufficient working capital in hand, the developer only then engaged a contractor to initiate the reclamation work, at an estimated overall cost of TK 1.2 crore (around $US 330,000).

A fleet of country boats and a large crew of labourers was then mobilized by the contractor to excavate dry fill from an upland location near Savar for transport to, and reclamation of, the site. Approximately one month after the work began about 30% of the filling had been completed, and some eight hundred boat loads of earth have already been delivered. The bustee along the crest and backslope of the new embankment now houses more than 8,000 displaced rural people.

A major negative impact concerns people living outside of existing and prospective embankments who would be disadvantaged by the heightened stream stage and velocity that often follow containment of river channels. As the new fill island became larger and larger, and progressed toward the existing embankment, interest grew in how projects like these were (or were not) authorized or regulated by the relevant authorities and how local government intended to coordinate such developments.

The NGO project developer had been in close coordination with a planning officer at the Dhaka Improvement Trust (DIT), who indicated that this project was "appropriately designed and sited", since the DIT's own zoning/land use maps showed the entire Bosillar Bil region as slated for full urbanization. Furthermore, DIT had indicated the general position of a new embankment along the Turag left bank, which was expected to be eventually constructed by a foreign donor or by the government. A large segment of the existing embankment at Shat Majid (within the portion erected and maintained by the Bangladesh Army) would be retired, removed, and replaced by a roadway when the extended west perimeter dike was constructed. Since the NGO's new housing estate would front directly upon this roadway, the provision of the infrastructure and utilities was a prerequisite to the construction of housing which would also be assured by DIT.

A sketch map in the office of the NGO's showed the embankment to be close to, and generally aligned with, the Buriganga left bank. It was apparently intended to protect the Bosillar Bil development zone from ordinary monsoonal inundation.

As the new west perimeter embankment is due for construction soon, real estate in Bosillar Bil is at a premium. The small NGO project was merely a prelude to full-bore reclamation and development of the entire bil, where millions of dollars worth of floodlands had recently been purchased by investors and speculators. The FAP 8 report had indeed proposed various embankment configurations for the metropolitan Dhaka area, but not one of them encompassed —

Plate V.9 "New and Old Net Mesh Sizes, Belai Bil"

Professional Hindu fishermen ("Jhele") reworking new superfine (c.5mm) netting into an old large-gauge net (mesh size 3-4 cm), nearly a *one-order of magnitude* reduction of minimum fish size now taken. Until the last decade or less- 4 cm was the normal net gauge of Jhele fishing at Belai, who used to number 12,000. The recent canalization and seasonal drainage of Belai for boro rice culture has decimated both the fishery and the fishing community there.

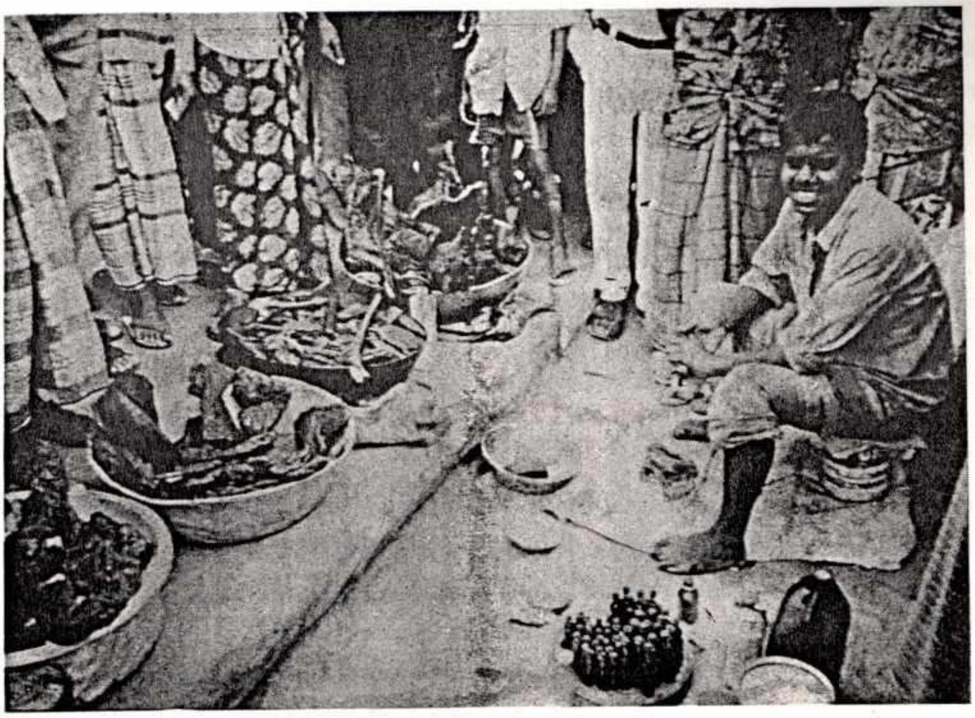


Plate V.10 "Street Vendor of "Shishu" Oil, Mohakhali, Dhaka".

According to some estimates, as few as 1500 Gangetic dolphins remain in the rivers of Bangladesh. If so some 1-2% of the entire Shishu population can be found here in the pans and vials on the sidewalks of Mohakhali.

Plate V.11 "Heads and Body Parts on "Shishu" (Platanistes Gangetica),"

Shown after being rendered down for medicinal oils. This species is listed as "vulnerable or threatened" on the IUCN red list, 1988 (see Plate V.9 above).

or allowed for — the reclamation and urbanization of Bosillar Bil. In fact, the proposals were quite the contrary indicating that Bosillar Bil development area not only falls entirely within the "flood danger zone", but also that it would lie and would severely obstruct a very major floodway, where peak stream discharge has been estimated to be as high as 8,000 to 10,000 cumecs. This massive volume of water not only derives from local drainage within the North Central area (receiving flows from the Turag, the Bangshi, and the Buriganga itself), but the waters passing through this channel are also comprised, in part, by flood flows from North Bengal, Assam, and above, delivered by the Jhenai and the Dhaleswari which are distributaries of the Jamuna and the Old Brahmaputra.

Bosilla Bil must certainly not be considered just another low-lying part of Dhaka; as suitable (or unsuitable) for urbanization and development as was Motijheel, or Agargaon. Here the resultant blockage of natural drainage routes and the filling of pre-existing storage ponds was of comparatively minor and local consequence. Nor is the proposed reclamation site "merely" an annual floodplain. If it were, it should on that basis alone be considered inappropriate for urbanization.

Although the discharge here ordinarily declines to nearly zero for several months of each year with most of the channel floor then completely dry and under boro rice cultivation, the extreme variability and seasonality of flow does not in itself make the site any less a critical stream course. Thus, if the flow through this part of the Buriganga-Turag floodway was constricted or throttled by the removal of this major part of the present channel cross section, severe upstream basin drainage congestion would be a certain consequence. The effects of such a blockage could possibly be felt as far north as Jamalpur.

The existing topography precludes re-routing the floodway west of the Buriganga mainstem. Furthermore, at peak flood flow conditions, such a constriction would be subject to enormous hydraulic forces, and construction of a permanent embankment or flood wall here would be a major engineering task.

Other, less serious problems would also arise. It is unclear how the drainage of west central Dhaka city will be accomplished once the expensive sluice gates and pumping stations now under construction by the Japanese were fully isolated from the Buriganga by filling the stream courses and floodplains outboard of the existing embankment.

If it can be assumed that there will be no embankment does this not, in itself, preclude the reclamation and urbanization of this site ? Just as the present NGO developer is carrying out its own little incremental landfill project, financed by the pre-payments of a hundred land-hungry allottees completely unaware of the larger hydrological context, so to could other landowners or speculators deploy an armada of country boats and an army of shovelers. The effects of an incremental, but cumulative reclamation of Bosillar Bil would be extremely disadvantageous hydraulically. The individual fill sites, un-engineered and uncoordinated, would soon to be covered with housing and would be even more vulnerable than an engineered embankment.

This is the recipe for a major urban disaster. But such an unpleasant turn of events is not automatically predicated on corruption or malfeasance. There seems no question that the NGO-developer has acted (until now) in perfectly good faith. It could also be reasonably assumed that DIT had approved and mapped the extension of new residential districts without personal vested interest as they are quite familiar with uncoordinated, unregulated, and de facto processes by which much of the rest of lowland Dhaka was previously developed.

Thus, in the absence of systematic administrative mechanisms assuring competent technical oversight of every land use decision enacted or authorized by DIT the ramifications of this scheme simply remained unrecognized by all the players. A serious attempt should be made to restrict further reclamation of this site and to refuse permission for any construction, even if this may be politically unpalitable to the many local people and investors who have already plunged materially and psychologically into the reclamation of Bosillar Bil.

With a stop in the construction, hydraulic modelling (or other appropriate studies) could be conducted that might well indicate that the danger has been greatly exaggerated here, or that an additional new west perimeter embankment is feasible, and that problems of urban runoff backing up behind the existing embankment are surmountable.

Conclusions for Planning

The point of this case study is that it exemplifies the detailed level of research and coordination between the rural and urban areas to find meaningful engineering conclusions that deal with social, economic and political realities. Thus, the next stages of the FAP must ensure that there is an integration of research to address the whole issues of drainage congestion around Dhaka. The dominance of agricultural objectives in FAP 3 so far have over-looked these urban development issues which are directly in the FAP 3 area. In practise, the influence of the Aricha-Dhaka road on the Turag Buriganga flood way is unknown and could already obstruct the drainage more than the reclamation of Bosillar Bil. The Metropolitan City Corporation must be drawn into the integrated analysis of FAP 3 as well as FAP 8.

IX.3 Case Study 3 - Embankment and Borrow Designs

The embankment under study is on the Old Brahmaputra right bank, northwest of Mymensingh town. It was built very recently, probably under a Food for Work (FFW) programme. The materials were provided from borrow pits on both the river and the inland sides. The borrow pits are contiguous with the embankment toe. The embankment was already severely eroding or slumping in several places on both face and probably would not withstand the coming monsoon. These problems could relate to poor embankment design, seismicity, settlement problems and wave action.

The commonly discussed idea, regarding the potential utility of borrow pits for fish culture, appears contradictory given the realities on this embankment survey. The survey showed that, in practice, they are likely to be extremely unstable structurally; to display poor water quality, and to be relatively short-lived.

As few farmers appear willing to convert agriculture lands to borrow pits they are excavated as close to the toe of the embankment as possible. This approach does not even comply to the offset required by engineering considerations alone. As a result, the cross-sectional area of the embankment is effectively constricted even before erection. The slope ratio is steeper than that appropriate to uncompacted earthen embankments built of materials of low cohesive strength. Two effects flow from this.

First, the pits directly receive most of the material eroding from the unprotected face of the embankment. This occurs following ordinary rainfall alone and even before river flows rise into contact with these structures. Where such erosion is relatively slight, the result is merely excessive turbidity. This, in itself is incompatible with successful fish culture. However, where the embankment has been severely eroded the pits can rapidly become filled. If this happens in the course of a single storm any fisheries stock would be removed.

Second, the gravitational load of earth on unconsolidated foundations tends to create a "mud wave". This can raise the height of the adjacent substrate as the fill structure consolidates and settles. If borrow pits are excavated within the area subjected to such uplift the borrow pits will effectively fill from the bottom upwards, even if no external sediment or debris is introduced.

Structurally there are also problems related to premature embankment failure which is induced by improper excavations at the toe, or by insufficient height to weight ratios.

The solution for these problems is for borrow pits to be excavated well away from the embankment site. The problems are that the most appropriate land requires moving for a greater distance and expropriating more intensively used and higher valued land.

This case study provides an example of how assumptions can be made on the potential use of borrow pits as future fish culture ponds. The realities would seem to suggest that there would need to be considerable changes to the design, siting and land expropriation programme to enable such possibilities to be realised.

IX.4 Case Study 4 - Navigation and Social Issues in the Middle Bangshi

With the great increase of population in the Madhupur region following its general deforestation, the Bangshi has come to serve as an important commercial navigation link - particularly in transporting the pineapples now widely grown in Madhupur upland soils by mechanized boat to Dhaka, via the Bangshi to Kalatia, and thence along the Kaliganga/Dhaleswari, and the Buriganga. At the height of the monsoon, as many as 150 mechanized boats per day ply the middle Bangshi, carrying passengers and produce, see Figure V-I.3.

According to many local boatmen, the Bangshi below Madhupur town was navigable by large country boat all the way through to the Dhaleswari only a decade ago, and even five years ago, such vessels were usable 8-9 months of the year. Now, siltation and low streamflow limit navigation to the 3-4 months at the height of the monsoon.

Widespread mechanization of country boats has come only since the late-1980's. It was during the 1987 floods, which snarled land transport, that the cheap Chinese diesels imported to drive irrigation pumps were first converted, by means of locally fabricated propellers and driveshafts, in large numbers to inboard marine engines. This had much improved life for boatmen, augmenting their incomes, and re-establishing, in many places, the competiveness of water transport with trucking, as river navigation could then be run on a comparatively-reliable timetable.

However, it appears increasingly evident that the wakes from the newly mechanized boats have been contributing to the degradation of at least the smaller, secondary rivers of the NCR; resulting - over a relatively short period - in substantive changes to channel morphology: waterways have become wider and wider, as banks are continuously undercut by boat wakes, and slough off into the stream. With the incremental deposition of bank materials, the overall depth decreases.

In terms of channel efficiency, this tends towards a reduction of the ability of a stream to convey upbasin and local runoff, since discharge through narrow deep waterways is generally less limited by friction and turbulence than is discharge though a wide, shallow channel of equivalent cross-sectional area.

Social conflict has also followed in the wake of mechanization. Wherever minor waterways (like the Bangshi), now heavily used by mechanized boats, abut embankments "reclaiming" bils and backswamps for agriculture, farmers have posted signs demanding that boatmen slow down. (Wake-induced embankment failure has become a serious threat in such places.) These signs are frequently ignored, and violent confontation between farmers and boatmen seems to be increasingly common.

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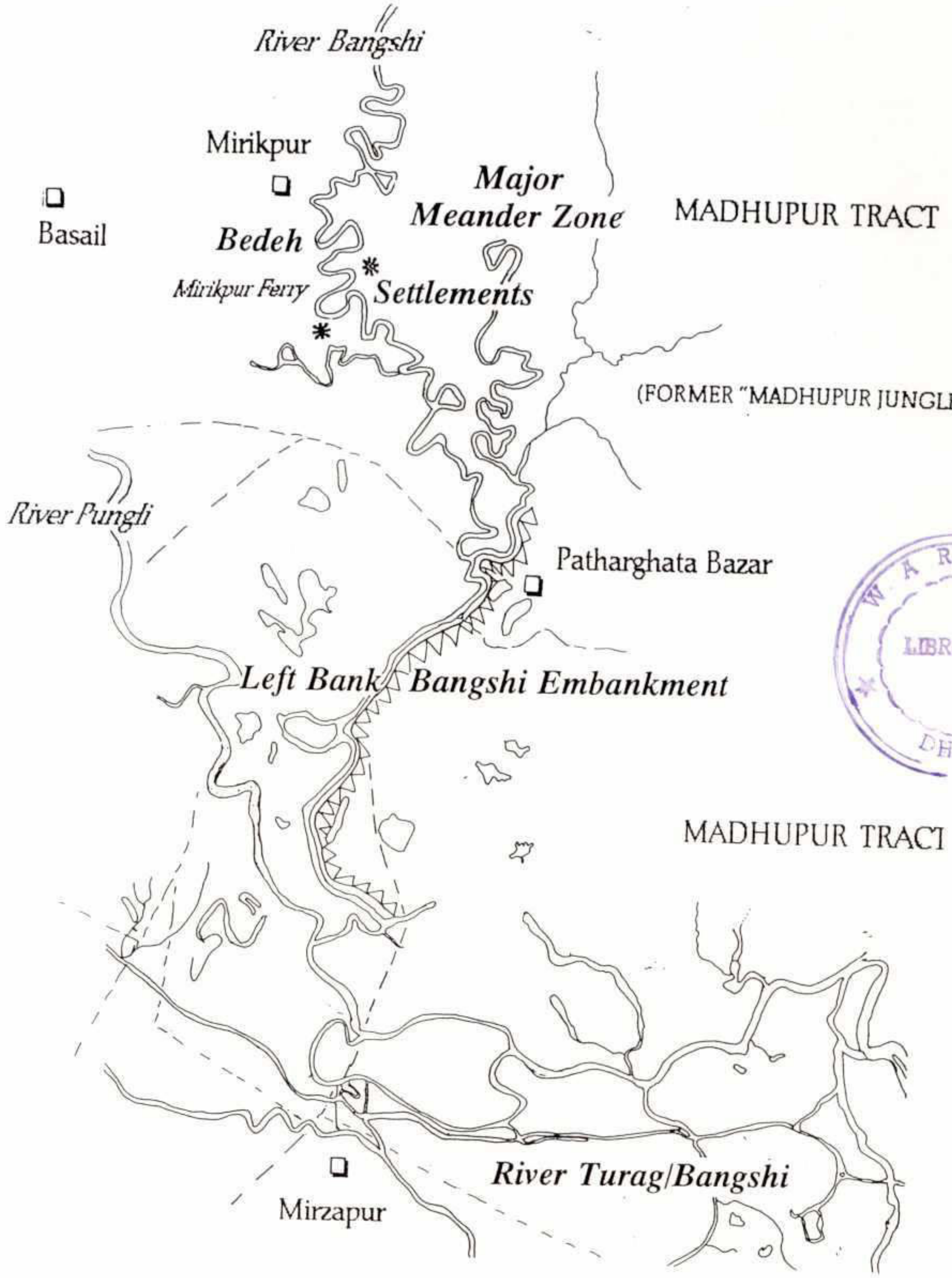
Kauljani Area (Part of RS4)



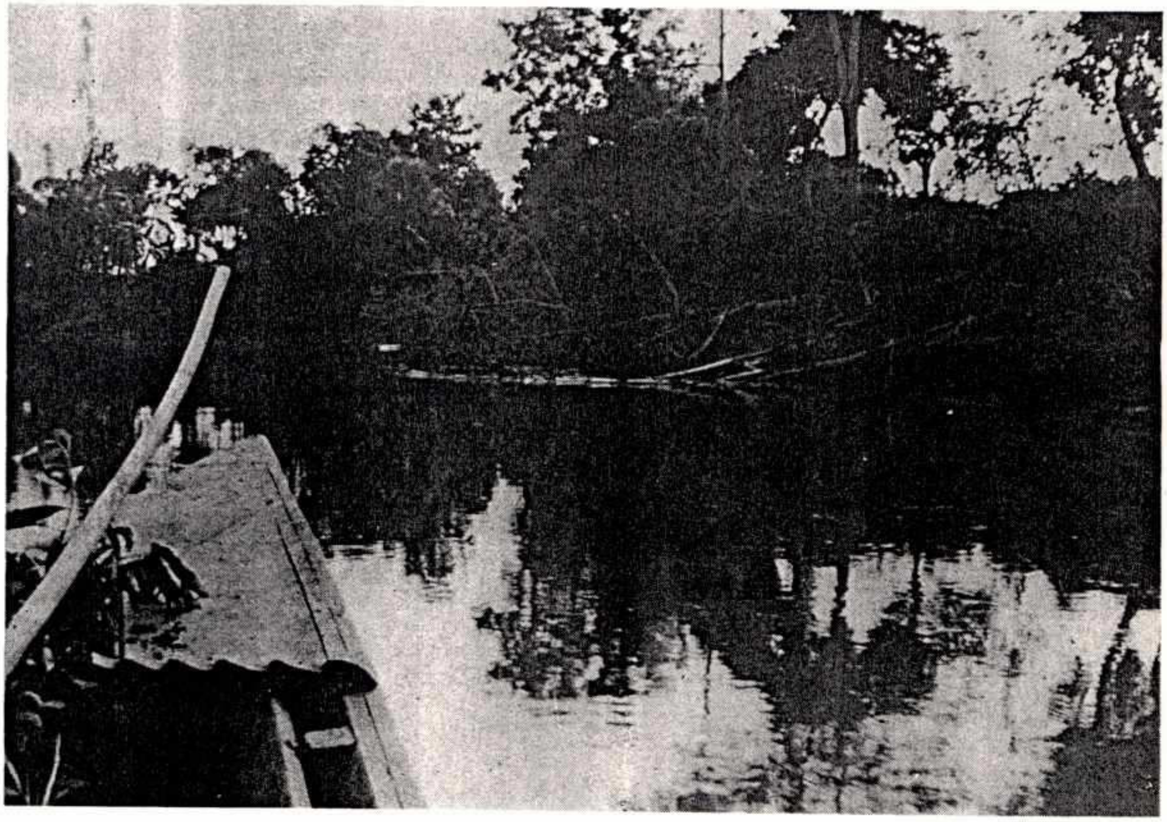


Plate V.12 "Riparian Vegetation Washed out by Flash Floods".

An example, at Banar river south of Madhupur-Muktagacha highway, of the kind of damage stretching some 20km along this reach of the middle Banar. Presumably, the recent deforestation of Madhupur National Park immediately up basin of this area is responsible for the increased flashiness of this stream (many trees so uprooted are 100 years old).