Government of the People's Republic of Bangladesh
Bangladesh Water Development Board
Flood Plan Coordination Organisation

FLOOD ACTION PLAN

NORTHEAST REGIONAL WATER MANAGEMENT PROJECT (FAP 6)

NORTHEAST REGIONAL WATER MANAGEMENT PLAN

September 1993

SNC ◆ LAVALIN International
Northwest Hydraulic Consultants Ltd.

in association with

Engineering and Planning Consultants Ltd.
Bangladesh Engineering and Technological Services
Institute For Development Education and Action
Nature Conservation Movement

Canadian International Development Agency

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NORTHEAST REGIONAL PROJECT

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April 20, 1994

Ref: 209

Mr. M.H. Siddiqi
Chief Engineer
Flood Plan Coordination Organization
7 Green Road, Dhaka

Subject: Northeast Regional Water Management Plan

Dear Sir:

It is with pleasure that we submit the Final Report of the Northeast Regional Water Management Plan. This final report incorporates comments from the various reviewers as agreed to in the technical review meeting held on April 10, 1994.

On behalf of the study team, I would like to take this opportunity to thank FPCO, BWDB, CIDA, and the World Bank for their useful guidance and strong support throughout this regional water management planning exercise. We would also like to thank the people living in the Northeast Region who in various ways helped the study team to better understand the concerns which are most important to them and who provided advice on what was required to stimulate social improvements as well as improvements in the economy and in the environment.

We trust that the proposed plan will provide useful direction for future investments in the region's water sector.

With Regards,

SLI/NHC JOINT VENTURE

Herb D. Wiebe
Team Leader, Northeast Regional Project

cc: Mr. Liaquat Hossain, Chief Engineer, Planning
Mr. Azahar Ali, Director, Planning Schemes I, BWDB
Ms. Sara Camblin Breault, First Secretary (Development) CIDA

ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BFDC	Bangladesh Fisheries Development Corporation
BGD	Bangladesh
BIWTA	Bangladesh Inland Water Transport Agency
BJRI	Bangladesh Jute Research Institute
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BS	Block Supervisor
BTRI	Bangladesh Tea Research Institute
BWDB	Bangladesh Water Development Board
CIDA	Canadian International Development Agency
cm	centimetre
DAE	Department of Agricultural Extension
DOE	Department of Environment
DOF	Department of Fisheries
DPHE	Department of Public Health Engineering
DSSTW	deep set shallow tube well
DTW	deep tube well
EIA	environmental impact assessment
EMP	environment management plan/planning
EPCD	Environmental Pollution Control Directorate (Department of Environment)
FAP	Flood Action Plan
FCD	flood control, drainage
FCDI	flood control, drainage, and irrigation
FFW	Food for Work
FPCO	Flood Plan Coordination Organization
FRI	Fisheries Research Institute
FW	future with (plan)
FWO	future without (plan)
GATT	Global Agreement on Tariffs and Trade
GDP	gross domestic product
GNP	gross national product
GOB	Government of Bangladesh
GRP	gross regional product
GSB	Geological Survey of Bangladesh
GWH	gigawatt hours
HTW	hand tube well
HYV	high yielding variety

IBRD	International Bank for Reconstruction and Development
IMR	infant mortality rate
km	kilometre
KSS	*Krishok Samabhai Samity* (farmer cooperative societies)
LGED	Local Government Engineering Department
LLP	low lift pump
m	metre
MCM	million cubic meters
MIWDFC	Ministry of Irrigation, Water Development, and Flood Control
MLGRDC	Ministry of Local Government
MOA	Ministry of Agriculture
MOL	Ministry of Land
MOEF	Ministry of Environment and Forests
MPO	Master Plan Organization
MW	megawatt
NEMIP	Northeast Minor Irrigation Project
NEMREC	Northeast Regional Environmental Management, Research, and Education Centre
NERP	Northeast Regional Water Management Project (FAP 6)
NMIDP	National Minor Irrigation Development Project
NGO	non-government organization
PBS	Palli Biddut Samiti (Rural Electrification Society)
PWD	Public Works Department
RHD	Roads and Highways Department
SODAPS	Soils Data Processing System
SPARRSO	Space Research and Remote Sensing Organization
SRTI	Sugarcane Research and Training Institute
STW	shallow tube well
SWMC	Surface Water Modelling Centre
T&V	training & visit
TCCA	*Thana* Central Cooperative Associations
UNDP	United Nations Development Program
USAID	US Agency for International Development
WARPO	Water Resources Planning Organization (formerly the Master Planning Organization)

MPO Land Classification Terminology

Class F0	Land inundated to a depth of less than 0.3 m
Class F1	Land inundated to a depth of between 0.3 m - 0.9 m
Class F2	Land inundated to a depth of between 0.9 m - 1.8 m
Class F3	Land inundated to a depth of more than 1.8 m
Class F4	Land inundated to a depth of more than 1.8 m and on which deepwater aman cannot be grown

GLOSSARY OF TERMS

Planning Terms

Development — A process based on intervention to improve the well-being of a defined group of people.

Effectiveness — Relationship between outputs and objectives (in a project or program, for example).

Efficiency — Ratio of outputs to inputs.

Equity — Distribution of costs and benefits to societal subgroups.

Goals — A qualitative statement of a development outcome to be achieved, often within a set time frame. Example: reduce unemployment significantly in city *x* by year *y*. See also *objective*.

Initiative — An interventionist action designed to meet development objectives. An initiative can be a policy, program, project, or action, and can be implemented by public, private, parastatal, or NGOs agencies, or by local communities or groups.

Issue — An area of contention or debate among informed parties.

Objective — Quantification of a *goal* making it operational in a planning context. Example: reduce unemployment in city *x* by the year *y* to *z*%.

Opportunity — An event or situation through which goals could be achieved. Opposite of *threat*.

Policy — A statement of intent.

Programme — A set of interventions at numerous locations based on replication, typically of a successful *project*, for example, a school curriculum replicated in many schools.

Project — An organized intervention to meet development objectives, with a specific geographic location.

Strategy — A set of interventions to achieve desired objective(s) in an efficient manner.

Strategic Planning A process to create a strategy, characterized by:

- focus on selected issues,
- explicit consideration of resource availability,
- explicit consideration of major changes occurring in the external environment, outside the immediate system of concern, and
- action-oriented, emphasis on results.

Strength An existing condition conducive to goals achievement; often defined in relation to comparable regions or entities elsewhere. Sometimes called a "plus" or a "pro". Opposite of *weakness*.

Sustainable Development Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Threat An event or situation (real or potential) which could inhibit or prevent goals achievement. Opposite of *opportunity*.

Weakness An existing condition detrimental to goals achievement, often defined in relation to comparable regions or entities elsewhere. Sometimes called a "minus" or "con". Opposite of *strength*.

Related Terms

Age Cohort All persons in an area or system falling within a given age range. Usually five year cohorts are used, but other cohorts can be used for specific planning purposes. Example: an elementary school age cohort might be all persons aged 6 to 12.

Formal Sector Component of the economy characterized by:

- paid (wage) employment
- payment of taxes
- permanent structures to undertake business
- inclusion in official data

Informal Sector Component of the economy characterized by:

- non-wage employment (subsistence, family labour sharing)
- not taxed, non-payment of taxes
- lack of permanent structures to undertake business
- not included in formal data

NERP DOCUMENTS

The Northeast Regional Water Management Plan is comprised of various documents prepared by the NERP study team including specialist studies, the outcome of a series of public seminars held in the region, and prefeasibility studies of the various initiatives. A complete set of the Northeast Regional Water Management Plan Documents consists of the following:

Northeast Regional Water Management Plan

Main Report

Appendix: Initial Environmental Evaluation

Specialist Studies

- Participatory Development and the Role of NGOs
- Population Characteristics and the State of Human Development
- Fisheries Specialist Study
- Wetland Resources Specialist Study
- Agriculture in the Northeast Region
- Ground Water Resources of the Northeast Region
- Nutrition Study in the Northeast Region
- Surface Water Resources of the Northeast Region
- Regional Water Resources Development Status
- River Sedimentation and Morphology
- Study on Urbanization in the Northeast Region
- Local Initiatives and People's Participation in the Management of Water Resources
- Water Transport Study

Public Participation Documentation

- Proceedings of the Moulvibazar Seminar
- Proceedings of the Sylhet Seminar
- Proceedings of the Sunamganj Seminar
- Proceedings of the Sherpur Seminar
- Proceedings of the Kishorganj Seminar
- Proceedings of the Narsingdi Seminar
- Proceedings of the Habiganj Seminar
- Proceedings of the Netrokona Seminar
- Proceedings of the Sylhet Fisheries Seminar

Pre-feasibility Studies

- Jadukata/Rakti River Improvement Project
- Baulai River Improvement Project
- Mrigi River Drainage Improvement Project
- Kalni-Kushiyara River Improvement Project
- Fisheries Management Programme
- Fisheries Engineering Measures
- Northeast Region Environment Management, Research, and Education Project (NEMREP)
- Habiganj-Khowai Area Development
- Development of Rural Settlements
- Pond Aquaculture
- Manu River Improvement Project
- Applied Research for Improved Farming Systems
- Narayanganj-Narsingdi Project
- Narsingdi District Development Project
- Upper Kangsha River Basin Development
- Upper Surma-Kushiyara Project
- Surma Right Bank Project
- Surma-Kushiyara-Baulai Basin Project
- Kushiyara-Bijna Inter-Basin Development Project
- Dharmapasha-Rui Beel Project
- Updakhali River Project
- Sarigoyain-Piyain Basin Development

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EXECUTIVE SUMMARY

The Northeast Regional Water Management Plan was prepared under the auspices of the Flood Action Plan to assist the Government of Bangladesh in planning and guiding the development of the project region with particular emphasis on water management. A strategic planning method was used, in which the planning problem is defined in terms of internal and external environments. The internal environment is the water system within the region while the external environment consists of regional systems other than water, plus relevant national and international systems. The strategic planning method also stresses action focused on key points of intervention. Public consultation was an important element of plan development.

THE PRESENT

The Northeast Region has area of 24,200 km^2 which is 17.5% of the total area of Bangladesh (Figure 1). Rice, pulses, and fish are the main food items for the 17.1 million people of the region. The diet is dominated by rice, which is generally consumed at every meal, though with increasing poverty and landlessness, wheat has replaced rice at one or more meals in many households. Cereals account for more than 80% of energy intake, more than 70% of protein, intake and more than 70% of fat intake.

The overall health situation is poor. Relevant indicators include the region's Crude Death Rate which is more than 11 per 1000 population and the Infant Mortality Rate (below one year of age) which is 106 to 138 per 1000 live births. Nationally, government expenditures for social services account for less than 20% of the development budget, of which one-quarter is for health and family planning. Private health services and facilities in the region are at least as important as those provided by government.

Literacy in the region is low. Most districts in the region report literacy rates of less than 20% for all age cohorts. This reflects low school enrolment rates; lower for girls than for boys at all levels (girls constitute 45% of the total number of students at primary levels, 36% at secondary levels, and 26% at the higher secondary level). Government aims to achieve a gross enrolment rate of 85% by 1995 and 95% by the year 2000.

The region's economy is based mainly on agriculture and fisheries. Together they account for 70% of employment but their productivity is below the national average and they produce less than 40% of the gross regional product. Agriculture (crops and livestock) contributes Tk 35,186 million annually to the gross regional product and fisheries contributes Tk 2400 million.

Agriculture production has been increasing by 1% annually during the past decade, but it has not kept pace with regional population growth which was 1.9% during this period. Average farm sizes have decreased, from 1.5 ha in 1977 to 0.6 ha at present.

Fish catch and biodiversity appear to be declining, mainly as a result of resource access and tenure regimes which emphasize short-term returns at the expense of long-term sustainability, and

containment of the aquatic environment by infrastructure designed to increase agriculture production or to facilitate road transport.

Industry is predominantly small-scale, notably hand loom textiles and rice milling. There are, however, large-scale industries in the Sylhet region associated with tea, sand and quarrying, oil and gas, and textiles. There are two cement plants and a bleach Kraft pulp mill at Chhatak, private sector fish processing and export plants at Ajmiriganj, Kuliachar, and Sunamganj, a Bangladesh Fisheries Development Corporation (public sector) facility at Dabor, and a garment industry in the area adjacent to Dhaka in which women dominate employment. Construction and industry each account for about 6% of gross regional product.

The region experiences some of the most severe hydrological conditions in the country. Annual rainfall ranges from 2200 mm along the western boundary to 5800 mm in its northeast corner and as high as 12,000 mm in the headwaters of some catchments extending into India. The region receives copious river water from catchments on the slopes of the Shillong Plateau across the border in India to the north and the Tripura Hills in India to the southeast. Interventions in these external catchments, which total 47,300 km^2 in area are beyond the control of Bangladesh authorities. Run-off from these catchments discharge into a large central depression in the region, the *haor* area or Central Basin, much of which remains flooded for more than six months each year. In the wettest year (1993), peak flooding affected an estimated 20,000 km^2.

Principal rivers of the region include the Surma and Kushiyara which drain the eastern side of the region, the Kangsha which drains the western side, and the Kalni and Baulai which drain the Central Basin. These rivers all discharge into the Meghna a short distance upstream of Bhairab Bazar. The Old Brahmaputra River and its distributary channel, the Lakhya form the western boundary of the region and discharge into the Meghna downstream of Bhairab Bazar. The downstream reach of the Old Brahmaputra below the Lakhya offtake is virtually abandoned and only carries flow during the flood season. The main source of flow into the Old Brahmaputra-Lakhya is spill from Jamuna-Brahmaputra just upstream of Bahadurabad.

The physical setting and hydrology have produced a unique hydraulic regime, which creates a variety of difficulties for inhabitants. Flash floods are generated in the steep, upland catchments adjacent to the region in India. These flash floods spill onto low-lying floodplain lands in the region, inundating crops, damaging infrastructure by erosion and channel shifting, and often causing loss of life. Channel shifts and avulsions during flash floods often result in substantial quantities of coarse sand being deposited on agricultural land or in drainage channels. The main lowland rivers such as the Surma-Baulai, Kalni-Kushiyara and Kangsha are currently adjusting their channel morphology in response to natural large-scale channel changes and the effects of past engineering works; embankment construction, distributary channel closures, and loop cutting. Many reaches on these rivers exhibit non-stationary trends in discharges and water levels. Past morphologic developments have often caused low-lying distributary channels in the deeply flooded Central Basin to be abandoned or obstructed, accompanied by gradual sediment infilling and obstruction of drainage.

Water transport is essential to the region's transport needs. Mechanized boats are more than twice as fuel-efficient as trucks and yield high rates of return on capital at prevailing freight rates. Thirteen of the 91 *thana* centres depend solely on waterway communication, and many of the rural market places in the region have grown up along waterways. The region's navigation

network is deteriorating due to sedimentation which has reduced the navigability of the Baulai/Surma, Kalni/Kushiyara, and Kangsha Rivers.

Past water resources management efforts in the region include a total of 66 major surface water projects constructed during the past two decades. Project types include full flood control, partial flood control, drainage improvement, and major surface water irrigation. The potential net benefitted area is an estimated 395,000 ha. A review of these projects reveals that most (80%) have had some positive impact, though not always in the intended manner, and some (45%) have had negative impacts including river confinement, loss of land to infrastructure, and destruction of fisheries habitat.

There are strong forces driving change in the region: relatively rapid population growth, the end of the potential to absorb significant numbers as rural landowning cultivators or as agricultural labourers, urbanization which is just entering its strongest growth period, and industrialization and economic restructuring away from land-based activities. Steadily improving communications will continue to strengthen these forces.

Population growth relative to land availability is almost certain to force restructuring of the region's economy, and urbanization. To be effective in supporting development objectives in the region, water management and planning will need to focus on areas of high economic value and new income-generating activities, both agricultural and non-agricultural.

THE FUTURE

The Northeast Region in 2015 will contain approximately 26.4 million people, of which about 10.1 million will be farming families on plots larger than 0.2 ha. The remainder of the population will be rural landless or urban, with the breakdown between these latter two categories dependent on the health of the industrial and service sectors. It is expected that the rural landless population will comprise about 7.3 million people and the urban population about 9.0 million.

The amount of land in agricultural use will decline slightly because of increased use of land for urbanization, and infrastructure. However, production per unit of agricultural land will increase significantly. The proportion of the increase in population that can be absorbed into agriculture will be partially determined by the development of market opportunities for agricultural outputs, which will be heavily influenced by non-agriculture sector expansion. While population density will increase through the Plan period, it is important to understand that population density *per se* is not the issue; rather, it is how the land and other resources are used.

The overall economy of the region will become considerably more diversified. In particular, the relative importance of agriculture in gross regional product terms will decline dramatically while the secondary (industry) and service sectors will increase in relative importance. By 2015, it is expected that the mainly urban-based non-agricultural sectors (services, construction, and industry) will account for 80% of the region's economy, as compared with 67% in 1991. Within the non-agricultural sectors group, the service sector will be characterised by growth in education, business and professional services, and possibly tourism and hospitality services. Within manufacturing, growth is likely to occur in the heavy industries, mass production, and resource-based subsectors; of these, the mass production sub-sector is likely to show the largest

relative gains. It is expected that manufacturing will become somewhat more export oriented over the course of the planning period.

The human resource base of the region is likely to change significantly during the planning period. The most significant change will be in improved literacy and education. For example, 41% of adults are likely to be literate in 2015 compared with 29% in 1991. In relative terms, girls and women are likely to make the biggest gains because of their relatively low current literacy and education levels. The population of the region is also likely to be healthier and live longer as a result of improved nutrition, smaller families, improved immunization programmes, and improved health services.

One of the biggest changes in the region during the planning period will be that national and international news and entertainment programs will become available, on a daily basis, to virtually all of the region's residents. This will contribute to social change, increased economic efficiency, urbanization, and modernisation.

Water transportation is, and will likely continue to be, the most important transportation mode in the region, particularly for agricultural and other bulky commodities. The major road transportation corridors, from Dhaka to the Indian border via Sylhet, and from Dhaka to the Indian border via Sherpur will be improved. The rail share of freight transport will continue to decline but passenger rail transportation will continue to play a role within the Dhaka-Sylhet corridor.

The region's biophysical environment will undergo significant changes during the period 1991 to 2015. These changes will mainly result from changes in rainfall patterns and trends, morphological changes in the major rivers, and developments in upstream catchments.

Future rainfall and rainfall variability cannot be predicted. Rainfall and flooding influence regional morphology through their influence on the sediment supply. The most sensitive subregions are the Meghalaya fans in the north and the Tripura piedmont areas in the south. The main lowland rivers such as the Upper Kushiyara (upstream of the Manu), the Upper Surma (upstream of Sylhet), and the Meghna, are less sensitive. If rainfall and rainfall variability stay at present levels, then conditions such as those experienced in the late 1980s and 1990s would prevail. If rainfall continues to increase, then existing structures throughout the region will be overwhelmed with increasing frequency, though wetter winter seasons could also directly benefit the *boro* crop, crop diversification, fisheries and wetlands. If rainfall decreases, then the flooding situation would improve, structural failures would be less frequent, and the drier winter seasons would adversely affect crop production and diversification, and fisheries and wetlands.

Aggradation of the lower Kalni-Kushiyara River, described previously, is expected to continue. This will increase spills into the Baulai River, and eventually lead to a partial avulsion from the Kalni River near Ajmiriganj towards the Baulai River. Pre-monsoon flood levels between Madna and Sherpur will increase, affecting 5000 km^2 of the Central Basin, including 14 existing submersible embankment projects. Sediment deposition in the channel and adjacent floodplain will adversely affect fisheries and navigation. Similar changes, but of lesser magnitude, are also expected on the Baulai.

India proposes to construct a dam at Tipaimukh and a barrage at Fulerthal on the Barak River. This project, during operation, would moderate flows along the Kushiyara River and Upper

Surma River, decreasing monsoon flood levels and substantially increasing dry season flows. During reservoir filling, these effects could be even more pronounced. Ramifications for biophysical and socioeconomic environments include changes in monsoon cropping, reduced infrastructure and homestead flood damage, slower post-monsoon drainage, increased dry season in-channel fisheries habitat and improved pre- and post-monsoon fish migration access. System operation will be outside the control of Bangladesh authorities.

Unless preventative action is taken, the quality of the environment in the region is likely to deteriorate as a result of a variety of pressures ranging from deforestation, encroachment on natural wetlands, over-harvesting of wetland resources, degradation of the various wetland habitats, and deteriorating water quality resulting in damage to public health, fisheries, and biodiversity.

A STRATEGY FOR CHANGE

The water resources management strategy proposed here resolves to manage water resources on an environmentally sound basis that is compatible with sustainable management of water-linked renewable resource systems such as soil, fisheries, and forests. It further resolves to identify development initiatives contributing to food self-sufficiency, increased human well-being, and improved protection for life and property, and to stimulate overall rural and urban employment and economic prosperity.

The strategy is based on three key tenets: a mix of structural and non-structural measures is required since there are limits to which nature can be controlled; a development-oriented stance is sought since it promises higher benefits than a defensive stance; and, recognizing that most of the people of the region are poor, the strategy should impact a large number of these people.

Forty-four initiatives were identified which enable the strategy. It is expected that over the planning period, these initiatives can be refined or other and possibly more effective initiatives may be identified to better comply with the principles underlying the strategic thrusts which follow. Initiatives should be acted upon with caution. No amount of diligence in analysis and planning can change the innate unpredictability of many biophysical and social processes. Furthermore, financially efficient technical solutions may not exist to solve all identified problems.

1. Protect Urban Centres and Infrastructure from Flood and Improve the Urban Environment.

It is expected that most of the region's economic output by 2015 will be produced in urban centres and that these centres will contain about nine million people (34% of the region's population). This shift in economic and demographic structures within the region should be facilitated by:

- Encouraging improved urban land use planning and siting of future development on higher ground to reduce flood risks.
- Promoting urban flood preparedness. Recommendations in this regard were prepared through Flood Action Plan components 14 and 23.
- Providing full flood protection or raise existing embankments where technically feasible and where there are large numbers of people and significant economic output. This

would be combined with erosion control and afforestation emphasizing multiple use of embankments.

- Using river diversions to re-route flood water away from urban centres.
- Implementing erosion protection for Bhairab Bazar as proposed by Flood Action Plan component 9B.
- Developing waste water systems using appropriate technologies.
- Enforcing regulations pertaining to industrial pollution.

The expected benefits would include protected and drained land for secondary and tertiary sector uses. This would include land for housing development required by the fast-growing urban populace of the region, and protected bases from which to mount emergency response measures in rural areas in case of natural disasters. It would also result in less disruption of key communication, electrical and transportation services during flood periods, and so mitigate human and economic losses.

The urban environment would become more attractive with better amenities such as domestic water supply and improved security from natural hazards. This would result in healthier and longer-living urban populations. It would further provide benefits to urban industries dependent on clean water such as electronic, biotechnology, beverage, and food industries. It could lead to an increase in the range of locally manufactured goods, and this in turn would lead to higher export earnings.

Initiatives which enable this strategic thrust are *Urban Potable Water, Urban Sanitation, Regional Water Quality Characterization, Pollution Abatement at Smaller Industrial Facilities, Duckweed-Based Wastewater Treatment, Habiganj-Khowai Area Development, Manu River Improvement Project,* and *Bhairab Bazar Erosion Protection.*

2. Intensive Agriculture for Urban Consumption.

Middle-class, mostly urban, markets are developing in Bangladesh for higher value agricultural produce such as fruits, vegetables, poultry, and fish. High market prices for such produce indicate they are in short supply. The potential exists for some rural households to significantly increase their standard of living by catering to the demands of these markets.

Intensive agriculture for urban consumption will be promoted by providing flood protection and drainage to seasonally flooded areas adjacent to large urban markets. This is of particular relevance to the area around Dhaka since by 2015 it is expected to contain approximately 20 to 25 million people and an intensive agricultural belt extending from Dhaka to the north of Narsingdi. This thrust will result in more productive high value agriculture and improve nutrition in urban centres leading to more balanced diets.

The initiatives enabling this strategic thrust are *Narayanganj-Narsingdi Project* and *Narsingdi District Development.*

3. Enhanced Production Systems on Seasonally Flooded Areas

Continued increases in rice production are desirable and likely. Improvements in monsoon season rice production will facilitate shifts in dry season production on seasonally flooded land to more intensive higher value agricultural crops. Increased agricultural productivity would further result from more intensive use of irrigated land and increases in irrigated area. Both private and public investment in agriculture is desirable and the primary focus should be on the eastern and western

seasonally flooded areas, and the intensive agriculture belt around Dhaka since these have the highest growth potential. The content of this thrust includes:

- Private sector funded, developed, and managed small-scale irrigation such as has been initiated through the Asian Development Bank *Northeast Minor Irrigation Project* and the World Bank *National Minor Irrigation Project*.
- Public sector monitoring of ground and surface water quality and quantity.
- Pond aquaculture in non-flooded areas.
- Improve drainage through channel excavation and provide protection from flood spills.

Effective implementation of this strategic thrust is expected to provide increased standards of living for farm households since they will be involved in more productive agriculture. This will further result in more balanced diets leading to improved nutrition and in alleviation of the severe poverty in the far northwestern portion of the region. It should result in management of ground and surface water resources on a sustainable basis and higher agricultural productivity, consistent with sustainable management of highland ecosystems.

The initiatives enabling this strategic thrust are *Ground Water Investigation, Jamuna Floodplain Floodproofing, Upper Kangsha River Basin Development, Upper Surma-Kushiyara Project, Mrigi River Drainage Improvement, Pond Aquaculture,* and *Surma Right Bank Project*.

4. Integrated Development of Deeply Flooded Areas

There are presently as many as 4.8 million people (likely to increase to 6.1 million by 2015) dependent on the deeply flooded *haor* areas in the region for their livelihoods. The *haor* agricultural system is coming under increasing pressure due mainly to a combination of increased population and reduced drainage effectiveness. The former results in increased demand for food and other basic needs, while the latter has constrained production. Falling rice prices, both nationally and internationally, combined with the fact that only one rice crop is produced annually in the *haor* areas means that the current economic system offers very limited potential in terms of poverty alleviation unless changes occur. These changes are reflected in the following:

- The need to increase fisheries productivity and the importance of fisheries in the economy, since the area has a substantive comparative advantage in these terms.
- The need to identify and adopt improved farming systems which promote some diversification to non-rice crops, increased production of livestock including water fowl, production of farmable reptile and amphibian species, and wetland plant products.
- The requirement to improve drainage of the system by re-excavating channels that drain *haors* and other deeply flooded lowlands into the larger main rivers, and effective dredging of the Kushiyara and Baulai Rivers which drain the region.
- The provision of protection from early pre-monsoon floods to ensure harvests.

The main benefits would relate to increased value of agricultural, forestry, and fisheries production. This would foster increased monetisation of local economies, leading to higher standards of living for *haor* residents.

The initiatives enabling this strategic thrust are *Applied Research for Improved Farming Systems, Surma-Kushiyara-Baulai Inter-basin Project, Kushiyara-Bijna Inter-basin Development, Dharmapasha-Rui Beel Project, Fisheries Engineering Measures, Fisheries Management Programme, Pulp and Paper Mill Effluent Treatment, Updakhali River Project, Baulai River Improvement Project, Kalni-Kushiyara River Improvement, Jadukata-Rakti River Improvement,* and *Sarigoyain-Piyain Basin Development*.

5. Biodiversity Enhancement and Sustainable Management

Freshwater wetland biodiversity of Bangladesh, once characteristic of much the nation's area, is concentrated now in the Northeast Region which contains all of the nation's remaining large semi-natural freshwater wetlands. Logically, then, efforts to preserve this important aspect of the nation's natural heritage should focus on the Northeast Region. The Government of Bangladesh's commitment to wetland conservation and improved management was expressed by its accession in 1992 to the Ramsar Convention, the main international agreement addressing wetland conservation and improved management. The content of this thrust includes:

- Locally-based management of internationally significant wetland sites.
- Lowland vegetation community enhancement.
- Upland biodiversity conservation.
- Recovery of threatened and commercially threatened plant and animal species.
- Biodiversity strategic planning exercise for the Ministry of Environment and Forests.

Regional biodiversity (number, quality, area of ecosystems, habitats, populations, species) would be enhanced as a result of implementing this thrust. The benefits flowing to local people from natural systems – fish, fuel, building material, marketable products, employment, earnings – would increase. Socioeconomic and gender equity of these impacts would be highly positive, given that natural resource gathering is mainly an occupation of the poor, including poor women. Long term management of biodiversity and surface water quality would be strengthened.

The initiatives enabling this strategic thrust are *Upland Biodiversity Conservation, Locally-Based Management of Key Wetland Sites, Threatened Ecological Community Recovery,* and *Threatened Species Recovery*.

6. Improve Liveability of Rural Settlements

Even in 2015, the majority of the region's residents (approximately 66%) will still live in rural settlements. It is not and will not be possible to protect extended areas of the region from flooding; this flooding must be accepted. Village homesteads provide for essential needs such as sanitation, food storage, privacy, work, fuel, food, and drinking water. Homesteads are highly productive areas, and many of these productive functions are the responsibility of women, and in some cases of direct benefit to them. In areas where flooding occurs, in the approximately 30% of the region's land area subject to deep flooding and the 40% subject to seasonal flooding in a typical year, homesteads are especially important for production and human welfare. Many homesteads in the deeply flooded area are experiencing increasing flood and wave erosion as swamp forest and other wetland vegetation which act as wave energy dissipators have gradually been removed. The homestead represents a high proportion of assets of poorer families, and accelerated homestead erosion can be a source of severe stress. Thus a strong rationale exists for a strategy thrust to improve the standard and quality of life in rural settlements. To this end, the following mix of measures would be implemented as appropriate:

- Raising homestead platforms.
- Extending the areal extent of homestead platforms.
- Protecting homestead platforms against erosion.
- Undertaking afforestation at the settlement scale.
- Increasing accessibility to safe potable water.
- Improving drainage and sanitation at the village scale.

Implementation of this thrust will result in the better protection of human property and improvement in living conditions, particularly during flood periods. Women, who spend more time within settlements than men will be particularly benefitted. Also protected will be areas for human resource development activities, rural industry and commerce, rice storage and drying, homestead gardens, livestock, and leisure activities. It would further lead to improvements in water quality in and around settlements.

Flood response will be improved since there would be protected base areas for storage of emergency response commodities, and from which to mount emergency activities.

This thrust also would improve the productivity and quality of life of women. It would facilitate carrying out the numerous key functions that women perform in the homesteads such as care of children and the sick, drying and storing grain, preserving seeds, and homestead agriculture and animal husbandry.

Initiatives enabling this strategic thrust are *Village Water Supply, Improvement of Homestead Platforms, Village Afforestation,* and *Improved Flood Warning*.

7. Improve Water Transport in the Region

As has been mentioned, water transportation is important in the region. The content of this thrust involves the following:

- Incorporation of water transportation needs in the design of all water management projects.
- Selective channel improvement, often utilising dredging, to improve navigation. To the extent practicable, this activity should be coordinated with overall drainage improvement programmes.
- A navigational aids programme which would result in more and better marked navigational channels, and boat passes where appropriate.
- A programme to improve docking facilities, loading and unloading facilities, boat construction and repair sites, water transport supplied wholesale/retail markets, and industrial sites along navigable waterways.
- A programme supportive of local country boat operators. This programme would focus on investment facilitation to enable boat operators to upgrade their boats, normally through motorisation, and so increase their efficiency and capacity.

This thrust would result in increased efficiency in the shipment of bulk construction materials from the alluvial fans in the north of the region to markets in Dhaka and other key centres of Bangladesh. The livelihood of a large number of people who work in this sector would be protected. Benefits from mechanisation would likely include lower tariffs, higher wages, and increased speed of transportation but total employment may not increase significantly.

Initiatives enabling this strategic thrust are *Dredging for Navigation* and *Support to Country Boats*.

8. Institutional Strengthening and Development

Evaluation and assessment of water sector programmes by a variety of agencies to date have indicated that past water sector planning and management has tended to be too centralised, dominated by engineers to the exclusion of input from other disciplines, and has not adequately involved local people in project development, implementation, or operation. Many existing water

projects and programmes have considerable potential, but are not performing or are performing considerably below potential. Government has indicated a desire to make developmental systems more decentralised and participatory in nature and the following would support this intent:

- Promote increased public participation in the design, construction, operations, maintenance, and rehabilitation of water sector projects. This would also involve improved rural planning to avoid investments working at cross-purposes (such as rural roads obstructing drainage).
- Increase the range and depth of expertise in government water sector agencies.
- Improve systems for monitoring the quantity and quality of ground water reserves and surface water.
- Improve operations and maintenance of currently operating projects. This would include changes in revenue systems so as to increase local revenue collection and mobilization over the planning period.
- Develop methods to provide more appropriate flood warning. This is of particular relevance in areas affected by flash flooding where frequent and interpretive assessments are required.
- Create a regional institution for environmental management, research, and education.

Implementation of this thrust is expected to result in improved technical quality of projects because of increased deployment of technical expertise at the local level, and increased input of knowledge of local conditions by local residents. There would also be increased support of local projects by local people which should lead to increased project effectiveness, and a reduction in community opposition and damage to projects (such as public cuts). Water sector planning would have a stronger developmental focus, and would also result in increased synergy in the content of local natural resource programmes which should lead to greater effectiveness. This would lead to improved drainage through reduction in cross-drainage problems, and more effective flood forecasting and warning resulting in property savings and reduction of human suffering. Also expected would be increased funding to, and autonomy of, local water institutions.

Initiatives enabling this strategy are *Institutionalize Public Consultation, Northeast Region Environment, Management, Research, and Education Centre, Surface Water Quality Management Strategic Planning Exercise, Biodiversity Strategic Planning Exercise* and *BWDB Strengthening*.

PORTFOLIO OF INITIATIVES

A portfolio of 44 initiatives was developed from the regional strategy described above. The Table on the following pages shows the initiatives, categorized by priority group and strategic thrust, with a brief indication of rationale. Priority groups were derived from factors such as dependencies between Plan projects and dependencies on factors external to the Plan. Each initiative conforms to the proposed strategy and has been subjected to the multi-criteria analysis specified by FPCO.

STRATEGIC THRUST	INITIATIVE	RATIONALE
Priority group *N*: Non-structural initiatives of a remedial nature		
Urban and Infrastructure Protection	*Urban Potable Water*	Essential services for urban development.
	Urban Sanitation	
	Regional Water Quality Characterization	Immediate attention is required to obtain information on water quality.
	Industrial Pollution Abatement at Smaller Industrial Facilities	Immediate action is required. Regional industrial pollution is likely to double over the next decade.
	Duckweed-Based Domestic Waste Treatment	Immediate attention required for the enhancement of health standards.
Enhanced Production Systems on Seasonally Flooded Areas	*Ground Water Investigation*	Immediate attention required to avoid over-extraction of ground water.
	Jamuna Flood Plain Floodproofing	This area is subjected to regular Brahmaputra River inundation resulting in greatly reduced quality of life.
	Pond Aquaculture	Improved socio-economic conditions for small and landless farmers.
Integrated Development of Deeply Flooded Areas	*Applied Research for Improved Farming Systems*	Immediate attention required so that mixed farming systems can be introduced into the deeply flooded area.
	Fisheries Management Program	Immediate attention required to increase open water fish production and to ensure the long-term sustainability of fish production.
	Pulp and Paper Mill Effluent Treatment	Immediate attention required to arrest environmental degradation.
Biodiversity Enhancement and Sustainable Management	*Upland Biodiversity Conservation Studies*	Immediate attention required to arrest environmental degradation.
	Locally Based Management of Internationally Significant Wetland Sites	
	Threatened Ecological Community Recovery Programme	
	Recovery Plans for Threatened and Commercially Threatened Lowland Plant and Animal Species	
Improved Liveability of Rural Settlements	*Village Water Supply and Sanitation*	Immediate attention required for the provision of essential services.
	Village Afforestation	Immediate attention required to arrest environmental degradation.
Institutional Strengthening and Development	*Pilot Project to Institutionalize Public Consultation*	Immediate attention required to improve the planning process.
	NE Regional Environmental Management, Research, and Education Centre (NEMREC)	Immediate attention required to arrest environmental degradation. This initiative linked to other environmental initiatives.
	Surface Water Quality Management Strategic Planning Exercise	
	Biodiversity Strategic Planning Exercise	
	BWDB Strengthening	

STRATEGIC THRUST	INITIATIVE	RATIONALE
Priority group *SI*: structural initiatives that are independent of other Plan structural initiatives		
Urban and Infrastructure Protection	*Habiganj-Khowai Area Development*	Project includes urban protection for Habiganj town and the reduction in flood damages to homesteads, infrastructure, and crops.
	Manu River Improvement Project	Project includes urban protection for Moulvibazar town, rehabilitation of Manu River Irrigation Project, and the protection of adjacent road and rail links.
	Bhairab Bazar Erosion Protection	Immediate action required to avoid further damage to Bhairab Bazar town, railway bridge, and electrical line.
Intensive Agriculture for Urban Consumption	*Narayanganj-Narsingdi Project*	Future plans need to focus more on agriculture for consumption by the Dhaka mega urban area.
Enhanced Production Systems on Seasonally Flooded Areas	*Upper Kangsha River Basin Development*	Consists of several sub-projects in the upper catchment. Benefits include improved operation of the existing downstream Kangsha-Thakurakona Project.
Integrated Development of Deeply Flooded Areas	*Fisheries Engineering Measures*	Immediate attention required to arrest the deterioration of fish habitats and to restore open water fish production.
	Baulai River Improvement Project	Drainage improvement scheme having a large potential impact on the region. Incorporates drainage improvement component of *Surma-Kushiyara-Baulai Basin Project.*
	Kalni-Kushiyara Improvement Project	Drainage improvement scheme to rehabilitate lower Kalni-Kushiyara River.
Improved Liveability of Rural Settlements	*Improvement of Homestead Platforms*	Homestead conditions are deteriorating rapidly and population is increasing.
Institutional Strengthening and Development	*Improved Flood Warning*	Better warning systems are critical to reducing loss of life, damage to crops and property. A pilot project is proposed to determine an appropriate solution.

STRATEGIC THRUST	INITIATIVE	RATIONALE
Priority group *SID*: Structural initiatives that are internally dependent (dependent on other Plan Structural initiatives)		
Enhanced Production Systems on Seasonally Flooded Areas	*Mrigi River Drainage Improvement Project*	Project affected by upstream work on the Karnajhora River.
Integrated Development of Deeply Flooded Areas	*Jadukata-Rakti River Improvement Project*	Project affected by *Baulai River Improvement Project.*
	Sarigoyain-Piyain Basin Development Project	Located in the upper catchment area but not affecting existing projects or urban centres.
	Dharmapasha-Rui Beel Project	Affected by *Baulai River Improvement Project*
	Updakhali River Project	Affected by *Upper Kangsha Basin Project* and *Baulai River Improvement Project*. Lead time for testing fish pass structures also needed.
Intensive Agriculture for Urban Consumption	*Narsingdi District Development Project*	Project affected by upstream development on the Old Brahmaputra channel.
Navigation Improvement	*Dredging for Navigation*	Project affected by *Baulai River Improvement* and *Kalni-Kushiyara River Improvement.*
	Support to Country Boats	Other action is needed before implementation as project is partly linked with water resource projects.
Priority group *SED*: Structural initiatives that are externally dependent (dependent on future developments outside the region, specifically, the Tipaimukh Dam project in India)		
Enhanced Production Systems on Seasonally Flooded Areas	*Surma Right Bank*	Project is located upstream of other initiatives on Surma River. The project will be affected by Tipaimukh Dam if constructed.
	Upper Surma-Kushiyara Project	Project is located in the upper catchment area and will affect flood discharges in the downstream reaches of the Surma and Kushiyara channels. The project area will be affected by the Tipaimukh Dam if constructed.
Integrated Development of Deeply Flooded Areas	*Kushiyara-Bijna Interbasin Project*	Project affected by *Kalni-Kushiyara River Improvement*, by other upstream initiatives, particularly *Upper Surma Kushiyara Project*, as well as by Tipaimukh Dam if constructed.
	Surma-Kushiyara-Baulai Basin Project	Project affected by *Baulai River Improvement*, by other upstream initiatives (*Surma Kushiyara Project* and *Surma Right Bank Project*) and by Tipaimukh Dam if constructed.

STRATEGY IMPACTS

Regional Economic Impacts

It is forecast that by 2015, the regional economy as measured by gross regional product will expand to almost Tk 550 billion and four times its 1991 size. An estimated one-third of this increase will be attributable to strategy implementation. It is also forecast that gross product per person will be 10% higher than the national average.

Annual capital investment in the region will more than double to Tk 1000 billion by 2015, but, with a decreasing proportion going into repair and replacement, the capital base is forecast to increase more than three times the 1991 level. Total incremental investment to implement the strategy would be Tk 248 billion through the Plan period of which an estimated 53% would be provided by the private sector and 47% by public funds including foreign development assistance.

Strategy implementation would tend to slow the transformation of the economy away from agriculture and would result in annual incremental wages of Tk 95.6 billion (an increase of 37% over the future without Plan value). Average household incomes would increase by Tk 18,300 per year over the future without Plan value.

Overall, strategy implementation is forecast to create 4.7 million job equivalents. The number of new jobs created would be less than this, as labour demands an increasing proportion of the incremental benefit in the form of higher wages. The split between job creation and wage increases is difficult to estimate. The strategy-induced incremental net return per rural household (landowning and landless) would be relatively low, at slightly under Tk 1,000 per year, with a disproportionate amount accruing to middle and larger landowners. These low returns to agriculture, compared to the potential maximum average wage increase (that is, setting new job creation to zero) of Tk 7,600 per job-year, suggest that wage increases will be moderated in favour of non-agricultural job creation; this would favour increased rural-to-urban migration, and increased rural non-agricultural employment.

Impacts of Flood Control Drainage Initiatives

Homesteads on a total of 400 ha, occupied by 107,000 persons, and cultivation on 4,500 ha would be displaced by project works (embankments, structures, and larger channels). This is 0.9% and 0.3% respectively of total settlement and cultivated areas within project areas.

Homestead flood damage protection, raising existing homesteads, and creation of new homesteads would compensate and enhance regional homestead area. A total of 6,400 ha of formerly flood-affected homestead land, occupied by 1.4 million persons would be protected from flooding. This is 9.7% of the total regional homestead area of 65,000 ha, and 52% of the 12,000 ha of formerly flood-affected homestead area within project areas. An total of 700 ha of new homesteads would be created and existing homesteads raised using dredging and excavation spoil.

Within flood control drainage projects, food production would change as a result of:

- Increased annual paddy production by 570,000 tonnes or 10% of present regional annual production of 5.6 million tonnes, mainly by reducing flood risk and damage to crops and altering land types;

- Increased annual production of other food crops by 123,000 tonnes, 12% of current annual production of 1.0 million tonnes;
- Fodder production as a second or third crop on 26,000 ha;
- Increased homestead agricultural production (spices, fruit trees, vegetables, livestock, etc.) on 7,800 ha (net of homesteads protected from flood damage, created and raised with spoil, taken from project works);
- Decreased annual openwater fish production by 10,600 tonnes or 11% of current regional annual production of 96,000;
- Increased annual aquaculture fish production by 1,600 tonnes (counting only effects of flood risk and damage averted) or 8.8% of current regional annual production of 18,000 tonnes; and
- Decreased winter grazing area (winter fallow dry lands) by 54,000 ha or 7.0% of the current area of 779,000 ha.

Negative impacts on fisheries would be compensated by the proposed initiatives specifically addressing this area. An overall increase in fish abundance, diversity, and catch could result through the implementation of measures proposed in the *Fisheries Management Programme* and *Fisheries Engineering Programme* initiatives.

Water quality (as experienced by domestic consumers, fisheries, and wetlands) changes cannot be quantified, but would be affected in a number of ways. Drainage improvement would tend to improve water quality, by increasing flushing and flushed volume and duration, and decreasing stagnant water volume and duration. Flood control would improve water quality at some times and places, by eliminating flooding of domestic-supply tube wells and pit latrines for example, and worsen it at others, by decreasing flushing and increasing stagnant water volume and duration. The flood control drainage led increment in pesticide use (47 tonnes, or 9% of current usage of 530 tonnes) would contribute to water contamination, especially in low pockets surrounded by hyv cultivation. The flood control drainage led increment in fertilizer use (46,000 tonnes, 20% of current usage of 226,000 tonnes) would increase nutrients available to the openwater fishery, but could also aggravate eutrophication problems. Negative regional water quality impacts would be compensated and water quality enhanced through a number of proposed initiatives specifically addressing water quality management. Water quality will be improved through initiatives such as *Duckweed-Based Waste Water Treatment*, and *Pollution Abatement at Smaller Industrial Facilities*.

Navigation would be benefitted by river and channel excavation, and disbenefitted by the 48 closures of major and minor channels at embankments and across spill channels. Negative navigation impacts would be compensated and navigation enhanced by drainage improvement and proposed initiatives specifically addressing navigation requirements.

Wetland areas (such as fallow areas with sufficient moisture to support hydrophytic plants) would decrease, in winter by 7,000 ha or 5.7% of the regional total of 124,000 ha, and in summer by 50,000 ha or 11% of the regional total of 440,000 ha. About half (250 ha) of the region's remaining floodplain grassland (550 ha) could be adversely affected by *Surma Right Bank Project*. Hakaluki Haor, a key wetland site and mother fishery, would be adversely affected by sediment deposition as a consequence of the *Manu River Improvement Project*; Tangua Haor and

Companiganj key wetland and mother fishery sites would be partially protected from sediment infilling by *Jadukata-Rakti Project* and *Sarigoyain-Piyain Project* respectively. Negative wetland and biodiversity impacts would be compensated and these environmental components enhanced by proposed initiatives specifically addressing this area. Nine wetlands sites have been identified for protection, conservation, and rehabilitation in the *Locally Based Management of Key Wetland Sites* initiative to compensate potential decreases in wetland area.

In some river systems, channelization of floodplain flows will increase river water levels, discharges, and velocities. These in turn may increase the cost of flood control measures (embankments will have to be higher and stronger) and infrastructure maintenance. If designs and maintenance are not upgraded enough, infrastructure may fail more frequently due to greater erosion and more frequent overtopping. When and where infrastructure fails, damage to crops, homesteads, and roads may be greater than in the unprotected situation because levels will be higher. Also, three areas in the region - the Mogra basin, Hakaluki Haor, and the lower Sarigoyain River basin – will remain both outside of flood control embankments and vulnerable to displaced flooding from Plan flood control drainage projects. Channelization, by raising river water levels, may in some cases result in improved conditions for river navigation and fisheries.

As for impacts outside the region, there would be no hydrologic or sediment impact on areas downstream, given conditions at the region's outfall. A possible exception could be transient effects due to turbidity from dredging. Pesticide loadings of regional drainage flows would increase, proportional to usage increases. Migrating waterfowl populations will be adversely affected by the overall reduction of winter wetland areas and adverse impacts on Hakaluki Haor. This could be somewhat compensated by positive impacts on Tangua Haor and Companiganj area.

Impacts of Non-Flood Control Drainage Initiatives

Impacts of Plan initiatives other than flood control and drainage are generally relatively straightforward and relate closely to intended benefits. These Plan initiatives address rural and urban water supply, sanitation, and rural hygiene education; biodiversity and surface water quality management; aquaculture; ground water management; applied research to improve farming systems in the deeply flooded area; openwater fisheries engineering and management; improvement of homestead platforms and village afforestation and habitat restoration to control wave erosion and generate biomass inputs (such as fuel and building materials) to village systems; navigation; flood warning; and institutional strengthening in selected areas. Some of these projects exhibit specific possible adverse impacts, all of which appear to be mitigable or otherwise manageable with reasonable effort. Examples of such possible impacts include displacement impacts associated with minor construction, regressive socioeconomic equity impacts, and intensification of social conflicts over resource management and control.

1. INTRODUCTION

The Flood Action Plan for Bangladesh is the first stage in the development of a long-term water management plan. It is comprised of a phased programme of initiatives to control flooding, supported by special studies, surveys and pilot projects.

The Northeast Regional Water Management Project (NERP) is Component 6 of the Flood Action Plan (FAP 6). The overall objective of the Project, as stated in the Terms of Reference, is:

> " .... to assist the GOB in planning and guiding the development of the project region and to provide criteria for the selection, design, implementation, operation and maintenance of individual water-management projects benefitting the agricultural, fisheries, and related sectors, with due attention to the growing landlessness of the rural population. In accordance with the objectives of the Action Plan, the Project is to provide the basis for the management of the Northeast Region's water resources with a view to creating an environment for sustained economic growth and social improvement."

NERP consists of two phases. Under Phase I (Aug 91 to Sep 93), present conditions in the region were characterized through specialist studies of key areas including existing water resources development, hydrology, river sedimentation and morphology, agriculture, fisheries, wetland resources, human resources development, and institutions (see NERP Report List, pages iii and iv) and, based on this background information, a strategic planning process was followed culminating in a plan for regional water resources development. Under Phase II, implementation of selected elements of the Plan is to begin.

1.1 DOCUMENT PURPOSE AND ORGANIZATION

This document is the final output of Phase I. The organization of the document and the steps in the planning process, which for the most part parallel each other, are described in Section 1.2.1

1.2 PLANNING APPROACH

1.2.1 Planning process

A strategic planning method was used, in which the planning problem is defined in terms of internal and external environments. The internal environment here is the water system of the Northeast Region, and the external environment consists of regional systems other than water, plus relevant national and international systems. In addition, the strategic planning method stresses action, in particular action focused on key points of intervention.

The steps or elements of the planning process (see Chart 1) are described below, more or less in the order in which work was begun on each of them. In practice, these steps are not carried out sequentially, but in a heuristic overlapping and iterative fashion. In particular, "...'plans require projects' and 'projects require plans'... Inadequate plans are first formulated using

inadequate methods of project appraisal. These in turn should permit improvements in project analysis and appraisal."[1]

The ***policy context*** (Chapter 2), consisting of overall national development policies and FAP goals and objectives, was reviewed and summarized.

An ***interpretive description of the region*** (Chapter 3) was prepared, to provide a profile of the region in terms of what is most important – from a development perspective – to understand, rather than on comprehensiveness. The information base for this is the NERP specialist studies which included review of existing secondary data and documentation, meetings with key informants, plus primary field-based research at NERP field stations and case study sites.

Major ***driving forces*** (Chapter 4) likely to be significant in shaping the region's future development were identified. Some driving forces are internal to the regional water system; some are external to the water system but internal to the region; still others are national or international in scope. This analysis relies on forecast data on regional, national, and international trends, content analysis of key media, interviews with influential and informed persons, review of futurist media, and modelling.

Key development issues (Chapter 5) were defined and articulated. Key inputs to this task are the driving forces, as these are often excellent indicators of issues that will emerge during the planning period. Issues reflect official policies, feedback from officials and the populace in the field, collected secondary and primary data or documentation, and NERP team concerns.

The ***regional analysis*** (Chapter 6) began with the formulation of two ***mission statements***, one for regional development and one for regional water management planning. These provided guidance during the regional analysis, which looked at ***strengths, weaknesses, opportunities, and threats*** in the regional development system and in the regional water system. Strengths and weaknesses were derived from the issues previously identified, covering the areas of perception and profile of issues (including private and public commitment to addressing issues), policy frameworks, institutional form and processes, financial resources, natural resources, human resources, present trends, and other aspects as required. Opportunities and threats, again of the regional development system and the regional water system, were analyzed. These were derived from the driving forces, and include competitors, environmental forces, international trading and business environments, international commodity markets, trends in future development aid flows, the Northeast Region's likely future role in Bangladesh and internationally, and other aspects as required.

The ***future regional development context*** (Chapter 7), that is, the future-without-Plan scenario, was characterized, emphasizing major areas of change and uncertainty.

The ***regional water management strategy*** (Chapter 8) opens with ***objectives*** for overall regional development and the regional water management plan. These were tentatively formulated as a first step in developing the strategy to provide guidance; once the strategy was finalized, they were revised to reflect the likely achievements and impacts of the strategy. The strategy was prepared as a set of interventions cross-referenced by strategic thrusts.

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[1] I. Little, as quoted in *Leading Issues in Economic Development* (Meier, 1976).

Pre-feasibility studies of proposed initiatives were prepared and summarized in Chapter 9. Identification, conceptualization, and acceptance into the final portfolio was carried out on the basis of technical feasibility, public consultation, economic feasibility, acceptability of biophysical, social, and economic impacts, and contribution to regional water management strategic thrusts and objectives.

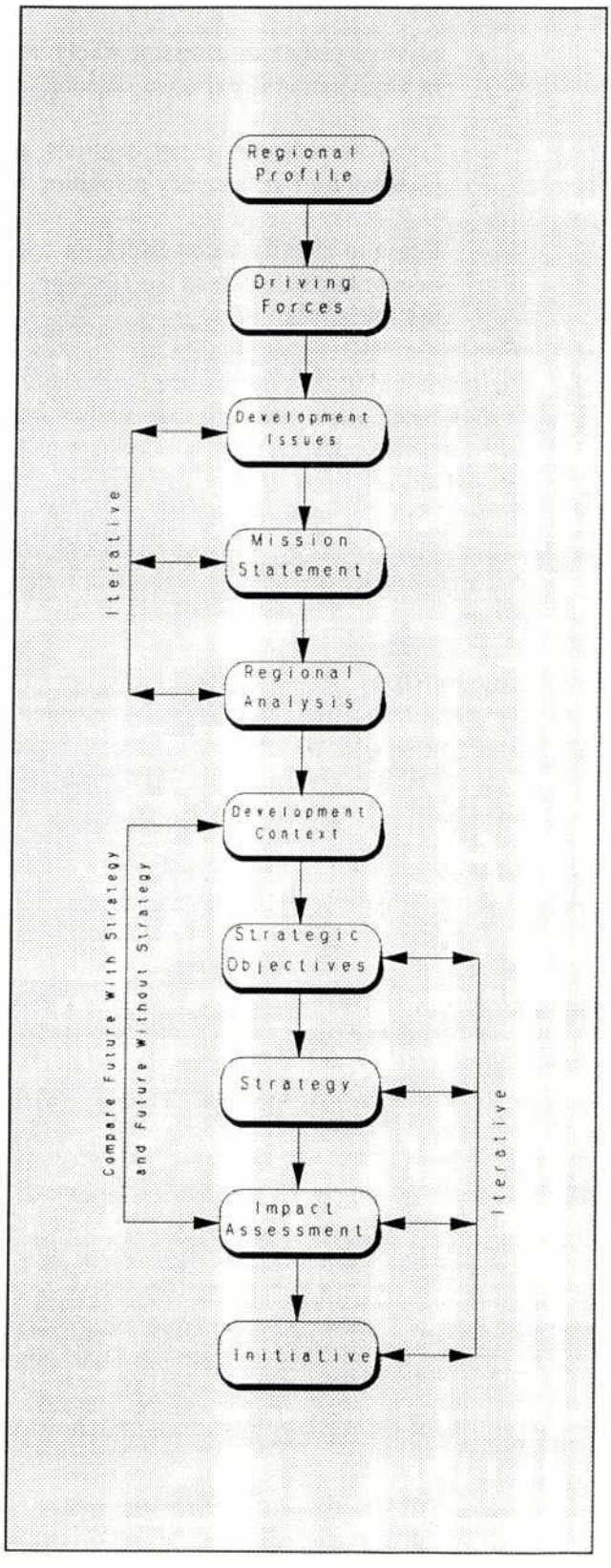
The ***impacts*** of the strategy and the proposed initiatives were characterized in general terms (Chapter 10). At this stage, the emphasis was on scanning for possible adverse impacts (including cumulative and environment-on-project impacts) that require additional attention during future feasibility work; characterizing by order of magnitude the impacts of the proposed FCD structural measures; preliminary sustainability analysis in specific areas; and noting broad options and constraints with respect to environmental management planning (EMP). A more detailed description of impacts and analytical processes is provided in the accompanying Annex *Initial Environmental Examination*.

1.2.2 Public Consultation

The goal of the public consultation process undertaken during the regional planning exercise was to lay the foundation for an on-going dialogue between the public and the technical and policymaking entities involved in water development planning. The elements of the foundation are:

- Obtain local knowledge and ideas relating to the development of the project plan;

Chart 1: Plan Process



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- Provide local people with the opportunity to have a voice in the exploration, planning, implemen-tation, monitoring, and evaluation of plan initiatives;

- Involve people in assessing likely impacts associated with implementing initiatives and in anticipating unexpected outcomes or side-effects;

- Uncover potential social conflicts arising from the intervention early and gauge the likelihood of satisfactory resolution through negotiation; and,

- Begin to identify a framework for appropriate institutions and procedures to enable local people to participate in the planning, construction, operation, and maintenance phases of the initiatives.

The consultation process involved interaction with regional water management stake holders at various levels, and included: case studies, public seminars, FAP interim conferences, informal field meetings between multi-disciplinary teams and residents, and specialist seminars (For more detailed descriptions of these, please refer to the Appendix: Initial Environmental Evaluation Chapter 5). In addition, NERP planning took into consideration the results of the National Conservation Strategy, National Environment Action Plan, and the Forestry Master Plan, each of which had its own public consultation inputs and ran concurrently with the NERP planning process.

1.2.3 Time horizons

In general terms, the future regional development context (Chapter 7) and the water management strategy (Chapter 8) look forward to the year 2015. The programme of proposed initiatives (Chapter 9) focuses mainly on a shorter time frame, generally 2000 but in a few cases later than this.

2. POLICY CONTEXT

2.1 NATIONAL DEVELOPMENT STRATEGY

In December, 1990, several Task Forces were created to review a variety of development issues related to the objectives of:

- Alleviation of poverty
- Greater self-reliance in the development process
- Ensuring a process of sustained growth for the economy
- Ensuring greater integration of women into the development process.

The Task Forces reported in August, 1991. In October, 1991, Bangladesh adopted a parliamentary form of government, and in November 1991, a Commission was created for reviewing and recommending the future structure of local government administration. The new Government drew up a vision for the future development of the country, known as the "New Development Perspective". The Fourth Five Year Plan (1990-95) was re-examined and adjusted accordingly.

2.1.1 National development issues[1]

The major problems faced by Bangladesh have been identified by Government as being:

- slow economic growth, related to
  - low domestic savings and investment
  - balance of payments gap
  - slow increases in public investment
  - curtailed private sector participation due to the policy environment
- poverty
- lack of self-reliance

The development strategy recognises the linkages between the major problems.

2.1.2 National goals and objectives

The central mission of the Government, as contained in *The New Development Perspective*, is:

> " ...[to] align participatory democracy with the country's development needs."

Economic development is put forth as the priority development need, with " ....top priority to accelerated and sustainable economic development of the country."

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[1]The material reflecting government development strategy has been extracted from *Memorandum for the Bangladesh Aid Group 1992-93*, dated April 1992, and from *The Fourth Five Year Plan 1990-95, Revised Draft II*, dated March 1991.

The goals of the New Development Perspective are:

- accelerated economic growth
- poverty alleviation and employment generation through human resource development
- increased self reliance

The proposed focus of the development approach is on human resources development, participatory planning, women's participation, and involvement of the poor.

Development objectives include several targets (Table 1):

Table 1: National Development Targets

Item	Actual (FY91)	Target (FY93)	
GDP growth	3.6	5.0	% per year
Agriculture and Fisheries growth	2.7	3.6	% per year
Industrial growth	5.9	9-10	% per year
Domestic investment	11-12	17-20	% of GDP
Domestic Savings	3-4	10-12	% of GDP
Taxation/GDP	8.3	10	%
Population growth	2.1	1.8	% by 1995

- A 5% growth rate in GDP (up from FY91 of 3.8%). "It has to be at least 5% and even higher in the near future."
- A 3.6% growth rate in agriculture and fisheries (up from FY91 of 2.7%). It " . . .has to grow at about 3.6% per year through not only crop diversification but also agricultural diversification with focus on the development of fisheries, poultry, livestock and community plantation."
- Industrial growth rate of 9 to 10% (up from FY91 of 5.9%) including appropriate growth in agribusiness and linkage of agriculture with industry; " . . .a resultant growth rate of about 9 to 10% per year in the industries sector is possible."
- increase domestic investment to 20% of GDP (up from FY91 of 11 to 12%).
- increase domestic savings to between 10 and 12% of GDP (up from FY91 of 3 to 4%)
- " ...generation of productive employment particularly to meet the basic needs of the lower 50% of the population thereby raising savings, investment and purchasing power of the community."
- " ...supplementary well-targeted relief and welfare oriented programmes for the poor and disadvantaged" (because there is a limit to what can be achieved in generating employment in the lower 50% of the population).
- " ...greater investments in social sectors" (unspecified, but up from the 20% of development expenditures in FY91, which is considered by Government to be totally unacceptable).
- " ...measures to address the environmental issues" (to include environmental impact assessments on all public and private sector investments).

2.1.3 National development strategy

Specific strategies towards achieving the national goals and objectives include (Table 2):

- Establishing appropriate organizational and institutional mechanisms for participatory planning, coupled with effective financial discipline, input and manpower support, and women's participation; with particular attention to generating employment to meet the basic needs of the lower 50% of the population.

- Developing human resources beginning with the removal of illiteracy, provision of basic health facilities, and appropriate population control measures. This is to be achieved, in part, through adequate budget allocations to socioeconomic sectors.

- Strengthening the national economy through development of the rural economy, with priority to development of the agriculture sector.

- Promoting competitive efficiency through appropriate transfer and adaptation of technology, targeted towards supporting employment in the agricultural and manufacturing sectors.

- Promoting joint enterprises, with a focus on agriculture, small trade and small industries.

Table 2: National Strategies

Financial discipline and accountability
Employment generation involving the lower 50% of the population
Participatory planning
Human resource development
Agricultural development and diversification
Appropriate transfer and adaptation of technology
Promotion of joint enterprises
Maximize inter-sectoral linkages
Integration of planning (micro/macro, participatory, NGOs, group-based, sectoral)
Integration of national conservation strategy
Diversion of investment to small/marginal farmers, businesses
Use of Human Development Indicators in planning
Recognition of the vulnerability of the hard-core poor
Combinations of government programmes and private investment

- Promoting private enterprises based on competitive efficiency, with the thrust on export-oriented industries.

- Maximizing intersectoral linkages with a focus on exports (including public investments in infrastructure which link productive sectors and markets).

- Integrating macro-level with micro-level planning, with built-in accountability at all stages of the development process. This would include further development of participatory planning at the local level, further integration of NGO activities into this process, and integration of group-based planning with sectoral planning.

- Integrating a national conservation strategy to prevent the degradation of the environment and improve its capacity to support sustainable development.

In the national development strategy, the poor are recognised as needing help, but, equally important, they are also recognised as offering the best short term solution to the economic problems of Bangladesh.

> " ...small and marginal farmers, and the small industry and business enterprises, have been contributing about 50% [of the] growth of the GDP in Bangladesh with very little support."

> " ...diversion of investable resources in their favour is expected to raise national savings, investment and effective demand of the economy."

A major challenge is to find ways to reach the poor and disadvantaged in the efforts to help them and to have them help the economy.

> " ...about one third of the economy is outside the formal sector and conventional instruments of structural adjustments (through exchange rate, interest rates, tariffs, etc.) do not affect this sector as envisaged in the traditional text books of economics. . . ."

> " ...not be possible for the delivery system to effectively reach the poor in the immediate future unless bold steps are taken for institutional reforms at the local level."

> " ...it is difficult to increase public investments in the social sectors because of a lack of absorptive capacity."

Specific measures for reaching the poor and disadvantaged include:

- planning with built-in human development indicators, in addition to the traditional project evaluation indicators.
- recognizing and understanding the vulnerability of the hard core poor in terms of access to income earning opportunities, as opposed to the assuming benefits will "trickle down".
- combining government programmes with private investment, particularly in the delivery of social services, for example, private education and health facilities.
- recognizing the sometimes higher efficiency of decentralized projects in reaching the hard core poor.
- decentralized participatory planning (a major theme which extends into the mission statement of Government).

Table 3: FAP Objectives

Safeguard lives and livelihoods
Improve agroecological conditions to increase crop production
Enhance development of public facilities, commerce, and industry
Minimize flood damage
Increase the amount of flood-free land to accommodate the increasing population
Meet the needs of fisheries, navigation, communications, and public health

2.2 FLOOD ACTION PLAN: GOALS, OBJECTIVES, AND GUIDELINES

The Flood Action Plan (FAP), covering the period 1990-95, is seen as the first of several stages in the development of a comprehensive and permanent solution to the recurrent flood problems in Bangladesh, and is intended to create an environment for sustained economic growth and social improvement. Specific objectives of the FAP are shown in Table 3.

Government established "Eleven Guiding Principles" to provide a broad framework for the physical works and measures to improve preparedness and management of floods (Table 4).

To further refine and standardize the planning process, *Guidelines for Project Assessment*[1] were prepared " ...to assist members of teams undertaking the Regional Water Resources Planning Studies and feasibility studies for investment projects under the Flood Action Plan." The guidelines specify that a multi-criteria approach for evaluating initiatives is to be used. Three general criteria are recognized: economic impacts, social impacts, and environmental impacts. The guidelines detail procedures for determining quantifiable economic impacts, outline the general nature of the social impacts to be considered, and specify the environmental planning, assessment, and management process that is to be followed. The multi-criteria analysis provides a framework for displaying the various impacts, to serve as an aid in decision making.

In recognition of the fact that the public needs to share responsibility in key decisions if investments made on their behalf are to be sustainable, an additional set of guidelines were prepared. These were entitled "*Guidelines for People's Participation*" and provided the study teams with a means for establishing a consultative process.

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[1] Flood Plan Coordination Organization, Ministry of Irrigation Water Development and Flood Control, Dhaka, May 1992.

Table 4: FAP "Eleven Guiding Principles"

1. Phased implementation of a comprehensive plan aimed at:
   - protecting rural infrastructure
   - controlling floods to meet the needs of agriculture, fisheries, navigation, urban flushing and annual recharge of surface and ground water resources.
2. Effective land and water management in protected and unprotected areas.
3. Measures to strengthen flood preparedness and disaster management.
4. Improvement of flood forecasting and early warning systems.
5. Safe conveyance of the large cross-border flows to the Bay of Bengal through the major rivers, with the help of embankments along both sides if necessary.
6. River training to protect embankments and urban centres.
7. Reduction of flood flows in the major rivers by diversion into major distributaries and flood relief channels.
8. Channel improvements and structures to ensure efficient drainage and to promote appropriate water conservation and regulation.
9. Flood plain zoning where feasible and appropriate.
10. Coordinated planning and construction of rural roads, highways, and railway embankments with provision for unimpeded drainage.
11. Expanded popular support and beneficiary involvement in the planning, design, and operation of flood control and drainage works.

3. INTERPRETIVE DESCRIPTION OF THE REGION

This chapter presents what is considered to be developmentally most important to understand within the region. It provides a review of the natural resource base, the human resource base, the infrastructure base, agriculture and fisheries, industrialization, urbanization and the settlement system, and the institutional framework. These are generally described in terms of the existing situation or practices, trends, and where applicable, sustainability.

3.1 NATURAL RESOURCES

3.1.1 Landforms, soils, and landuse

The Northeast Region encompasses an area of 24,200 km^2 (Figure 1). Principal rivers include the Surma and Kushiyara rivers, which drain the eastern part, the Kangsha River which drains the western part and the Kalni and Baulai rivers which drain the central part. These rivers all discharge into the Meghna River a short distance upstream of Bhairab Bazar. The Old Brahmaputra River and its distributary channel, the Lakhya River form the western boundary of the region. The downstream reach of the Old Brahmaputra River (below the Lakhya offtake) has been virtually abandoned and only carries flow during the flood season. The main source of flow into the Old Brahmaputra/Lakhya River is from spills from the Jamuna/Brahmaputra River just upstream of Bahadurabad.

The region is comprised of six main landforms (Figure 2): the Sylhet depression, lowland floodplains, alluvial fans, terraces, and uplands. Most of these landforms are of fluvial origin, although some have been modified by tectonic subsidence or uplift. Land use relates closely to topography, soil, and flood depth, time, and duration. Approximately 50% of the region lies below 8 m elevation; 25% lies below 5 m (PWD datum).

The ***Sylhet Depression*** (Central Basin) is a low-lying bowl-shaped basin covering about 25% of the region or 6,000 km^2. Virtually all of this land is below 8 m and is flooded to depths of 5 m and more during the monsoon. Saucer-shaped, seasonally-flooded, interfluvial areas called *haor* characterize this unit; the small permanent lakes in the lowest pockets are called *beels*. The main rivers traversing the Depression include the Surma, Kalni, Kushiyara, Baulai, and Dhanu. These rivers are characterized by highly sinuous, meandering sand-bed channels with cohesive banks. Channel shifting occurs erratically, and consequently the Depression is covered by a maze of ancient channel scars, abandoned distributaries, and oxbow lakes. Soils consist of grey or bluish grey clay, black herbaceous peat and yellowish grey silt. Alternating beds of peat and peaty clay are common in *beels* and *haors*. Historically, much of the depression was forested with *hijal* Barringtonia racemosa and *koroch* pongamia pinnata, a key habitat for many species of fish, waterfowl, and other species. During the last two centuries, land use has been altered to meet the needs of an ever-expanding human population. The forest has been consumed and in its place, winter season rice is now being cultivated. Submersible embankments, which confine the rivers within their channels during pre-monsoon storms, have been constructed to protect some of this rice. However, the combination of embankments, deforestation, changes in sediment deposition patterns, and poor biological management have adversely affected fisheries production.

The ***Lowland Floodplains*** were created as a result of deposition and erosion from the Surma, Kushiyara, Meghna, Old Brahmaputra, and Jamuna Rivers. This landform covers about 55% of

the region or 13,260 km^2. Land elevations typically range from 16 m to 9 m on the Surma/Kushiyara floodplain, from 22 m to 9 m on the Old Brahmaputra floodplain, and are less than 7 m on the Meghna floodplain. This landform includes channel deposits such as point bars and fills, overbank deposits such as natural levees and crevasse splays, and fine-grained flood basin and back-channel deposits. The soils of the Surma/Kushiyara floodplain are mainly alluvial silts and clays while the Old Brahmaputra floodplain consists of poorly stratified fine sandy to clayey silt. The main cropping pattern within the Surma/Kushiyara floodplain is at least one, and often two, rice crops annually. In the Old Brahmaputra and Meghna floodplains, the dominant cropping pattern is at least one rice crop in combination with a *rabi* crop. To improve monsoon crop production on this landform, river control works including full flood embankments with drainage regulators have been constructed at various locations. The infrastructure has disrupted easy and timely fish migration which has adversely affected fish abundance.

The ***Piedmont Floodplains*** are found along tributary streams that join the larger mainstem rivers and cover about 4% of the region or 960 km^2. Land elevations range from 24 m to 9 m. Principal piedmont streams include the Khowai, Manu, Sutang, Dhalai, and Juri Rivers which flow northwards from the Tripura Hills in India to join the Kushiyara River. Gradients of the streams are generally steeper than the mainstem rivers and are characterized by meandering sand-bed channels which have often developed natural levees of sand and silt. The dominant cropping pattern is two rice crops annually.

The ***Alluvial Fans*** are found along the foot of the Meghalaya Plateau and cover about 6% of the region or 1490 km^2. The fans result when steep mountain streams exit from their canyons and spread over the flat, unconfined land of the Lowland Floodplains and Sylhet Depression. The decrease in channel gradient and reduction in velocity as the streams leave their canyons causes deposition of sand and gravel sediments which take the form of a fan-shaped or conical delta. The long-term aggradation on the fans appears to be more or less in balance with the lowering of the land due to subsidence. Principal streams which have developed alluvial fans include the Someswari River, Jadukata River, Umium River, Jhalukhali River, and Dauki/Piyain River. Typically, elevations range from 16 m to 12 m in the west and from 11 m to 9 m in the east. The dominant cropping pattern is two rice crops annually.

The ***Terraces*** occur along the western edge of the region and confine portions of the Old Brahmaputra River. This landform covers about 2% of the region or 500 km^2. It has been raised by uplifting and faulting so it is no longer subject to inundation by normal flooding. Elevations range from 10 m to 8 m and the soils are comprised of Madhupur clays. The dominant cropping pattern is two rice crops followed by a *rabi* crop.

Uplands occur as outliers extending into the region from the Tripura hills and cover about 8% of the region or 1970 km^2. These hills are composed of weathered and poorly consolidated sandstone, siltstone, and conglomerate. Where the land has been left in its natural state, it has a cover of upland forests, thickets or grasses. Cultivated areas are predominantly used for tea, although some rubber, pineapple, and other citrus fruits are produced here.

3.1.2 Water

The principal catchments which drain from India into the region are:

- Meghalaya Hills which form the northern boundary of the project and drain 13,466 km^2 of steep mountains along the southern face of the Shillong Plateau;

- The Barak River basin which drains 25,263 km^2 in the states of Assam, Manipur, and Mizoram; and the

- Tripura Hills which drain an area of 6845 km^2 from the state of Tripura.

Figure 3 shows the pattern of mean annual rainfall over the region and its adjacent catchments during the period 1961-1990. The rainfall pattern is clearly dominated by the island of high rainfall centred near Cherrapunji. From this centre, rainfall decreases radially in all directions across the Northeast Region and its tributary areas but at a decreasing rate. The temporal variation in mean annual rainfall was assessed using 51 rainfall stations that operated over the period 1901-1990. Two remarkable features were noted:

- a gradual and slowly accelerating increase in rainfall over the region;

- a more rapid and rapidly accelerating increase in the variability of rainfall over the region.

These conclusions suggest, quite strongly, that the regional climate has been changing over the last 90 years, and changing at an accelerating rate.

Total surface water supplies to the region excluding the Old Brahmaputra River are 173 km^3 (estimated annual mean). Of this, 40% originates as rainfall over the region and 60% as rainfall over the Indian catchments. An estimated 95% of the total surface water supply runs off during the period between May 1 and November 30. During this period tributary streams draining the Meghalaya and Tripura catchments are characterized by very flashy floods which rise to a peak in a day and recede in a day or two. These floods carry high sediment loads are often accompanied by channel instability and erosion and can have a disastrous effect on the region's agriculture and infrastructure. However, even the main lowland rivers such as the Surma-Baulai, Kushiyara-Kalni and Meghna Rivers can display a very rapid rise and fall in water levels during flood times. The main monsoon rise typically peaks between August and October. Almost 60% of the region, principally the Sylhet Depression, Sylhet Lowlands and Meghalaya Lowlands, may be inundated to a depth of 1 m or more during the peak of the monsoon (based on 1:2 year floods: SODAPS). At this time deltaic and lacustrine sedimentation occurs where the main rivers enter the deeply flooded portions of the region. This creates an aquatic environment which supports a vibrant open water fishery, an extensive inland water transport system, and numerous other products and services. These conditions however constrain agricultural development where land is flooded too deeply to produce monsoon season crops, where *boro* crops are damaged by pre-monsoon flash floods, and where sand deposition renders agricultural land unfit for any purpose. Flooding also encroaches on homestead space, damages infrastructure, and at times takes human lives. Figure 4 shows a generalized representation of the flooding extent during the recession of the 1988 flood (based mainly on NOAH satellite imagery).

During the past two decades, water resources infrastructure has been provided to about 30% of the agricultural land or 3950 km^2 to facilitate flood management; some of this area is provided with major surface water irrigation as well. The singular focus of these schemes was on increasing rice production, but the projects also disrupted fisheries migration routes, reduced wetland habitat, and hampered navigation.

An estimated 5% (8.5 km^3) of the total surface water supply is available in the region from 1 December and 30 April. During these months, water is required for irrigation (rice and *rabi* crops), for some domestic uses (washing), for some industrial use (cooling), to provide an overwintering habitat for fish, to sustain biodiversity within the wetlands, and to maintain navigation routes. The volume of water used to provide irrigation during these months is 3 km^3 (an estimated 4500 km^2 are irrigated) and indications are that there is little scope to expand further the surface water irrigation volume. So doing would result in small incremental gains in rice production and have significant adverse impacts on all other uses.

Ground water is used for irrigation, potable water, and industry in the region. Annual available ground water recharge is estimated at 3.16 km^3. At present, about 1.52 km^3 is being utilized annually to irrigate about 2130 km^2 of land. A further 0.29 km^3 is used annually for potable water and industrial supply. Irrigated area could be significantly increased overall, but signs of over-abstraction are present in particular locations.

3.1.3 Water quality

Surface water quality is of serious concern. The most urgent concern is the public health impact of domestic waste contamination of surface water. Water-borne disease is common; so much so that it is the main cause of death of children under five years of age. The reasons for this are clear: the prevalence of sanitary latrines in rural areas is low (15% of households), and sewage collection, wastewater treatment, and properly-managed municipal garbage disposal sites in towns are non-existent.

The surface waters of the region also suffer from industrial pollution. There are many industrial facilities in the region that discharge untreated liquid effluent into surface water: textile industries, oil and gas facilities, fish- and tea- processing plants, a Kraft pulp and paper mill and an ammonia fertilizer plant at Fenchuganj. Discharges from these last two facilities are known to have caused fish contamination and kills in the deep water upper reaches of the Surma and Kushiyara Rivers. In particular, the mill reportedly discharges more than 550 kg per year of mercury, a highly toxic heavy metal. Pollution control is the responsibility of the Department of Environment, and pollution control legislation does exist, but DOE's enforcement capabilities are very weak. For the future, industrial pollution need not increase as fast as the industrial sector itself, but this would require shifting to a preventative approach emphasizing the use of cleaner process technologies.

Ground water quality in the region is suitable for irrigation, but high concentrations of manganese and iron in some locations affect potable water supplies.

3.1.4 Fisheries

Fisheries is a major economic sector of the region generating about Tk 2400 million annually. The general perception is that overall fish catch and fish biodiversity have been declining in the region over the last half century. The reasons for this are:

- Resource access and tenure regimes that provide little incentive for biological management practices oriented to medium- and long-term returns.
- Modification and containment of the aquatic environment through infrastructure designed to increase agricultural production, to facilitate road and water transport, or to control

the lateral movement of rivers but which almost entirely lacks provision for fisheries needs.

- Industrial effluent from Fenchuganj fertilizer factory and Chhatak pulp mill which is discharged into the Surma and Kushiyara Rivers, contaminating and killing fish.

- Extensive deforestation of *hijal*, *koroch*, and other inundation-tolerant wetland trees which are a key support of high fisheries production in this environment.

- Sedimentation of many *beels* has converted them from permanent to seasonal status thereby reducing fish production.

Significant improvements in these trends will be required to avert continued deterioration of fisheries productivity and diversity.

3.1.5 Forestry

Trees are found in four basic settings: upland natural forested areas, lowland natural forested areas (swamp forest), upland tea gardens, and on homestead high land. The latter two types are cultivated. Trees of all types provide nesting and roosting sites for many of the remaining wildlife species of the region, and are key to their continued survival.

The extent and condition of the upland natural forest for the region as a whole is difficult to characterize. The Forestry Master Plan[1] indicates that the Forest Department, through its divisions in Sylhet and Mymensingh, has jurisdiction over 814 km^2 of upland natural forest within the region (includes reserved, acquired, and unclassed forest). Unclassed forest is estimated at 20 km^2 within the region. Reserved and acquired forest under Sylhet Division is estimated at 747 km^2: 207 km^2 in Sylhet, 106 km^2 in Sunamganj, 129 km^2 in Moulvibazar, and 140 km^2 in Habiganj. The remaining 47 km^2 is located in the Mymensingh forest range under Mymensingh Division.

Most of the upland natural forest areas in Sylhet Division are situated on low hills. These hills have a cover of evergreen trees combined with deciduous species. Additionally, these areas produce a variety of valuable species of bamboo and rattan including: *mitinga* Bambusa Tulda, *pharu* B. polymorpha, *muli* Melocanna baccifera, *dollo* Neohouzeaua dullooa, *kali* Oxytenanthera nigrociliata, *jalibet* Calamus tenius, and *gollabet* Daemonorops jenkinsian. The Forest has recently started a program to re-plant *gollabet* and *murta* inside the forest. Within Mymensingh Division, the forest is mainly deciduous with *sal* Shorea robusta as the dominant species. Natural forested areas throughout the region are under increasing pressure, due to expansion and intensification of agriculture and the growing demand for and monetization of forest products.

Remnant stands of lowland forest species (mainly *hijal*, *koroch*, and *barun* crataeva nurvala) are still widely distributed and common in the wetland areas, as they provide several highly valued services. None are on Forest Department land, though Department permission is required – in theory – for felling *any* mature tree. Stands of swamp forest trees protect homestead and embankment highlands from wave erosion – a serious problem, especially around the larger *haors* where larger waves can be generated. They provide shelter and feeding areas for fish, both

[1] Forestry Master Plan 1993, Statistical Data, Table 48, pp53

directly and indirectly when coppiced branches are placed in fishery areas. And they produce a sustainable (if correctly managed) harvest of branches and leaves for use or sale.

Swamp forests, like upland forests, are under pressure from agriculture, gathering and grazing, and monetization. These processes appear to be very rapid and accelerating for lowland forest remnants. Some are still under traditional community tenure, which is proving to be vulnerable to economic and outside pressure. Natural regeneration is quite rapid, however: one area that has been totally protected from human activity for nine years is in excellent condition, with many established trees of half mature height. And afforestation is technically possible and evidently can be economically attractive, judging from the very recent development of private nurseries and plantation programs by fisheries lessees in a few *haors*.

3.1.6 Other biological resources

The region's wetlands support large natural wetland plant communities. These are extensively exploited by local people, particularly the poor, and provide significant amounts of food, fodder, fuel, building material, and medicines to them. Quantification of this production and its socioeconomic distribution is still needed.

The wetlands also support an internationally significant population of migratory waterfowl (384,479 individuals were counted during the January 93 migration peak). Populations of many other terrestrial and semiaquatic wildlife species, including a number of threatened species, are also found. Stocks of both waterfowl and other wildlife are declining generally, with hunting (for sport and for domestic and international trade) and habitat destruction being the main threats. The strong international demand for some wildlife species presents both a threat and an opportunity, depending upon whether yields and populations can be managed sustainably for each valued species.

3.1.7 Natural gas

Known recoverable reserves of natural gas in the region are 242 thousand million m^3 which is 81% of Bangladesh reserves. Location of gas fields is shown in Figure 5. The total value of this gas to the region at current prices is estimated at Tk 675 thousand million. Known recoverable reserves will last an estimated 20 years. Estimated total reserves in place in the region are 559 thousand million m^3 which is 93% of the Bangladesh total.

About 35% of the natural gas produced in the region is utilized in the region; the remaining 65% is piped to other parts of Bangladesh (see Table 5). Two cement factories – at Ampur and at Jalalabad – will come on stream in the region during the next several years though utilization rates have not been forecast. Table 6 presents natural gas consumption by category for all of Bangladesh.

Table 5: Natural Gas Utilization

Name	Annual volume (Mm^3)
Chhatak Cement	36.79
Sylhet Pulp Mill	26.87
Kumargoan Power	31.01
Tea estates	10.34
Domestic and commercial	26.46
Outside of region	244.16
TOTAL	**375.36**

3.1.8 Quarrying and gravel mining

The largest quarry in the region is at Bholaganj on the alluvial fan of the Dhalai River north of Sylhet. The gravel pit was first opened in the early 1900s for construction of Chittagong harbour and construction of Kaptai dam. It is reported to have supplied on the order of 500,000 m^3 of stone material for the dam. The quarry extends over an area of about 2.5 km^2 and consists of gravel from 600 mm diameter down to sand composed of granite, gneiss, chert and greywacke. In the 1970s the quarry was expanded and an 11 km long ropeway transport system was constructed to move materials from Bholaganj to Chhatak. The project was intended to produce 170,000 m^3 per year. However, during the Independence War the facilities were damaged and manpower and barge transportation were used when operations resumed. In 1974 the volume of materials in the quarry were estimated as shown in Table 7.

Table 6: National Natural Gas Utilization (By Sector)

Sector	Consumption (%)
Electricity	39.6
Fertilizer	32.9
Industry	9.5
Commercial	1.9
Household	6.1
Total	**100.0**

Table 7: Quantities at Bholaganj Quarry

Class	Gradation (mm)	%	Volume m^3
Pitching stone	>225	3.6	330,000
Gravel	100-5	49.2	4,470,000
Sand	<5	47.2	4,300,000

Similar large sand and gravel deposits can be found on other large alluvial fans in the region, notably on the Jadukata River and the Dauki/Piyain River fan near Jaflong. Exploitation of these sites is occurring by manpower and small boat transportation. Operations on the Jadukata River were observed in October 1992 where sand and gravel from near the fan apex at the Indian Border was transported by *barki* boats down to Fazilpur. Here it is stockpiled for transport by larger deep draft vessels. At the time of the site visit there were in the order of 5,000 to 6,000 barki boats working on the river. It was estimated that 71,500 m^3/month of sand and 32,500 m^3/month of gravel were being produced at this time. This represents a direct income of Tk 17 million to the local economy. However, operations are seasonal due to restricted navigation during the dry season.

3.2 HUMAN RESOURCES

3.2.1 Basic demography

The Northeast Region has 16% of the total population of Bangladesh or an estimated 17.5 million persons. The region's population increased by an annual compound rate of 2.2% during the last intercensal period (1981 to 1991). Low population densities occur in the Sylhet Basin and the hilly areas; high densities occur in and around urban centres. Population distribution based on 1991 district and municipal census data and on adjusted 1981 *thana* data are shown in Figure 6.

The average household within the region contains 5.33 persons and there are 105 males to 100 females which ratio is slightly lower than the national average. The average household size increased during the period 1960 to 1981 and then declined slightly between 1981 and 1991. It is still higher than in 1960. The proportion of population younger than 14 years of age is high, more than 46% in the 1981 census, which characterizes a very high dependency ratio. The high proportion of people now of reproductive and working age has profound implications for the fertility and employment situation. The proportion of younger population is somewhat lower in the 1991 census. In the lower age groups, females outnumber males, while for higher age groups the reverse is true.

Table 8: Gender Distribution of Students

Level	Male Students (%)	Female Students (%)
Primary	55	45
Secondary	64	36
College	74	26

The Crude Birth Rate per 1000 population ranges between 35 and 50 in most parts of the region; this is very high. The Total Fertility Rate at more than 4 births per woman throughout her reproductive phase is also very high. The Crude Birth Rate and the Total Fertility Rate have however shown a declining trend since 1975. Average life expectancy at birth is 56 years, a marginal increase - of about one year - since 1981. Difference in life expectancy by sex is negligible.

3.2.2 Educational levels

The level of literacy is very low. According to the 1991 census, in most districts of the region the literacy rate is less than 20% for all age cohorts. The school attendance rate (1981 census) was less than 20% in most parts of the region for those aged 5 to 24 years. School enrolment of girls is low at all levels (see Table 8) and decreases at higher educational levels. Girls constitute 45% of the total number of students at the primary level, 36% at the secondary level, and 26% at the higher secondary (college) level. The enrolment rate of females has increased significantly during last ten years, particularly at the secondary and the college level.

The government aims to achieve a gross enrolment rate of 85% by 1995 and 95% by the year 2000. Many of the schools are privately funded, and this trend is continuing. Principal deterrents to schooling appear to be economic (the need to assist the family in economic activities) and distance to school.

3.2.3 Health levels

The overall health situation is poor. Relevant indicators include the region's Crude Death Rate which is more than 11 per 1000 population, the Infant Mortality Rate below one year of age which ranges from 106 to 138 per 1000 live births, and the Child Death Rate which is as high as 15 per 1000 children aged one to four in some parts of the region. The Child Death Rate is higher for females. The situation improved marginally during the eighties, but in some areas it is still worse than the national average ten years ago.

To reduce the Infant Mortality Rate and the Child Death Rate, an Extended Program of Immunization is being implemented nationally in collaboration with UNICEF. Under this programme, children are vaccinated against six diseases; measles, tetanus, whooping cough,

polio, diphtheria, and tuberculosis. This has helped in bringing down the mortality rate among children in many areas. Still, more than 75% of children under two years of age have yet to be immunized in about half of the region. The government has set a goal under the Extended Program of Immunization to cover as much as 85% of children by 1995.

Table 9: Access to Health Services

Indicators[1/]	Number
Population per doctor	21,596
Population per nurse	27,470
Population per hospital Bed	5,256

1/ Includes Government Hospitals and *Thana* Health Complexes.

Nationally, government expenditures for social services account for less than 20% of the development budget, of which one-quarter is for health and family planning. Public health infrastructure is mainly oriented around government hospitals at the district and *thana* levels. These facilities were decentralized in the 1980s. At present, each *thana* has one health complex with several graduate physicians, some laboratory facilities, and a few beds for in-patients. In addition, family welfare centres are gradually being set up in all the unions. Currently, there are 5256 persons per government hospital bed in the region, which is almost the same as ten years ago. Population per health worker is shown in Table 9.

Private health services and facilities in the region are at least as important as those provided by government, and most are located in areas having large numbers of people who work abroad. This highlights the significance of foreign remittances to the region, and the plausibility of private sector participation in providing social services as envisaged in the national development strategy.

3.2.4 Cultural traditions and values

Rice, pulses, and fish are the main food items. The diet is dominated by rice which is generally consumed at every meal. With increasing poverty and landlessness, wheat has replaced rice at one or more meals in many households. Cereals account for more than 80% of energy intake, more than 70% of protein intake and more than 60% of fat intake.

People grow their own food in rural areas where subsistence farming is still the dominant mode of production. Agricultural activities are undertaken mostly using family labour. The household is the basic economic unit where all members participate according to roles defined by societal norms and traditions. Male household members usually work in the field, preparing the land, tilling, sowing, planting, weeding, and harvesting. Female members work at home performing mainly post-harvest activities which include threshing, drying, husking, winnowing, and storing. Women also grow fruits and vegetables in and around the homestead and look after poultry and livestock.

Purdah restricts women's activities outside the home. The dominant view is that women do not need higher education, and should devote their life to cooking, rearing children, and other home-building activities. With increasing economic hardship, women are engaging themselves in extra-household economic activities, particularly those women from the lower income strata of the population. Women's gainful employment is also being promoted by the NGO community.

Male domination is socially and legally protected and promoted through laws of inheritance, marriage and divorce which favour men. Polygamy is still in practice. These values are being

challenged by educated youth and new values are slowly emerging due to increasing urbanization and mass media penetration.

3.3 INFRASTRUCTURE

This section describes the infrastructure base, an understanding of which is essential to planning further investments in water management. This description covers existing infrastructure and planned infrastructure – where the information is available. The infrastructure described here includes roads, rural electrification, communications, water transportation, potable water, sanitation, and water management works.

3.3.1 Rural electrification

The Rural Electrification Board functions through consumer owned autonomous co-operatives (PBSs). At present, programmes are being implemented to extend the distribution grid and to construct and upgrade substations in various districts in the region, including Sylhet, Moulvibazar, Habiganj, Netrokona, Sherpur, and part of Mymensingh. The length of existing lines in the distribution system by PBS is provided in Table 10. Plans to extend the rural power grid further are not yet final. The existing grid is shown in Figure 5.

The Power Development Board (PDB) maintains a grid within those areas not covered by the REB but it is much less extensive, serving mainly larger communities.

The primary end use for this power at present is irrigation. Consumption for this use peaks in March at about 85% of total consumption.

Table 10: REB Power Distribution Network

PBS [1]	Existing Line (km)
Habiganj	1244
Moulvibazar	1129
Narsingdi I	998
Narsingdi II	713
Sylhet	621
Kishorganj	848
Sherpur	250

[1] The Power Development Board (PDB) services the remaining areas within the Region but with much less intense coverage.

Table 11: Regional Telephone Status

Exchange	Total	Connect	Demand	Planned
Phulpur	150	79	35	
Netrokona	400	385	130	1000
Kishorganj	400	400	288	1000
Bajitpur	200	134	43	
Sherpur	400	18	98	1000
Shastaiganj*	10	10	68	
Rajnagar*	10	10	53	
Barlekha*	16	16	6	
Tajpur*	20	20	123	
Habiganj	400	395	277	1000
Chhatak	200	184	35	
Srimangal	400	380	97	
Sylhet	5600	5337	6037	
Sunamganj	400	371	120	1000
Moulvibazar	700	685	1357	3000
Total	**9306**	**8424**	**8767**	**8000**

* These exchanges include extensions on the existing lines.

3.3.2 Communications

Telephones are the region's primary existing communications infrastructure. At present there are 9306 lines, of which 8424 are connected to subscribers and in use. There is an existing, unfulfilled demand for an additional 8767 lines; 8000 new lines are planned and have been approved. The status of these lines, by exchange, are presented in Table 11.

3.3.3 Potable water

Access to safe drinking water has improved considerably in recent years. Efforts are being made to ensure rural water supply through sinking of three types of tube wells: shallow, deep, and deep-set Tara pumps. In 1985, there was one public hand tube well for about 150 persons, now there is one operational tube well for about 134 persons. In 1981, only about half of the households in the region had access to potable water. Presently, more than 80% of the population has access to potable water for drinking according to official statistics. Tubewells however tend to be associated with wealthier and more influential households. Parts of the region essentially do not have access to tube wells, and potable surface water is scarce, difficult to obtain, and of poor quality. Universal access to potable water has been set as a target to be achieved within the Fourth Five Year Plan period (1990-95).

3.3.4 Sanitation

Primary sanitation facilities consist of sanitary latrines. Waterseal latrines, using low-cost concrete ring and slab, are being promoted by the Directorate of Public Health Engineering (DPHE). Presently, only about 15% of the households in the region possess a fixed latrine. In some parts of the region, this proportion is less than 4%. However, considerable improvement has been observed during the last decade. The production index of DPHEs sanitary latrines has quadrupled and the number of production and sales centres has doubled since 1981. In addition, many NGOs and private firms are now in the business.

The Government has targeted that 35% of all households be provided with sanitation facilities by 1995. Planned actions include the promotion of do-it-yourself (home-made) pit latrines and low-cost waterseal (concrete ring and slab) latrines on the one hand, and advocacy and social mobilization activities on the other.

3.3.5 Water management

During the past two decades, there has been considerable progress in providing infrastructure for improved management of water resources in the region. A summary of the current development status is provided in Table 12.

A total of 66 major surface water resource projects have been constructed or are nearing completion. These include full flood control projects, partial flood control projects, drainage improvement projects, and major surface water irrigation projects. All are administered by BWDB; their potential net benefitted area is estimated to be 395,000 ha. Nearly all were constructed during the past two decades.

Table 12: Water Resource Development Status

Project Type	Project Number	Net Benefitted Area (ha)
Flood Control & Drainage		
Full Flood Control	27	96,000
Partial Flood Control	33	172,000
Drainage Improvement	5	18,100
Surface Water Irrigation		
Large Scale Irrigation		6,000
Water Retention Structures		4,200
Low-Lift Pumps		154,000
Traditional		286,000
Ground Water Irrigation		
Manually Operated Shallow Tube Wells		5,300
Shallow Tube Wells		126,000
Deep-Set Shallow Tube Wells		700
Deep Tube Wells		80,000

A review of these projects revealed that most (80%) have some positive impact – though not always for agriculture, the intended beneficiary. It was also observed that negative impacts were fairly common as a result of the water management infrastructure. These included effects of river confinement, loss of land to infrastructure, and destruction of fisheries habitat. The most notable conclusion of the review was that where significant input from the local community was provided (for example, where projects grew out of local efforts) overall project performance was significantly better.

3.3.6 Water transportation

Water transport is essential to the region's transport needs. Boats are more than twice as fuel-efficient as trucks and, at prevailing freight rates, mechanized boats yield high rates of return on capital. Thirteen *thana* centres depend solely on waterway communication and many of the rural market places in the region have grown up along waterways.

The Inland Water Transport Authority (IWTA) under the Ministry of Shipping, Ports and Inland Water Transport administers navigation and water transport. There are about 1400 km of classified navigation routes in the region. These are used by larger commercial boats – carrying passengers or freight – operating in the formal sector. The inland waterways of the region are shown in Figure 7.

Changes are taking place in the region's river network. Sedimentation has reportedly reduced the navigability of the Surma River. The lower Kushiyara River is infilling with sediment and the Kangsha from Gaglajor to Mohanganj can no longer be used for navigation by the larger commercial boats.

Country boats make an important contribution to the rural (informal sector) economy of the region. The Country Boat Pilot Project estimates[1] that as much as 60% of all employment in transport is in country boats. This employment is predominantly rural and under relatively equitable conditions. In much of the deeply flooded area, inland waterways are the only form of transport for goods and passengers and with the mechanization of country boats people now travel more than before. It enables them to find employment in urban centres while still living in nearby villages. Boats thus enhance rural mobility and contribute to alleviating the problem of rural unemployment. They also provide direct and efficient market access for rural people and their goods.

There are operational problems. Infrastructure obstructs navigation routes. For example, submersible embankments are not always sufficiently submerged to allow boats to pass; it was observed within Shanir Haor that 14 of 17 embankment cuts (in 1992) were made to facilitate navigation. Aquatic grasses create navigation problems and the absence of landing facilities hamper efficient country boat operation.

3.3.7 Roads and railways

The Roads and Highways Department (RHD) is responsible for national highways (374 km in the region) that connect regions; regional highways (165 km) that connect major towns to each other and to national highways within a region; and most Feeder Roads Type A (1395 km) that connect

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[1] *Experimental Project for Improving the Efficiency and Profitability of Country Boat Operation.* Draft Report of Country Boat Pilot Project. BIWTA, Dhaka 1992.

thana centres to the highways. The Local Government Engineering Department (LGED) is responsible for Feeder Roads Type B (870 km) that connect rural growth centres to *thana* centres or higher-order roads; and Rural Roads Types 1, 2, and 3 (length unknown). The rail and road network (national, regional, and feeder roads) is shown in Figure 8.

In 1990, the proportions of total freight (tonne-km) and passengers (person-km) moving by road were 50% and 60% respectively. By 2000, these are expected to increase to 60% and 70% respectively. Current estimated annual traffic growth rates in the region are 6.3 to 6.8% for trucks and buses, and 7.7 to 10.9% for micro-buses, cars, baby-taxis, and motorcycles.

No new roads are planned for the region, but several ongoing and planned projects address road improvement and maintenance. The Dhaka-Sylhet-Jaintiapur national highway is to be improved under the Second Road Improvement Project (estimated cost US$90 million, ADB/Japan financing under discussion). Six contracts are ongoing under the Feeder Roads Improvement Project (US$35 million for the six contracts, ADB funded). In addition, a GOB project addresses maintenance and improvement of Feeder Roads, Type A (US$4.45 million per year from 1993). Several projects under LGED include study or implementation of road improvements in the region; the value devoted to Northeast Region roads is substantial but difficult to estimate (well over US$4 million per year).

Investments for the region proposed by the Road Master Plan include US$2.6 million per year for 1991-1996 and US$7.8 million per year for 1996 to 2000, focused mainly on the Dhaka-Sylhet highway, the routes radiating out of Sylhet, and the Bhairab Bazar-Kishorganj-Mymensingh-Netrokona routes. Investments proposed by RHD include straightening of the Dhaka-Sylhet highway, a new route from Joykalash-Mohanganj to link Sylhet to Netrokona, and a bridge at Bhairab Bazar. Existing roads in the Sylhet basin have very high maintenance requirements due to wave erosion. However, current and proposed projects are oriented mainly to constructing new works in the higher corridors on the periphery of the Region rather than addressing maintenance requirements in the Sylhet basin.

Railway lines servicing the region run from Dhaka to Sylhet, and Dhaka-Mymensingh-Bahadurabad. Their proportion of freight carriage is small (nationally, about 2%).

3.4 AGRICULTURE AND FISHERIES

The economy of the region is based almost entirely on agriculture and fisheries. Both have relatively low productivity, accounting for 70% of the regional labour force but producing less than 40% of the gross regional product. As a result, gross product per person is about 10% below the national average. Both also have relatively low economic growth rates (the national agricultural and fisheries growth target is 3.6% per year, while the overall national target is 5% per year), with the result that the region's overall growth probably cannot keep pace with national growth unless the there is a shift from agriculture and fisheries to activities with more growth potential.

3.4.1 Crops

The contribution of crops to the gross regional product is estimated to be Tk 31,346 million. Total agricultural production in the region is increasing gradually, but not as fast as population. Declining production per person is impacting most seriously on poor people. There is some

inter- and intra-regional movement of foods, but it appears that the poor are becoming worse off nutritionally because of their inability to procure food. Nationally, daily intake represented 91% of calorie requirements in 1965, and only 83% in 1988. Girls and women suffer the most, and the situation is worst during the pre-monsoon months when prices are higher. This situation is aggravated by the inability of the poor to take precautionary measures against food shortages.

3.4.2 Livestock

Livestock contribute an estimated Tk 3840 million to the gross regional product. In terms of working animals, the most important livestock are cattle, which provide the necessary draught power for ploughing, threshing, road and farm transport, and crushing of sugar cane and oilseed. There are an estimated 3.8 million head of cattle within the region, 0.1 million buffalo, 1.0 million goats, 0.1 million sheep, and 11 million poultry. While there have been small increases in all livestock populations over the past 25 years, on a per person basis, only poultry has increased.

3.4.3 Fisheries

The contribution of fisheries to gross regional product is estimated at Tk 2400 million. While there appears to be potential for expansion in fisheries and in value-added related to this sector, fish catch as well as fish biodiversity have been declining. Since fish provide a significant source of protein and the largest source of animal protein, the consequence is reduced per person protein availability.

3.4.4 Land distribution and carrying capacity

In 1977, the number of farm households in the region was 1.1 million and average farm size was 1.5 ha. By 1983-84, the last available year of record, the number of farm households had increased to 1.7 million and average farm size decreased to 0.9 ha. This trend would suggest that the number of farm households is now about 2.6 million and average farm size is about 0.6 ha. The per person availability of cultivable land is estimated to be slightly less than 0.1 ha. While agriculture production has been increasing over this time frame, it has not kept pace with population increases.

However, the production potential of land changes over time. Large increases in rice production have resulted in recent years from technological change, coupled with liberalization of agricultural inputs, and favourable flood conditions. Opportunities for further production increases through technology improvements are unknown. In many developing countries, average annual production increases exceed those currently achieved in Bangladesh (about 3% per year).

3.5 INDUSTRIALIZATION, URBANIZATION, AND INTERNAL MIGRATION

3.5.1 Industries

Industry in the region is predominantly small-scale, notably handloom textiles and rice milling. There are, however, large-scale industries in the Sylhet region in tea, sand and quarrying, oil and gas, and textiles. There are two cement plants and a bleach Kraft pulp mill at Chhatak; an ammonia fertilizer plant at Fenchuganj; private sector fish processing and export plants at Ajmiriganj, Kaliachar, and Sunamganj, as well as a BFDC (public sector) facility at Dabor; and a garment industry in Dhaka region; women dominate employment in the garment industry. The large-scale industries are in various states of economic health; it appears likely that the fertilizer plant at Fenchuganj will be replaced by a new plant at Chittagong. Two new cement factories

– at Ampur and Jalalabad – are scheduled to come on stream during the next several years. A ball pen manufacturing plant is presently under construction near Moulvibazar. Construction and industry account for about 6% each of gross regional product.

3.5.2 Urban areas

Urban areas as defined by the Bangladesh Bureau of Statistics include municipalities, *thana* headquarters and other urban centres around industrial complexes. Urban centres develop around sites of administrative and economic importance, and where public utilities and services (roads, electricity, communications, and so on) are available to support non-agricultural economic and other activities.

Table 13: Populations of Largest Municipalities

Municipality	Population 1991
Sylhet	114,284
Narsingdi	100,120
Bhairab Bazar	75,747
Kishorganj	64,676
Sherpur	63,030
Netrokona	46,203
Habiganj	42,898
Moulvibazar	35,371

The rate of urbanization accelerated during the 1980s, partly as a result of the upgrading of *thanas*. The *thana* (for a time called *upazila*) was made an important establishment in the local government system, and *thana* upgrading included transferring to them government personnel from most of the line ministries. Although the system was changed in 1992, *thana* physical infrastructure was substantially developed by this time.

The employed urban population is mainly composed of government employees, professionals, industrial workers, workers in the service sector, and traders. Urban-rural economic and cultural links are still very strong. A considerable proportion of urban dwellers have homestead and cultivable land in rural areas. It is common for men to stay in the towns for employment while wives and children stay in the village, which has contributed to the higher male/female ratio in towns.

While settlements are spread quite uniformly throughout the region, the most densely populated areas are municipalities; all are legally constituted urban centres. Presently, the region has 14 municipalities out of 95 in the whole country. Among these are eight district headquarters and six *thana* headquarters where 6% of the total municipal population of the country reside. They account for 4% of the region's population. Among the municipal towns in the region, two have populations of more than 100,000, whereas five have populations below 25,000. The eight largest municipalities with their populations are presented in Table 13.

3.5.3 Internal migration

Migration reflects the state of employment and social mobility of an area. In the past, some districts of the region, particularly Sylhet and Sunamganj, were gaining population by net in-migration. However, since 1974, most of the region, except Dhaka region, has lost population to net out-migration.

Nationally, urban-to-urban and rural-to-urban migration are about the same in quantitative terms. However, the migration rate from urban-to-urban is higher. While the urban-to-urban migration rate is highest for the male population, the opposite is true for females, for whom rural-to-rural and rural-to-urban migration are higher. Migration rates have been increasing.

3.6 KEY INSTITUTIONS

3.6.1 Water resources development

Large-scale infrastructure
Ministry of Irrigation, Water Development and Flood Control (MIWDFC) has overall responsibility for water resource development in Bangladesh. This responsibility is exercised through the Bangladesh Water Development Board, the Water Resources Planning Organization, and the Flood Plan Coordination Organization.

Bangladesh Water Development Board (BWDB), a semi-autonomous agency of the GOB since 1972, is responsible for planning and design, construction, and operation and maintenance of flood control, drainage, and major irrigation works. Since the creation in 1959 of BWDB's predecessor agency, the water arm of the East Pakistan Water and Power Development Authority, an impressive number of water control structures (about 5000) and many kilometres of embankment (about 6000) have been constructed. But, the organization has numerous difficulties:

- programming that exceeds local currency availability;
- lengthy and cumbersome government procurement, tendering, consultant recruitment, fund release, and land acquisition procedures;
- division of public sector implementation between different ministries and agencies of ministries, and between central and *thana* administrations;
- difficulties with involving farmers and farmer groups in implementation and in subsequent operation and maintenance; and
- an inability to take into account farmer's needs, existing practices, and local circumstances in project planning and design.

The consequences of the above are: (1) persistent and worsening start-up delays; (2) a doubling of the time needed to implement most projects and programs thereby reducing economic returns and viability; (3) substandard construction resulting in early deterioration and shortened economic life; and (4) a widening implementation gap between programmed project implementation targets and achievements.

Water Resources Planning Organization (WARPO) was created in 1983 as the Master Planning Organization (MPO). Its mandate was to develop and establish: (1) a comprehensive dynamic assessment of Bangladesh's water resources; (2) a framework for decision making; and (3) a continuous process national water resources planning capability. Accordingly, a National Water Plan was presented in 1986. This was succeeded by a follow-up Phase II National Water Plan Project.

Flood Plan Coordination Organization (FPCO) was created in early 1990 as an arm of the Ministry of Irrigation, Water Development, and Flood Control to provide support directly to the Ministry in its planning, project preparation, monitoring, coordination, and processing of Flood Action Plan components. The organization consists of personnel seconded from other government organizations (BWDB, DOF, DOE) and with additional support from a Panel of Experts (local and expatriate specialists from the private sector with various technical backgrounds).

The Flood Plan Coordination Organization coordinated and managed the completion of the numerous studies associated with the Flood Action Plan and is continuing with follow-on activities. At the outset, the Flood Action Plan was fraught with controversy, particularly with regard to issues such as public participation and environment. In its response to these and other concerns, the organization demonstrated considerable adaptability in the leadership it provided. The organization was, however, constrained by:

- inadequate decision making authority,
- bureaucratic formalities which results in delays, and
- the tendency of the consultants working on the various FAP components to comply with their sponsor's (donors) requirements at the expense of specifications set by FPCO.

The future role of FPCO is uncertain. There is some indication that the organization may be merged with WARPO and become part of an on-going national water resources planning agency.

Small-scale infrastructure

Local Government Engineering Department (LGED) was created under the Ministry of Local Government, Rural Development, and Cooperatives in 1984 to provide technical support to the district and *thana* administrations in the design, construction, operation, and maintenance of local[1] civil infrastructure, including water control structures and embankments. A 1985 GOB decision gave LGED responsibility for operation and maintenance of small BWDB schemes once completed. On a pilot basis, BWDB identified a group of projects for which LGED was to assume responsibility. Several problems emerged: LGED was provided with insufficient funding to carry out its mandate; The projects turned over to LGED were not fully operational at the outset; and LGED staff were generally inexperienced and lacked the technical background to deal with larger surface water facilities effectively. LGED is receiving technical and financial support from various donors to strengthen its capabilities.

Other agencies with water resources functions

Other government agencies also carry out functions directly linked to water resources development:

Ministry of Food. Food-For-Work (FFW), an initiative of the UN World Food Program with the Ministry of Food, allocates food-grains to BWDB earthwork construction. Grain is disbursed in daily grain payments to the rural poor in exchange for their labour.

[1]Located within a single *thana*, except in special cases.

Ministry of Land Administration and Land Revenue. MOL acquires land needed in the construction of civil works. The field staff of the Ministry are insufficient in number which leads to delays in processing land acquisition applications.

Bangladesh Space Research and Remote Sensing Organization. SPARRSO uses remote sensing data, performs resource surveys, monitors natural hazards (such as flood and cyclone), and creates various products, such as specialized thematic maps; can acquire some new data.

3.6.2 Agriculture and fisheries

Agricultural extension

Department of Agricultural Extension (DAE), in the Ministry of Agriculture, emerged in 1982 as the agency responsible for disseminating crop production information to farmers. The northeast extension division is administered by an Additional Director, posted at Comilla, who supervises four Deputy Directors, one at each District Headquarters. These in turn supervise the work of *Thana* Agricultural Officers, one at each *thana* Headquarters. The *Thana* Agricultural Officer, with technical support from Subject Matter Specialists, supervises the activities of extension agents called Block Supervisors, who in turn are responsible for providing farmers with the latest policy and program information, research findings, and farm management practices.

The activities of BSs are organized on the basis of the Training and Visit system (T&V). Under this system, a union is geographically partitioned into several "blocks" of about 1,000 farm families each, and each block is further divided into eight sub-blocks. Within each sub-block, the BS identifies and works closely with ten contact farmers or "change agents". The ratio of BS to farm families at present is 1:900. BSs also operate demonstration plots.

The extension service has several identified weaknesses. Despite the emphasis on T&V, the T&V system is not operating as effectively as it could (UNDP, 1989), and about 80% of the improved practices adopted by farmers were not obtained through T&V extension activities, but from farmer observation of demonstration plots (Karim, 1989). The extension service lacks proper links to other agencies involved in the sector. One important example of this is the absence of extension capability to support irrigated agriculture, even though irrigation development contributes substantially to sector growth. And poor communications, especially in the northeast, hinders delivery of extension services to remote areas.

Women landowners, farmers, sharecroppers, horticulturalists, and labourers are served by a small female extension service, but the system has not been very successful. The women extension agents are posted at district towns without transportation or adequate travel allowances, and thus rarely visit even adjacent villages. Their links to research are ineffective and their agricultural training inadequate, and their responsibilities include non-agricultural topics such as health and sanitation. Recent extension policies are de-emphasizing single-sex extension cadres, and have focused instead on (1) integrating men and women agents into a single cadre appropriately, and (2) finding ways to ensure that women agriculturalists get the information they need given that men dominate the extension cadre and will continue to do so for the foreseeable future.

Agricultural research

Research is coordinated by the Bangladesh Agricultural Research Council and carried out through five major research agencies, each specializing in a particular crop or crops. Four of these have

research stations in the region; the fifth, the Bangladesh Sugar Cane Research and Training Institute, does not and is not described here.

Bangladesh Agricultural Research Council (BARC) is responsible for coordinating the national agricultural research system. The long-term goal of the national agricultural research system is:

> ". . . to provide sufficient technologies to sustain increased farm productivity for all agricultural and environmental situations (in support of the national goals and strategies)."

Bangladesh Rice Research Institute (BRRI) conducts basic and applied research on rice production, and provides comprehensive training on rice cultivation to officials of various agencies. In the northeast, BRRI has a substation at Habiganj for research on deepwater rice and development of cropping systems for deeply flooded areas. Relevant on-going projects include:

- outreach program for development of site-specific rice technology packages,
- strengthening program for BRRI's adaptive research training division,
- accelerated development of BRRI regional stations' physical facilities, and
- decentralization of rice breeding.

Bangladesh Agriculture Research Institute (BARI) conducts research on non-rice food crops except sugar and tea. Presently, BARI operates a substation at Moulvibazar for citrus fruit research. One relevant on-going project is their 'Establishment of a Centre for On-farm Research and Development' program.

Bangladesh Jute Research Institute (BJRI) is responsible for conducting research on jute. BJRI has a substation in Comilla.

Bangladesh Tea Research Institute (BTRI). Tea is a major crop of the northeast region and a principal export crop. BTRI is located in Srimangal.

Agricultural inputs

Bangladesh Agricultural Development Corporation (BADC), positioned within MOA, was established in 1961 to promote the use of modern agricultural inputs among farmers. Its role has evolved and today its main activities are:

- marketing and installing minor irrigation equipment, mainly deep tube wells;
- supplying seed; and
- distributing fertilizer through Primary Distribution Points.

Irrigation equipment is distributed through an Executive Engineer at the District level. Unit officers posted at *thana* headquarters report to the Executive Engineer and are supported by pump maintenance mechanics. Appropriately stimulative policies in the past two years (an import ban, duties on pumps and engines, and a regulation "standardizing" engines were all eliminated) have

allowed private sector sales of equipment, which in turn has allowed net irrigated area to expand rapidly, and has reduced on-farm equipment prices.

BADC's Field Wing produces and distributes certified seed for most crops, but this accounts for less than 10% of all seeds used. Most seed (about 90%) is multiplied and kept by farmers themselves; less than 1% is handled by the modern private sector (private traders and importers). Increased private sector participation in the development and promotion of new varieties is inhibited by GOB policies: for example, GOB regulations set seed prices and specify that only National Seed Board approved seed varieties may be imported. Other GOB seed programs include testing local and imported varieties, and producing breeder seed.

The fertilizer subsector is changing rapidly. Retail markets and prices are being progressively deregulated, reflecting the GOB's concern for supply availability and prices. In 1982, BADC's distribution monopoly was reduced from one outlet per *thana* to 75 wholesale outlets for the whole country, called Primary Distribution Points, and prices below Primary Distribution Point prices were deregulated, permitting an expanded role for private wholesalers and retailers. Then, in 1988, BADC offered discounts for large volume lifting, and nominal retail prices fell for the first time. In 1989, wholesalers and dealers were allowed to procure directly from the five area factories and prices fell further.

BADC subsidizes fertilizer from its revenue budget. Triple super phosphate (TSP) subsidies account for about 75% of the total. A sizeable muriate of potash (MP) subsidy also exists, along with an indirect subsidy to BADC for distribution and storage costs.

Cooperative formation, training, and credit

Bangladesh Rural Development Board (BRDB) is responsible for organizing farmers into cooperatives and providing them with credit. Farmers are organized into cooperative societies (KSS) with the *Thana* Central Cooperative Associations as the apex organization. The TCCA then provides short-term credit for crop production and medium-term credit for the procurement of draft power, implements and irrigation equipment.

Only about 15% of all agricultural credit is currently provided by institutional sources (TCCA and conventional financial institutions such as Bangladesh Krishi Bank, Bangladesh Samabaya Bank, commercial banks). About 85% of agricultural credit is still supplied by traditional moneylenders who provide quick, uncomplicated access to funds, but at usurious rates that stifle investment expansion. Institutional credit disbursements grew rapidly in the late 1970s and early 1980s but sound banking practices were not adhered to and credit recovery was abysmal (as low as 26% in FY86). The recovery rate has increased to about 40% in response to stringent GOB measures, but the expansion of institutional credit availability has stopped. Grameen Bank, an extremely successful NGO, has extended credit to millions of rural poor, especially rural women, demonstrating in the process that institutional credit can play an important role in poverty alleviation.

Fisheries

Department of Fisheries (DOF) is the line agency of the Government responsible for fisheries management, development, enforcement, statistics, quality control, extension and training. The staff consists of some 4,300 persons, 28% of whom are professionals.

Hotta[1] notes that the DOF suffers from shortcomings in planning, project implementation, design of extension activities and inter-agency coordination. With regard to the latter, the absence of a clear mandate for the DOF results in "confusing and/or overlapping divisions of responsibility" between DOF and MIWDFC, MLGRDC, FRI, BFDC and *thana* administrations. There is also a proliferation of staff. Key persons are usually delegated to projects, thus perpetuating weaknesses of DOF's main structure. Insufficient staff are trained in planning, economics, social sciences, management finance, and accounting. The DOF staff and resources are overextended. All funds available for development projects cannot be spent. The absorption capacity of the DOF for more external assistance is nil, and committed assistance cannot be fully utilized.

The *Fisheries Research Institute* (FRI) was established in 1984. It operates four research stations:

- Aquaculture station in Mymensingh;
- Riverine fisheries station in Chandpur;
- Marine fisheries station in Cox's Bazar;
- Brackish-water fisheries station in Khulna.

There are 59 scientific staff and 105 supporting staff. The FRI is involved in some 26 research projects. There is a need for involvement of DOF in programme prioritization of FRI research activities.

The *Bangladesh Fisheries Development Corporation* (BFDC) established in 1964, is concerned with developing marine fisheries, Kaptai Lake, fish processing and marketing. A number of fish landing centres have been built around the country and are intended to operate as commercial enterprises. Only those in Chittagong and Cox's Bazar are functioning properly. Another nine (including Dabor centre near Sunamganj) are practically lying idle. The BFDC's financial performance is particularly poor. It loses Tk 50 million annually, and the total liability of the Government now stands at Tk 75 million. Given the generally efficient marketing system for fish which exists in Bangladesh, it would seems difficult to justify a government agency such as BFDC entering into fish marketing and competing with the private sector using public funds.

Environment and forests

Department of Environment (DOE), within the Ministry of Environment and Forest (MOEF), is responsible for environmental planning, management, and monitoring. Recently DOE's mandate was expanded, increasing its involvement in environmental impact assessment (EIA) and in providing advice to line agencies on their activities affecting soil and water conservation, forests, wildlife, critical habitats, fisheries, and other natural resources. DOE is linked to the Planning Commission of the Ministry of Planning via the commission's newly-created environmental cell, which screens new projects for environmental soundness.

At present DOE is restricted in its ability to carry out many of its responsibilities, due to insufficient institutional resources such as staff, equipment, and so on. Currently, two initiatives to strengthen the institution are active.

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[1] Hotta, M 1990. Annex 6 (Untitled Report) Institutional strengthening in the Fisheries Sector; UNDP/FAO BGD/87/045 Project

Department of Forests, within the Ministry of Environment and Forest, has historically had the role of protecting Government-managed forests from local people. Gradually, this is evolving towards a more people-oriented role of protecting, maintaining, developing, and using the forests with the help and for the benefit of local populations.

The Forest Department, like DOE, is restricted in its ability to carry out its responsibilities due to insufficient institutional resources. Currently, initiatives to strengthen the institution's monitoring and enforcement capabilities are active.

3.6.3 NGOs

Of the 6,946 registered[1] voluntary agencies in Bangladesh in 1985, 1011 were either located in or had programs within districts covered by the region. Though they tend to be concentrated in the districts near Dhaka they are also found throughout Sylhet region. These agencies are overwhelmingly rural-based, and are involved mainly in social welfare activities. A summary of where the NGOs are located and their primary focus is provided in Table 14.

Table 14: Distribution of Registered Voluntary Organizations

District	Urban Based	Rural Based	Total
Narayanganj	14	180	194
Narsingdi	15	108	123
Gazipur	27	82	109
Mymensingh	28	129	157
Kishorganj	7	58	65
Netrokona	9	31	40
Jamalpur	14	70	84
Sherpur	6	25	31
Sylhet	19	57	76
Moulvibazar	11	29	40
Habiganj	6	18	24
Sunamganj	8	19	27
Kurigram	5	36	41
Total	**169**	**842**	**1011**
Percentage	17	83	100

Source: Ministry of Social Welfare and Women's Affairs, 1985

BRAC is a pioneer of the NGO sector in Bangladesh and started working in the deeply flooded areas of Sylhet in 1972. Presently, it operates programmes throughout the region. Other notable national NGOs having activities in the region include: the Grameen Bank, Proshika, ASA, Caritas, Bangladesh Family Planning Association, Bangladesh National Society for the Blind, HEED-Bangladesh, NGO Forum on Drinking Water and Sanitation, and Concern Women for Family Planning. In addition, local NGOs such as FIVDB, IDEA, and Grameen Jana Kallyan Sangstha have been operating in the Sylhet area and Village Development Society, Samaj Progoti Sangstha, SARA, and others are working in the Mymensingh-Jamalpur area. International NGOs including RDRS, Concern, World Vision and CARE also have activities in the region.

Most of the NGOs follow a "target group approach", where the landless and women are the target audience. They may be broadly grouped into two categories in terms of their activities: service delivery and catalytic. Some of them have been quite effective in combining "social mobilization" work with that of "rural development". The major thrust of the NGOs since the

[1]With the Ministry of Social Welfare and Women's Affairs.

eighties has been in the field of social mobilization and rural development, a switch from the earlier thrust on relief and rehabilitation. Their main areas of work are as follows:

- capacity building and institutional development of the vulnerable groups, particularly the landless and women, through the formation of village-based groups or cooperatives by the "conscientization process";
- health and family planning services, particularly community health education;
- non-formal education, particularly for adults;
- rural credit;
- promotion of employment, particularly among rural women, in the field of livestock, poultry, fisheries, and sericulture;
- training for income generating activities.

Government-NGO collaboration has increased in recent years. The collaboration has been strongest in fields such as health care, education and training, however, recently NGOs have begun to work jointly with organizations such as BWDB. The NGOs are becoming increasingly active in the mainstream development process and many of them are implementing programmes funded by bilateral donors and multilateral agencies.

4. DRIVING FORCES

The future development of the region will be shaped, in part, by driving forces at the international, national, and regional levels. There are, of course, many parallels and linkages between forces at the different levels: improved communications appears internationally in the form of satellite television and nationally in the form of increasing ownership and access to communications in the form of telephones, televisions, fax machines, and so forth.

4.1 INTERNATIONAL DRIVING FORCES

1. Globalization.
World trade barriers are likely to fall through the next decades; this may take the form of three trading blocks centred in eastern Asia, western Europe and North America, with barriers separating them, or overall liberalisation of international commerce through GATT mechanisms. This driving force represents an opportunity for Bangladesh in that other countries will be spinning off opportunities as they develop into areas of new comparative advantage; in addition, populous markets should become more accessible. However, products will have to be competitive in price, delivered in a timely fashion, and be of consistent quality among other things if suppliers are to survive in the emerging highly competitive globalised economy.

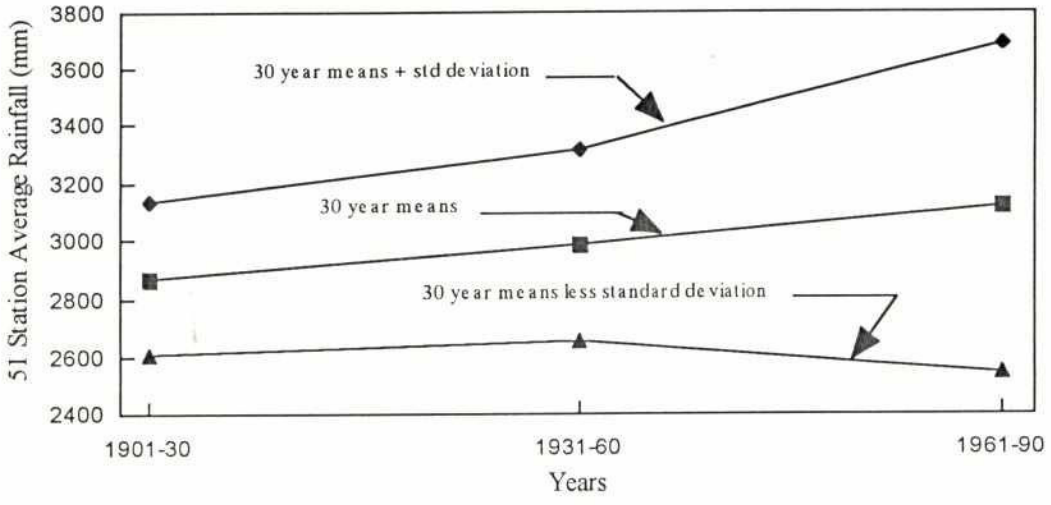
This force is likely to have a differential impact on the region, affecting urban areas and the Dhaka-Sylhet corridor most because it is in these areas that non-agricultural activity is most likely to emerge. Indirect impacts on the region could also surface from this force. For example, demand for market garden products in Dhaka, through increased prosperity generated by taking advantage of global forces, could result in high value agriculture such as fruit, vegetables, and poultry becoming important in those parts of the region closest to Dhaka.

2. South Asia Association for Regional Cooperation (SAARC).
It is likely that SAARC will continue to give more priority to issues with a goal to reduce tariff barriers between South Asian nations.

This development would have a mixed impact on the region. On one hand, it might reduce the price of consumer goods; on the other hand, it could create more competition for producers of agricultural produce and processed goods in the region.

3. Climate change.
Climate change over long periods, a century or more, may be an important driving force affecting the region's development. Current models of anthropogenic climate change are not yet accurate enough to provide useful information relevant to the planning time frame being utilised by FAP 6. For example, current models do not agree on whether or how much the monsoon circulation will intensify. However, regional data suggest that rainfall has been increasing for the past 30 years (Graph 4.1); it is not clear whether this increase is part of a long-term cycle, or a transition to a new climatic regime. Hydrological changes add urgency to the need to mitigate impacts associated with excessive rainfall.

Graph 4.1: Time Variation of 51 Station Rainfall



4. Development in upstream areas and deforestation.

Large scale development projects in upstream areas which affect water flows can have significant impacts on the region. An important example is the proposed dam at Tipaimukh, India (see box next page).

Continued deforestation of the Meghalaya and Tripura hills is likely to result in more extremes in river flows making water sector planning and management more difficult, probably less effective than would otherwise be the case, and management almost certainly more expensive.

5. Biotechnology.

Enormous strides are being made in biotechnology; such research and development is occurring primarily in the developed countries. Since primary agricultural activity still accounts for over one third of Bangladesh's economy as measured by GDP, biotechnological advances will very much affect Bangladesh. This force could be positive for Bangladesh, application of biotechnology is more research than capital intensive.

6. Remittances.

Remittances from temporary labour and permanent residents abroad is an important source of capital for Bangladesh. An estimated 500,000 people, mostly men, work outside the country. Opportunities for temporary labour abroad may stagnate for reasons such as geographic changes in fossil fuel production patterns, increased competition from other labour supply sources, or more restrictive immigration policies. On the other hand, emerging labour shortages in ASEAN may compensate for stagnation in the demand for labour in the Middle East. For example, 67,000 Bangladesh citizens currently work in Malaysia.

TIPAIMUKH PROJECT

Location:	Manipur State, India
Planned date of implementation:	Proposed to start 1993 but delayed pending resolution of various issues, including impacts on Bangladesh
Objectives:	Generate 3,609 GWH of electricity annually and irrigate 1680 km^2 of Cachar Plain
Physical works:	161 metre high rock-fill dam at Tipaimukh gorge on the Barak River with an installed generating capacity of 1,500 MW
	Barrage on the Barak at Fulerthal, about 100 km downstream from the dam
	Irrigation distribution system, Cachar Plain
Direct impacts:	Moderation of flood flows of the Barak, Surma, and Kushiyara Rivers. Amalshid peak flows reduced by 25%, flood water volumes reduced 20%, water levels reduced 1.6 metres. Sylhet Basin would experience lower floods, less area inundated, lower monsoon drainage flows. Surma and Kushiyara channel erosion and sediment transport would be less.
	Augmentation of dry season flows. Amalshid average February flows estimated to increase by a factor of 4.2, total dry season volume +60%, water levels +1.7 metres. Other dry season water levels: Sherpur +1.5 metres, Ajmiriganj +1.0 m. Drainage congestion possible in some areas.
Other impacts:	Monsoon season: less flood and erosion damage to crops, homesteads, urban areas, infrastructure.
	Dry season: increased water availability during the critical period for irrigation, fisheries, navigation.
	Hazards: reduced flood hazards. Dam failure could have catastrophic effects on Northeast Region — issue requires further study/environment management planning.
	Implementation phase impacts: reservoir filling could affect hydrology in Northeast Region — issue requires further study/environment management planning.

Source: Joint Rivers Commission; NERP estimates

This driving force is of particular significance because the region has historically been, and continues to be, an important source for overseas labour with associated remittance benefits flowing back to the region.

7. Changing export mixes.
Bangladesh has been affected by decreased demand or prices for key traditional exports, in particular, jute and tea. The price of tea is virtually the same as five years ago, while the current price of jute has declined almost a third over the last five years. Taste preferences in tea are changing, and synthetics are increasingly replacing jute,

Although these trends could be perceived as threats, Bangladesh is showing considerable promise in restructuring its export base to items such as garments, leather goods, and frozen seafood products; potential exists in terms of electronics, electrical goods, extruded plastic goods, toys, and shoes, among others, to further diversify the export mix.

Since the region is the major tea producing area in Bangladesh, it will be affected by decreases in tea demand or prices; however, the region is much less sensitive to falling prices for jute because the major jute producing areas in Bangladesh are outside the region. As noted earlier, export mix shifts to manufactured goods will affect subregions differentially.

8. Communications.
The growth of Asian-wide satellite television service is removing national barriers to information flows. Five-channel Star TV, broadcast throughout Asia, is doubling its audience every few months. Currently 45 million people in Asia receive Star — four times those accessible in June, 1992. During the planning period, virtually all urban households in all socioeconomic classes in Bangladesh will have access to cable networks which will relay programmes from these satellite stations. In most of Asia, videos have permeated virtually all rural areas as a source of information and entertainment.

These international communication forces will increasingly affect Bangladesh in rural areas as well as urban ones; the impact will is being felt first in urban areas such as Dhaka.

9. Development assistance.
Development assistance to Bangladesh is very important, particularly in terms of Bangladesh's development budget. In the 1980s, the development budget was virtually entirely funded by foreign assistance. Now approximately 75 to 80% of the development budget is funded by development assistance. Development assistance pledged to Bangladesh totals US$2.15 billion in 1993. Although this is down from last year's US $2.5 billion, it is an indication that Bangladesh still has the confidence of donors, given current stiff competition for aid. The 1993 development assistance allocation is US $120 million more than the Government of Bangladesh had requested.

The Bangladesh Aid Group, formed in 1974, has given some temporal consistency to development funding, donor assistance is subject to the vagaries of developmental fashions. Although it is impossible to predict future developmental assistance priorities of the international community, any changes that do occur will have a significant impact on Bangladesh.

Since the region benefits from international development assistance flows along with the remainder of the country, changes in levels of developmental assistance or priorities associated with aid flows will affect the region.

10. Asian region geopolitical and economic change.

China is likely to have one of the fastest growing economies in the world during the planning period. The growth of a large middle class in China will have enormous implications on world consumption and production. From the point of view of Bangladesh, this force may be perceived as a threat in that China will be producing many of the same low-end manufacturing goods as Bangladesh, such as garments and leather goods, and high volume mass-produced consumer items such as toys, extruded plastic items, electronics, and electrical goods. However, the fact that Bangladesh has traditionally had good ties with China may mean that Bangladesh can become vertically linked to some production opportunities in China.

Although South Asia is unlikely to grow economically as quickly as China and Southeast Asia, there is evidence that the two largest nations of South Asia, India and Pakistan will grow more quickly economically than they have in the past because of structural changes in these countries which are making them more attractive to private enterprise. If this growth is coupled with lowered tariff and non-tariff barriers within SAARC, a large middle class market could open up for Bangladesh goods and possibly services in certain niche areas in neighbouring populous South Asian countries.

As was the case for globalisation, communications, and other driving forces discussed above, the emergence of Asian regional powers is more likely to affect those areas in the Northeast Region where local economies are less agricultural in nature.

4.2 NATIONAL DRIVING FORCES

1. Population growth.

Population growth is a key driving force affecting Bangladesh's development. Depending on source, population growth in Bangladesh is estimated at an annualized rate of 2.1 or more. The current population is approximately 117 million up from 71 million measured in the first post independence census in 1974. The population could reach 235 million by 2025. Because virtually no new land is available for cultivation, and 10 million of 18.5 million families are already landless, although approximately 20% of families are now urban, population growth has enormous implications for the types of developmental policies that should and must be pursued.

2. Urbanization.

Even though about 80% of the Bangladesh populations still resides in rural areas, Bangladesh already has a large urban population in absolute terms — approximately 27 million people. Urbanization is occurring at an annual rate of approximately 6%, which is very rapid. The rate will gradually decrease, but is unlikely to be less than 4.8% by 2000 or less than 3.6% by 2015. By 2015, it is estimated that the urban population will be approximately 65 to 70 million.

Bangladesh is at an early stage in the rural-to-urban migration cycle. The Dhaka mega-urban region may have added three million people since 1990. If so, it experienced one of the faster, if not the fastest, rate of growth of all global mega-cities during the 1990 to 1993 period. It would appear that Bangladesh is now entering the period of most rapid urbanization that it will experience in its history. Although data on intermediate and small cities is much less available and reliable, these smaller centres are also probably currently entering or about to enter their fastest periods of growth.

3. Economic restructuring.

Bangladesh's non-agricultural economy is restructuring rapidly; as noted earlier, this is reflected in its rapidly changing mix of exports. This restructuring is occurring primarily in the formal sector; however, the informal sector continues to be very important in terms of production and employment.

In the formal sector, the trends toward garment manufacture (which employs perhaps 500,000 people and is still growing quickly), leather goods production, and frozen seafood preparation have been well documented. However, potential exists in other manufacturing areas as noted earlier. Ironically, some potential industries, for example shoes, are being lost to competitors such as Vietnam and Sri Lanka because of purported lower real wage rates in competitor countries. Bangladesh wage rates are high relative to the country's overall economic situation. Local service industries such as finance, have considerable potential for growth.

The informal small business sector continues to grow. This includes small manufacturing shops, repair shops, rickshaw drivers (employing 500,000 to 800,000), small boat operators (employing 2,000,000), and small retailers, among others.

The informal sector accounts for two-thirds of the employment in manufacturing and one-half of the output of the sector. Real earnings in the informal sector are, on average, much higher than in agriculture and frequently compare favourably with formal sector non-agricultural employment.

Given the non-agricultural sector's (1) promising track record in terms of employment creation, (2) potential for production and employment growth through diversification and growth in existing activity areas, and (3) relatively high wage or informal earning levels; this sector represents an enormously powerful driving force in Bangladesh. Although non-agricultural employment is still in early stages of development in the region, the potential for large scale increases in such activity are considerable.

4. Human resource development.

Human resource development is a key driving force reshaping Bangladesh. Approximately 35% of the population is literate; however, the literacy rate for men is approximately double that for women, although the ratio is narrowing through time. Given the fact that females dominate employment in the formal industrial sector, this driving force is related closely to restructuring issues discussed above. Education receives a fair share of fiscal year routine or operating budgets (approximately 17 to 20%) but a small share of development budgets (less than 5%).

Enormous strides were made in child immunization during the 1980s which have lowered child and infant mortality and sickness substantially. Real, but lesser, progress was made in terms of delivering health care to adults. The government's goal of universal health care access by 2000 may be achievable then, or in the early years of the next century.

The improvement of health and education levels in Bangladesh represents a key driving force. If human resource development continues to improve, additional developmental opportunities will open up and restructuring of the socioeconomic system will be more rapid.

The region generally has lower levels of human resource development and well-being, particularly in terms of literacy and education, than for the country as a whole. However, through time, it is expected that the gap between human resource development levels in the

region and Bangladesh as a whole will narrow. If this occurs, there will be significant developmental implications for the region associated with this change.

5. Environment.

Many of the environmental driving forces affecting Bangladesh are global, multilateral, or bilateral in nature and were identified above. However, other environmental forces are driven by national forces with impacts in terms of erosion, soil quality, and changes in biodiversity.

Because Bangladesh is still highly dependent on its rural areas for support of most of the population, any deterioration in environmental quality can undermine the ability of the land to support the very large populations dependent on it.

Natural forest ecosystems have been all but eradicated, with associated diminution of fauna. Wetlands pose a complex developmental challenge in terms of balancing food needs with biodiversity objectives.

As elsewhere in much of the world, concern with environmental issues is becoming a higher priority in Bangladesh as is indicated by Bangladesh signing international environmental agreements such as the Ramsar Convention, by the increasing numbers of environmental NGOs operating in Bangladesh, and by the acceptance of donor country environmental reports and guidelines. As rapid urbanization occurs over the next two decades, urban environmental issues will become increasingly important and the object of much greater attention.

6. Privatization.

Contrary to some stereotypes, Bangladesh has a small public economy which is becoming smaller in relative terms through measures such as privatization and loosening of controls. For example, over 60% of industrial assets are in private hands, almost the entire agricultural sector, which accounts for over a third of GDP, is in private ownership, and the civil service is relatively small, though the Bangladesh Aid Group argues that 20,000 public sector jobs should be cut this fiscal year (ending June 30, 1993) and a further 25,000 in the next fiscal year. This situation and trend is a key driving force behind restructuring of Bangladesh's socioeconomic system.

This driving force is being slowed by a very significant lack of private capital, both from national and international sources. At the micro, informal sector level, the Grameen Bank, developed by Dr. Muhammad Yunus has attracted positive attention by addressing this need. The lack of capital is one of the strongest forces working against more rapid restructuring in Bangladesh. Private investment is currently 5 to 6% of GDP. The Bangladesh Aid Group argues it should be 9 to 10% of GDP to finance the feasible developmental opportunities that exist.

Lack of capital could be a significant constraint to development in the region, since areas remote from the primate city tend to have more difficulty raising capital. On the other hand, there is considerable private capital in Sylhet which could possibly be mobilised for developmental purposes.

7. Land availability.

Landlessness is a major characteristic of modern Bangladesh. Even if agricultural productivity increases substantially as is likely, few new people will obtain land because of constraints related to ownership and inheritance. Thus a key driving force in Bangladesh is the fact that the land will probably not absorb many more people in terms of significant positive marginal economic

returns to labour and certainly in terms of land ownership. The end of absorption of population through new rural land owners has extremely important ramifications for Bangladesh development policy.

8. Revenue collection.
A key driving force, probably negative, in Bangladesh is the very low public revenue collection. Bangladesh collects only about 10% of GDP annually in public revenues, primarily from customs duties and sales taxes rather than income taxes. This is less than half the norm for developing countries and less than one third the norm for developed countries. This lack of public revenue collection constrains strategic actions that could be taken by the government in terms of developing key infrastructure in support of private enterprise, supporting key sectors, or delivering accelerated human resource development programmes.

If Bangladesh were to collect more public revenue, a secondary issue would be the extent to which such incremental revenues would flow to remote regions, such as the Northeast Region.

9. Telecommunications.
As noted above, international communications forces are reshaping Asia. Internally in Bangladesh, similar forces are at work. For example, although there is still only one telephone per 465 people; this is up dramatically from 1988 when the ratio was one telephone per 1,000 people. Similar dramatic growth rates are being exhibited in terms of ownership of televisions, radios, and video machines. As telephones increasingly become available in smaller centres, making fax connections possible, rural industrial opportunities will increase significantly. Mobile telephones have been available for some time in Dhaka.

This is a key driving force affecting Bangladesh. Rural - urban distinctions in terms of information, behaviour, values, and attitudes are breaking down, the population is becoming better informed, and modernisation dynamics from telecommunications processes are supportive of economic restructuring.

10. National political changes.
The change to a democratically elected government in 1990 has opened up public discourse and policy in a variety of areas, among them are water resources development, economic policy, and environmental management. This situation affords an opportunity to re-examine entrenched policies and attitudes toward development. The democratic government is more supportive of public participation.

4.3 REGIONAL DRIVING FORCES

1. Pressure on rural land.
This is the most significant driving force affecting the region. Natural population increase in the region is greater than for Bangladesh as a whole, although net rates are mitigated by higher mortality and out-migration. The mean farm size in the region is already approximately 0.6 ha and farms are becoming smaller through inheritance and other processes. Farms below 0.4 ha are not economically sustainable with the technology presently available, depending on soil fertility and other factors.

Functional landlessness in the region amongst the rural population already exceeds 50% and will increase rapidly because of the lack of new land to develop agriculturally, the small size of existing farms, existing land ownership patterns, and rapid population growth.

With existing technology, agricultural productivity can be increased to levels three times higher than is currently the case in the region. Yields similar to those achieved in Asian countries practising extremely intensive agriculture such as Japan could be achieved, but it does not follow that three or four times as many people would or could be absorbed on the land because of human factors noted above, such as ownership patterns, or the desire of landholders to translate higher yields into higher household incomes rather than the support of more people.

2. ***Pressure on fragile regional ecosystems.***

As land becomes scarcer, farming is being carried out on fragile ecosystems. Of particular concern are:

Wetlands. Wetland areas are increasingly being encroached upon and drained to support. agricultural activities. In addition to serious environmental concerns about such encroachment, farming in these areas exposes farmers to considerable risk in terms of probability of harvest.

Alluvial fans (desilting areas). These areas in the north of the region are increasingly being farmed. This agricultural activity disturbs the silt deposits, resulting in increased silt deposition to the south. As is the case for wetlands, farming in these areas exposes farmers to considerable risk in terms of probability of harvest.

3. ***Urbanization and migration.***

Previously it was noted that Bangladesh is probably just entering its period of fastest urbanization. The region is lagging behind much of the remainder of the country in this regard; partly for cultural reasons in the sense that regional residents have preferred rural life, and partly because of relatively poor accessibility to urban areas though this is improving. However, given the rapidly growing rural population in the northeast, increased landlessness, and population pressure on fragile ecosystems, it is likely that urban centres in the region will experience rapid urbanization and that there will be increased migration from the region to major urban areas such as Dhaka.

At present, cyclical migration does occur, particular from central wetland (*haor*) areas to urban centres such as Sylhet. Some migrants have settled in northeast urban centres on a permanent basis, but they usually retain ties, frequently through land ownership, to their rural homestead or community.

Given the enormous pressures on rural land, urbanization in the region can represent a positive force, particularly if well managed. Inevitably, a much higher percentage of the gross regional product (GRP) will be accounted for by urban areas. An emerging urban settlement system exists upon which to build; Sylhet has a population in excess of 200,000; Narsingdi over 100,000, while seven urban centres have populations between 25,000 and 100,000; several smaller centres exist. Since all urban centres in the region are still relatively small; they can be shaped to improve future human well-being, environmental pudency, and economic effectiveness.

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4. Transportation improvements.

Accessibility in the region is improving significantly. The most important factor contributing to this change is the mechanization of country boats. To a more limited extent, improvements to road networks are also a contributing factor in improving accessibility. Based on ongoing, committed and planned road programmes and projects, road network improvements are more likely to reflect initiatives in rehabilitation and maintenance rather than network extension.

Improved access facilitates rural-urban physical linkages which contribute to: (1) marketing of agricultural produce (to the extent that surpluses exist); (2) migration — cyclical and permanent; (3) better access to private and public services such as health facilities, banks, government offices, located in district and *thana* centres; and (4) possible links between local resource user groups and urban-based environmental and community development groups. Improved physical linkages between rural areas and larger settlements increases access of outsiders to local rural resources while at the same time improving the economic bargaining positions of rural residents. That is, improved access can result in beneficial development or outside exploitation of rural areas depending upon other factors at work.

If not planned carefully, highways can alter drainage patterns, impede navigation, and create other negative environmental or economic impacts. Similarly, efforts to improve navigation such as straightening of rivers can cause unexpected hydrological impacts with negative environmental and / or agricultural consequences.

5. Improvements to communication and electrical systems.

The number of telephone lines is increasing rapidly and plans have been approved to approximately double the capacity of the regional telephone system measured in terms of lines. This development creates potential for rural small scale industry and facilitates communication linkages between rural and urban areas.

Improved access to information by local farmers strengthens their knowledge of market prices, and techniques, and improves service response time for public and private sector services such as health and agricultural inputs. However, at the same time, local rural elites may differentially benefit from increased information available through improved communication linkages.

Improved communications represents an important factor contributing to monetisation of the rural economy; communications systems are the basis of market information.

Rural electrification is occurring in the region; however, in terms of present service and immediate plans, it is highly geographically skewed to major corridors. Associated with rural electrification is a rapid spread in televisions although non-electrified villages often have televisions operated with car batteries. Radios are ubiquitous while video machines will almost certainly become important over the planning period. This information and entertainment infrastructure will contribute to modernisation, monetisation, and associated changes in values, attitudes, and behaviour.

6. Emergence of the Dhaka-Sylhet corridor.

The Sylhet urban centred area is relatively prosperous. Given rail, air, road, and infrastructural linkages between Dhaka and Sylhet, plus other factors such as the linkages between Sylhet and Europe including the UK, natural gas reserves in the east of the region, commercial agriculture in the east of the region consisting of plantation crops to the north and market gardens to the

south, and existing plus planned industrialization, the corridor is likely to increase substantially in prosperity. Industrialization, urbanization, and prosperity in the region is likely to be driven increasingly by this dynamic corridor anchored in the north by Sylhet which will increasingly act as a regional growth centre.

7. Regional economic diversification.
The economy of the region is becoming more diversified, particularly in urban centres and in the Sylhet-Dhaka corridor. The region is lagging slightly behind the nation in this regard but will soon restructure more rapidly in terms of rural off-farm activity, urban manufacturing and formal and non-formal service activity. Already in 1989-90, 62% of the GRP is accounted for by non-agricultural activities; manufacturing (6%), construction (6%), trade (8%), transportation (8%). This restructuring process will be driven by both push factors such as lack of access to land; and pull factors such as demand for non-agricultural products from the region, for example, natural gas.

8. Continued dependence on local resources for biomass.
For most of the region's residents, local surface and aquatic resources are the only source of biomass for fuel and building material and, to a lesser extent, soil nutrients in the form of fertilizer and compost, medicines, and fodder. In particular, growing rural populations, including the landless who increasingly engage in wetland gathering as a means of livelihood when denied access to land, are placing increased demand on wetland resources. As pressure on local resources increases, over-exploitation is likely to lead to a downward cumulative cycle in terms of production and sustainability unless (1) better management of natural resources occurs, and (2) population pressures on the land are reduced through development of non-primary agricultural income opportunities.

Given the fast population growth outlined above, sustainable development will be virtually impossible without major changes in developmental trends. Pressure on local surface and aquatic environments will be relieved somewhat through increased rural electrification and increased local household use of the abundant natural gas reserves, convertible to liquified natural gas, in the region.

9. International demand for wetland products.
Although less significant in terms of environmental degradation, wetlands in the region, as they become more accessible, may become subject to increased international demand for species specific products they yield.

10. Adoption of new agricultural technologies and approaches.
The rate of adoption of high-yielding varieties (HYV) varies throughout the region. The fastest rate of adoption is in the west of the region where extension of irrigated areas is driven by ground water availability and is occurring rapidly.

Although there can be negative impacts of hyv adoption, such as water pollution and encroachment of wetland areas, given the high population growth in the region, with associated food needs; hyv adoption, if managed well, represents a positive force.

Currently, rice yields in the region are increasing at only about 2% a year, slightly less than population growth. Since rice prices are unlikely to increase substantially, and most rice is

consumed locally at any rate, there is a need to diversify agriculture in the region for food consumption / nutritional, and economic reasons.

11. Adoption of other rural technologies.
In addition to mechanization of boats, introduction and diffusion of communications equipment and technologies, and hyv adoption as discussed above, other technologies are driving change in the life of the region.

Examples of other technologies playing an increasingly important role in the region are: (1) diesel pumps which are being used for drainage, sometimes with negative consequences, and to power irrigation systems, (2) improved fishing implements, and (3) increased use of ice plants for fish packing. Innovative uses of the technology are being developed. For example, the same diesel engine might be used part of the year to power a boat and part of the year for irrigation. These, and other emerging rural technologies, have potential for negative impacts, but if managed correctly can contribute to improved livelihood in the region.

12. Traditional cultural emphasis on rice and rice cultivation.
Farm management decisions, reflected in the economy of the region, are influenced by factors other than economic return. In Bangladesh society, there is an extremely strong preference for rice. Rice connotes pleasure and plenty, and rice cultivation confers considerably higher status than other activities producing similar economic returns.

Creating areas suitable for rice cultivation sometimes leads to draining of marginal areas or management practices which inadvertently create secondary impacts such as the silting up of wetlands. Although much of the region is ideally suited for rice cultivation, sometimes rice is planted when other crops would probably yield higher nutritional and/or economic returns, and/or be less environmentally damaging.

13. GOB ownership of wetland areas.
Wetland areas, originally defined as permanent water bodies and lowland forest and reed areas, were identified through various surveys prior to 1956. Tenure over these wetlands and other government-owned lands is vested in the Ministry of Land (MOL) which has a revenue collection mandate. MOL generally leases out its holdings - be they fisheries, quarries, grazing lands, or swamp forests.

The major beneficiaries of the current leasing system are the money lenders and lessees who derive high profits from land leases; those paid to collect the tax; and specific government agencies holding accounts to which the tax is credited. The system is not totally in conformity with the national development strategy because:

- The system of rent and taxes stimulates resource depletion rather than sustainable development,
- Rents and taxes on wetlands transfer wealth from rural areas to the centre, and from poor resource gatherers to members of the elite, and
- The land system subsidizes concentration of control over natural resources.

14. Risk.
Because of the high risk of flooding and widespread poverty in most of the region, households are, not surprisingly, risk averse. This affects behaviour, particularly in the agricultural sector, to a considerable extent. To the extent that natural hazard risks, particularly those associated with flooding, can be lowered, it is likely that more innovative approaches to agricultural and other activities will emerge.

Certain risks exist in the region, such as earthquakes, about which little can be done; however, these risks generally do not affect human behaviour to any significant extent.

15. Social change.
The economic role of women in the household and the community is becoming more valued in the region. In part, this trend is a product of necessity; the labour of men and women is required to earn a living in an increasingly densely populated environment.

Also, as noted above, modern communications technologies are contributing to social changes in the region.

The population of the region, as for Bangladesh as a whole, is very young. Although the dominance of the less than 14 years population cohort has recently decreased somewhat, in 1981, 46% of the population of the region was under 14 years of age. Since young people are more amenable to change, it is likely that the youth will be influential in driving change in the region. Given, the age structure, the employment needs to absorb this population over the next two decades will be enormous, labour force growth in the range of 10% or more annually will be needed as the peak of this group enters the regional labour market.

16. Local initiatives and decentralization of power.
Historically, local people have requested government assistance for local projects. For example, many BWDB initiatives and plans reflect locally generated project ideas or actions started locally. Of late, with the return to democratic government, there is increased involvement of local people in the identification of local needs in terms of intervention by bodies such as the BWDB.

17. Changes in agricultural subsidies and prices.
Recently, subsidies to agricultural production have been reduced. It is not yet clear whether this is a long-term change. If so, it will be a major force driving the type of agriculture practised in the region and consequently will affect the location and types of water initiatives that are most effective.

The price of rice is falling and this could be a long term trend. If it is a long term trend, it would constitute a significant driving force in the region and would affect what constitutes an effective water management plan for the region.

18. Tectonic processes.
The northern part of the region is subject to subsidence as a result of collision between the northward moving Indian Plate and the stationary Eurasian Plate. However, at the same time, the northern part of the region is subject to considerable sedimentation. To some degree, these two powerful forces seem to be counterbalancing each other.

4.4 CONCLUSIONS

Because of strong driving forces acting in and upon the region, it appears that the region will change significantly in economic, social, demographic, and environmental terms between now and the year 2015. Thus, to develop a water sector plan based on the present characteristics of the region or the region that has existed from 1971 to the present, is unlikely to yield an effective plan. The challenge is to develop a futures view of the region and then devise a water management plan that will support and promote development over the next two decades, instead of a "rear view mirror" plan that reflects the past.

The strongest forces, which interactively are bringing about this change are those related to: (1) relatively rapid population growth, (2) the end of potential to absorb significant numbers as rural landowning cultivators or as agricultural labourers, (3) urbanization, which is just entering its strongest growth period, and (4) industrialization and economic restructuring away from land based activities. Improved and increasingly geographically diffuse communication systems are likely to strengthen the aforementioned driving forces.

At the regional scale, both strong traditional forces such as emphasis on rice and modern technological forces such as communication systems are at work. Change forces, as is always the case, will be stronger in some areas than others: for example, it appears that communications changes and water transportation technology will lead spatial restructuring in the region relative to roads and perhaps rural electrification.

The strongest driving force in the region is population growth relative to land availability. It is almost inevitable that this process will force restructuring in the region's economy and geographic distribution of population. Water management and planning will need to support and protect areas of high value in terms of new income generating activity in agricultural and non-agricultural activities if it is to be effective in supporting developmental objectives for the region.

Resources for water management initiatives should be distributed on the basis of future developmental objectives rather than solely on the basis of hydrological analysis or present economic activities and population distribution. In addition to protecting rural areas where most of the population of the region currently lives, urban areas and integrative systems, such as communication, electricity, and transportation, need also to be protected because these latter areas and systems represent the core physical skeleton for change in the region. In rural areas, water management needs to reflect changes in agricultural patterns and activities being brought about by driving forces. Lastly, but very important, water management related strategies need to protect the environmental quality of the rural landscape which is so essential in supporting and improving human livelihood in the region.

5. REGIONAL ISSUES

Development planners and decision-makers are faced with difficult choices in shaping an appropriate and effective development strategy. The main issues, in the areas of regional development and regional water management, are described below.

5.1 REGIONAL DEVELOPMENT ISSUES

1. Equity versus efficiency.
Potential investment opportunities in the region vary widely in terms of economic and social benefits and costs. For example, investment in a petrochemical industry based on the region's abundant natural gas reserves may generate significant economic benefits, but few of these benefits might accrue to the most needy. Conversely, a programme focusing on enhancing the yield of the *boro* rice crop, through measures such as submersible embankments and expansion of high-yielding varieties, might yield most of its benefits to the relatively poor but not generate as high an economic return.

Basic decisions will have to be made regarding how increased productivity is to be traded off against distress alleviation.

2. Cultural traditions versus change.
Cultural traditions and norms very much influence what is developmentally feasible. For example, the importance of rice to certain people of the region extends well beyond its nutritional value: rice connotes pleasurable food and plenty, whereas wheat connotes poverty and hardship. Hence, a project to increase rice production would likely be accepted more readily than a project to increase wheat production. However, in Bangladesh as in other cultures, cultural acceptability is not static but constantly changing.

Cultural traditions can act as barriers to change and development, particularly in relation to traditional activities. In contrast, new forms of activity, for example employment in the garment industry, often carry fewer cultural connotations and constraints, and thus may offer more flexibility.

3. Environmental issues.
Conversion and degradation of natural ecosystems, both wetland and upland, for human use has been a dominant historical mode of landuse transformation in the region, as in Bangladesh as a whole. The inhabited and cultivated landscape we see today is the result of this process. Yet the remaining natural ecosystems, in particular the region's wetlands, provide immediate economic and non-economic benefits to local people – ranging from a harvest of wild plant foods by the poorest to flood storage which moderates in-channel flood peaks. They also shelter what remains for this habitat of nature's legacy to future generations – the biodiversity that once lost cannot be recovered.

The issue today is how to best serve the needs of current and future generations: what is the proper balance between conservation and its benefits, and continued conversion and degradation and their benefits such as increased cropped area. Specifically, "best use" of each particular site

or regime needs to be decided upon: are the remaining large *haors* to be managed for maximum sustainable yield of natural wetland products - including the openwater fishery - or are they to be flood protected and/or drained where possible for rice cultivation?

There is also a balance to be struck between sustainability and the maintenance of the productivity of renewable resources on the one hand, and current management practices and the yields produced by them on the other. Renewable resources, such as water, soil, forests, and fish, can be managed sustainably, but implies changes in current management practices and yields. Issues include:

- Do current management and exploitation practices under- or over-exploit the resource, compared to the maximum sustainable yield? Maximum sustainable yield, given the biophysical setting, can itself be a matter of debate.

- In cases where over-exploitation is occurring, the productivity of the resource base is being reduced over time. To stop this erosion of productivity (achieve sustainability), current yields would have to be reduced, all other things being equal. How much reduction in current yield can be accepted in exchange for sustainability?

- What types of management improvements are possible? Which are preferable?

Some natural resources in the region, such as natural gas, are non-renewable and thus cannot be managed on a sustainable basis, although they can be harvested on an environmentally sound basis while maximizing total production and recognizing needs of the future.

Finally, environmental quality and public health are related: water quality affects human health directly through the quality of domestic water supplies, and indirectly through contamination of fish and other foods consumed by humans. But restoring and maintaining environmental quality - directly or by actions taken to mitigate environmental impacts or replace environmental values lost to human activity - is not free. What is the proper balance between economic growth or other primary development objectives and any accompanying environmental and public health impacts?

4. Land and people.

Probably the most important issue facing the region is the growth of population relative to arable land. Because most people in the region live in rural areas and obtain their livelihood from the land, population growth inexorably increases pressure on the land. Although there is no doubt that agricultural productivity can be significantly improved, it will be very difficult to generate substantial improvements in well-being unless rural population growth can be further slowed. Productivity increases in agriculture will not necessarily lead to commensurate increases in the number of people working in agriculture. Land tenure and other factors are likely to result in increased numbers of landless people in any case.

The problem is further exacerbated by the fact that arable land is being lost to infrastructure, urbanization, villages, and so on, and by the fact that agricultural production increases sometimes lead to declines in agricultural commodity prices through surpluses on markets, effectively wiping out any rural income gains from increased agricultural production.

An important issue is the future relationship between potential agricultural productivity increases and the likely number of people in the region's rural areas, when rural population stabilizes sometime in the next century.

5. Dependence on rice versus regional economic restructuring.

The importance of rice to the people of the region is well known. It accounts for about 50% of the total agricultural and fisheries output of the region, it is the staple of choice, and it has deep-rooted cultural significance. But this heavy dependence on rice will make it difficult for the region to keep pace with economic development in the balance of the nation. Rice production has been growing at something less than 2% per year, while the balance of the national economy has been growing almost twice this fast. This implies that the region, with its heavy reliance on rice, is becoming worse off relative to the balance of the country. Furthermore, regional rice production per person appears to be decreasing, indicating that many people are becoming not only relatively worse off, but absolutely worse off. The greatest impact is likely focused on the poor and disadvantaged.

In total, predicating a development strategy based purely on rice production would not be advisable. The issue is to what extent the regional development strategy should advocate significant restructuring of the regional economy. Restructuring would involve breaking with tradition, introducing new dimensions of risk, and would probably be associated with social change.

6. Urbanization.

A key issue facing the region is the extent to which urbanization is desirable. Urbanization can have several desirable effects: it lessens pressure on rural land, absorbs some landless, and generally increases the incomes of rural-to-urban migrants. Both permanent and seasonal rural-to-urban migration is currently accelerating in the region. But urbanization can also be negative, in particular if migrants cannot find productive work in the informal or formal urban sectors.

The key questions here are: To what extent should urbanization be encouraged? Which urban centres in the region are best placed to grow, based on comparative advantage?

7. Geographic emphasis.

This is a key, but very difficult, issue. An emphasis on comparative advantage would tend to focus development on different areas than an emphasis on distress alleviation. The Dhaka – Sylhet corridor appears to offer considerable potential in terms of industrialization, urbanization, high-value agricultural production, and so forth. The highland corridor from Dhaka through Netrokona may also possess comparative advantages, in regard to natural resources, infrastructure, communications, capital, and so on. By contrast, the most distressed areas[1] are Sherpur District, and to lesser degrees Jamalpur, Netrokona, and Kishorganj districts.

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[1] "Distressed areas" as used in this Regional Water Management Plan are based on the Distress Factor System analysis carried out by World Food Programme. This analysis weighs selected socio-economic indicators of poverty, maps the relative levels of distress geographically, and estimates the volume of food and other assistance that should be "notionally" mobilized and allocated to one Thana relative to another. The selected socio-economic indicators are: agricultural production, food grain prices, agricultural wage rates, and incidence of natural disaster.

8. Payoff period.
An important issue to be resolved will be the payoff period. For example, investment in human resources is generally very productive, but benefit realization occurs after a relatively long period compared to investment in rural infrastructure such as feeder roads and electrification.

The payoff period and the age cohorts targeted in the planning process are strongly linked. For example, choosing initiatives with longer payoff periods is likely to result in a much stronger focus on youth than would choosing quick-yielding initiatives.

9. Planning versus action.
The needs of the region and of the nation are pressing. There is a choice to be made between an emphasis on careful planning, which takes time during which benefits are foregone, and quick implementation of projects that may then under-perform due to inadequate planning. How much time taken for planning is optimal?

10. Institutionalization of developmental initiatives.
A key issue facing the region is the extent to which development should be led by the private, public, community, or parastatal sectors. In Bangladesh, there is presently a trend toward increased reliance on the private sector for development. Nevertheless, a variety of institutions will need to be identified to take action to implement the regional strategy.

Identification of the appropriate institutions to implement initiatives will, to some extent, influence the related issue of centralization versus decentralization. There is considerable scope for centralization or decentralization of project implementation and operation, in any case.

Related to this issue is the question of local participation and empowerment. Decentralized, community-operated projects will generally strengthen the power base of local communities. The poor and disadvantaged account for up to half of the regional population; there are enormous economic and social benefits to be had if this group could be involved in the development process. The group is potentially very efficient, and it has the most pressing needs for improvements in the basic quality of life.

11. Gender issues.
Important gender issues in the development of the region include:

- *Division of labour.* Women and men in the region observe a strict division of labour. This is particularly true in traditional areas, such as rice growing, and less true in newly emerging activity areas such as factory work, post-secondary education, and so on.

- *Access to and enrolment in education.* At all levels of the educational system in the region, fewer women than men are enrolled. This differential increases the higher the level in the system; for example, the disparity between numbers of females and males enrolled is greater at the secondary eduction level than at the primary level. The only apparent exception is in fishing communities where more girls than boys are enrolled in school.

- *Design of rural development projects and programmes.* When rural development projects are designed, including water management projects, local women who will be affected are often not involved in the design process. As a consequence, benefits to women such

as employment and training may be limited when the project or programme is operationalized.

- *Village space*. Villages in the region, particularly in the *haor* belt, are generally located on very limited space because of the cost of creating additional high land. This shortage of village space significantly reduces the quality of life for women, particularly during the wet season when they are effectively confined to the village. Additional village space could be used for gardening, livestock, processing of food, playing grounds for children, and so on.

- *Access to and acceptance of health services*. The majority of medical practitioners in the region are men. This results in women using health services less than would otherwise be the case. Also, from a family perspective, men are usually given first access to the limited resources which can be spent on health services by poorer families.

  The success of family planning efforts in the region will be critical to the success of any regional developmental strategy. Family planning is accepted differently by families throughout the region. As a generalization, women in the east of the region are generally less receptive to family planning than women elsewhere in the region; this could reflect the eastern zone's relatively higher levels of income and wealth, combined with more traditional attitudes towards women's roles.

- *Economic restructuring and change and the roles of women*. This issue has been discussed in general terms above. Diversification or restructuring of the regional economy may work to the advantage of women.

12. The role of the Northeast Region in Bangladesh.

There is little national-level official documentation concerned with the various regions' roles in the national system, to which planning for the Northeast Region could refer. Decisions about the proper role of the region in national development will have to be made.

5.2 REGIONAL WATER MANAGEMENT ISSUES

1. Definition of benefit criteria and units of measurement.

In order to generate a plan for the water management of the region, a set of objectives and criteria must be identified in regard to desired benefits. Cost/benefit analysis and related techniques are of little help in directing the planning process as they do not address this need. They are generally applied in later stages of project preparation (project feasibility studies) to gauge general economic acceptability.

In the case of water management for the Northeast Region, very different plans for the sector are likely to emerge depending on which criteria are used to guide the planning process. Before a mix of water management initiatives can be recommended, what is to be achieved in terms of benefits must be determined.

2. Equity versus efficiency.
In many developmental situations there are trade-offs between achieving a desired efficiency (ratio of outputs to inputs) and a desired equity profile (distribution of costs and benefits to societal subgroups). In the water system this appears to be the case. For example, fishing seems to be a residual activity in that it provides economic opportunity for some of those who have become landless. Thus a 20 to 30% loss in fish production resulting from a water project may not be compensated for by a 100% gain in rice production because the negative incidence falls on poorer people than does the benefit stream. Another example would be wild lands in the *haors*. The poor and disadvantaged, often poor women, use these lands to collect foods. If a water project destroys or reduces the areal extent of these lands, is it desirable even if the project meets strategy objectives and criteria and generates an acceptable cost/benefit ratio?

An important equity issue is related to land distribution. Since most water management projects service land, thereby making it more valuable, benefits from these projects are distributed mainly on the basis of the current land ownership/use patterns.

3. Spatial, sectoral, and other trade-offs.
Some initiatives may be neutral in terms of equity but still involve gains that are displaced from losses in some other way. Example: embankments constructed to protect can hamper wet-season water transportation. The project's costs and benefits may be equity-neutral, even affecting the same groups of people. if farmers who benefit from the flood protection are also disadvantaged by the degraded wet season transport, but there is still a trade-off involved, in this case between agricultural benefits and transportation costs.

4. Institutionalization of implementation, operation, and maintenance.
Important issues focus on the type of implementation systems and institutions that will be utilized to construct and operate water systems. In Bangladesh, as in most other countries, there is a general movement toward privatization. In the water system, this trend has been most manifest in the case of ground water.

A major institutional issue is the effectiveness and absorptive capacity of institutions operating in the water sector. Sub-issues include:

- To what extent do users pay for the benefits they receive from investments in flood control and drainage? Do they pay capital (amortization) and operating costs or only operating costs?

- Where capital gains windfalls are created, for example, when a farmer's land is protected from flooding and thus becomes much more valuable, does the increase accrue entirely to the farmer or does the implementing authority have a right to recoup some of this windfall through taxes, annual levies, or other mechanism?

- To what extent should water management projects and sub-components be operated by public entities versus private entities such as community and local groups, and private enterprises? Who should be responsible for funding and overseeing construction?

- To what extent should there be local participation and input in the design of water management programmes and projects? Or, should water planning be centralised?

5. Resource constraints.
What will the future availability of funds for water system initiatives be? Availability of funds will affect the water management plan, regardless of project cost/benefit ratios. What will the future availability of funds be for operations and maintenance? Capital costs?

What constraints will exist in terms of key water management inputs, for example electricity or diesel fuel to power pumps?

6. Labour versus capital intensiveness.
Should construction and maintenance be based on labour-intensive versus capital-intensive mechanized approaches? Employment generation and quality construction are both key concerns. In cases where they conflict, a trade-off will be required.

7. Environmental issues.

- The best use of each particular site or regime needs to be decided upon. Example: are the remaining large *haors* to be managed for maximum sustainable yield of natural wetland products – including the openwater fishery – or are they to be flood protected and/or drained where possible for rice cultivation?

- How should the emphasis in water planning and management be balanced between near-term productive gains and environmental sustainability?

- What priority should be given to water quality in water systems planning, particularly in terms of potable water? Water quality management of necessity must reflect consideration of point-source pollution, agrochemical pollution, and village sanitation practices.

8. Linkages with other initiatives.
The main benefits of water projects are indirect: they improve the environment for valued activities such as agriculture and industry. Water projects offer limited direct benefits: protection of life and property. Thus determining the benefits of a proposed water project requires an understanding of the range of planned and unplanned developments likely to occur in the project area, in response to the new water regime or independent of it.

The issue, then, is: Should water management initiatives lead the development process and other sectors be planned to create linkages (synergy) to justify them? Or, should water management be a dependent variable in the development equation in support of initiatives in other sectors?

This issue has spatial implications. It may be that certain geographic areas of the region will be given priority in terms of developmental investment. Because of linkage considerations, this would very much affect the set of water projects that should be built. For example, a different geographic mix of water projects would result from a focus on the Dhaka-Sylhet corridor than from a focus on increasing the value of the regional *boro* rice crop.

9. Integrated versus sectoral approaches to project planning/delivery.
As noted above, the success of water projects is dependent on their linkages with activities in agriculture, fisheries, and so on. Should elements such as agricultural extension be built into water projects in an integrated fashion or should inter-sectoral coordination and cooperation be encouraged?

10. The mix of water management measures.
This issue is related to the foregoing points. The mix of flood protection, drainage, irrigation, and other types of projects in any water management plan for the region must reflect the positions taken on the issues listed above.

6. REGIONAL ANALYSIS

6.1 INTRODUCTION

Water management must take into account:

- Current strengths and weaknesses of the developmental system as a whole, and of the water system in particular, and

- Future opportunities (phenomena or situations that can be turned to advantage if acted upon) and threats (phenomena or situations which could decrease human or environmental welfare if appropriate management actions, including preventative, are not taken) in the developmental and water systems.

In general (but not always), strengths and weaknesses are linked to issues; and threats and opportunities are linked to driving forces. Water system is here defined to include water resources management (flood control, drainage, irrigation, sediment management), plus aquatic biological systems dependent upon in-stream and floodplain water (fisheries, wetland management, navigation). The developmental system include all other relevant regional systems. The information presented here in some cases refers generically to the entire region or to many places in it, and in other cases to specific locations. Geographically identifiable information is presented in a series of maps (Figures 9 through 15).

A given entity can be both a strength and a weakness or opportunity and threat, depending upon the impacts associated with it, including those dependent upon how the entity is managed.

To provide context and general guidance for the analysis, mission statements were first prepared. These are presented in Section 6.2.

The concluding section summarizes the information in a balance sheet format (Tables 17 through 20).

6.2 MISSION STATEMENTS

6.2.1 Regional development

To identify development initiatives for the Northeast Region of Bangladesh that will contribute to food self-sufficiency, increased human well-being, and improved protection of life and property.

To identify measures conducive to overall rural and urban economic and employment growth in the region that will enable the people, particularly the youth of the region, to have opportunities to significantly better themselves.

To identify development initiatives that are environmentally sound and that help to improve the well-being of the poorest and most disadvantaged people.

6.2.2 Water management plan

To produce a Water Management Plan that will contribute to regional development in the Northeast Region of Bangladesh by:

- Increasing the effectiveness of existing water management infrastructure through improvements to operating and maintenance systems.
- Providing water management infrastructure to areas of existing and potential high economic productivity.
- Providing protection to key infrastructure corridors and facilities.
- Providing protection to people, property, and food supplies in localized areas of particular vulnerability.
- Providing benefits in terms of fish production, navigation, and transportation.

To manage water resources on an environmentally sound basis to contribute to sustainability of water-linked renewable resource systems such as soil, fisheries, and forests.

6.3 STRENGTHS — DEVELOPMENT SYSTEM (Figure 10)

6.3.1 Socioeconomic strengths — development system

Families in the region show strength and resilience with the ability to sustain loss and survive adversity.

The region contains a large work force with an ability to switch from one activity to the other according to seasons and opportunities.

Voluntary labour can be marshalled when needed at the community level, particularly in cases where no government assistance is likely to be forthcoming.

Sylhet is an important and dynamic secondary city in the region. It has reached a critical mass (approximately 220,000 population) whereby it is acting as a growth centre for the eastern and central areas of the region.

The growth corridor between Dhaka and Sylhet is growing in economic and demographic terms. Although improvements are needed, the infrastructure is basically good in the corridor, and thus serves as a basis for development in the eastern area of the region. The Dhaka-Mymensingh corridor plays a similar, although lesser role to the northwest of the region. Most of the Dhaka-Mymensingh corridor is located outside the Northeast Region; however, its effect on the western side of the region is important.

Regional road infrastructure in much of the region is good; a core system exists for extension of road networks where feasible. Numerous ongoing public works projects, particularly bridges, are underway to improve accessibility.

There is an extensive ongoing project in the region to improve roads (ADB assisted). This project will improve the transportation network from *thana* headquarters to district headquarters in Sherpur, Mymensingh and Netrokona Districts as well as improving large sections of the main road between Dhaka and Sylhet.

As discussed earlier, the strong connection between the region, particularly Sylhet/Moulvibazar and London, acts as a source of capital and entrepreneurial ideas. However, a portion of the remittance and returnee capital is not invested productively.

The region's economy and settlement system are undergoing structural change as indicated by rapid growth in non-agricultural employment in areas such as construction, manufacturing, and personal and business services; plus rapidly increasing rural to urban intra-regional migration.

National policy changes to create a more open and market oriented economy are likely to benefit the region, especially given its history of entrepreneurship.

6.3.2 Biophysical strengths — development system

Local varieties of rice are dominant, especially in the central and eastern parts of the Region. These varieties of rice are less susceptible to disease and require less expensive inputs; for subsistence farmers, these are positive factors.

The adoption of high yielding varieties in the western part of the region is high.

The region's soils are rich; the climate can support three crops per year if hydrological conditions are good.

The region contains significant natural gas reserves.

There are good sources of sand and stone along the northern border of the region.

There is increased importance being placed on environmental values in Bangladesh, as well as in the region. This is being reflected in areas such as GOB development policies and the emergence of environmental education. National and international environmental NGOs are showing increased interest in the natural resources of the region.

6.4 STRENGTHS — WATER SYSTEM (Figure 9)

6.4.1 Institutional strengths — water system

There has been some learning from past projects; a limited information base exists in terms of the effectiveness or lack thereof of past projects.

As evidenced in part through the Flood Action Plan, there is a commitment from the GOB and the international development community to address water development and management problems in Bangladesh in a manner which is appropriate and cost-effective.

6.4.2 Biophysical strengths — water system

Navigation, fisheries, and wetlands
Major rivers are navigable by larger vessels; lower order channels down to small country *khals* are navigated by large numbers of mechanised country boats and smaller unmechanised vessels.

The abundant water resources of the region and the associated terrain make it a "fish mine". The region contains 25 main rivers totalling 2,150 km in length, about 5000 (58% permanent and 42% seasonal) *beels* (totally about 500 square km), and over 200,000 ponds.

At least five spawning grounds and about 325 *duars* exist within the region, containing about 150 fish species.

Fisheries is a major source of livelihood in the region, accounting for about 9% of the regional labour force.

Several wetland areas remain of value in terms of biodiversity; some are of international significance. Important representative habitats still exist.

Most wetland areas are still very productive in terms of biomass production of local and regional value for food, shelter, medicinal, and other purposes.

GOB legally owns fisheries and wetlands, which would facilitate central government interventions to improve management.

Surface and ground water strengths, non-spatial
The area at high risk from channel instability and erosion makes up less than 20% of the Region's land area, mainly in the alluvial fan areas, some piedmont streams, and parts of the *haor* and flood basin lands. Most of the region, particularly the flood plains of the Surma, Kushiyara, Meghna and Old Brahmaputra river is morphologically stable.

Most of the rivers are still basically natural alluvial systems; they have been modified by engineering works to a limited extent only. The rivers are not highly channelised or trained in spite of some efforts in the past to do so.

The region has a very large capacity to absorb sedimentation without seriously affecting flood levels. This is because the active width of the main rivers such as the Kalni or Baulai covers virtually the entire Central Basin lowlands during the monsoon season. Under these conditions, siltation in the main river channels will have very little affect on the overall flow pattern or water levels.

There is considerable debate concerning the fertility value of fine sediments on agricultural land. Some farmers consider these deposits beneficial. The steep border rivers transport coarse sand and gravel which has a high economic (including employment) value. This is a sustainable resource (from the perspective of Bangladesh) which could be harvested at greater levels.

The region contains unused (sustainable use criterion) ground water resources although they vary considerably within the region. Table 15 describes total use of ground water (domestic and irrigation use). As can be seen, ground water is being used to a much greater extent in the west

and northwest of the region than in the central and eastern areas.

At present, the quality of ground water in the region is generally good.

Surface and ground water strengths, Sylhet Basin
The Sylhet basin is well defined in a hydrological sense; the relative homogeneity of the area facilitates planning.

There are substantial volumes of (post monsoon) residual surface water available for winter season irrigated agriculture.

The basin acts as a giant flood reservoir and desilting basin which provides excellent opportunities in water transport.

Table 15: Total Use of Ground Water, Northeast Region

Subregion	Mm^3/year	(%)*
Northwest	576.9	94
West	999.5	57
Central	30	9
East	75.7	36
Regional Total	1682.1	58

* Total use of ground water as a percentage of ground water recharge.

Surface and ground water strengths, Seasonally Inundated Areas
Improved water management is an option for most of the land in this subregion.

The western half of this area is mainly flood free; two to three crops per year can be produced without costly flood control infrastructure.

In the eastern half of this area, the land can support two crops per year; with irrigation it is possible to shift to high yielding varieties of boro as one of the crops.

Surface and ground water strengths, upland areas
The upland areas are flood free and well drained with little erosion occurring. While mostly under tea, there are still some areas of forest cover and some unused or undeveloped land. Generally access within these areas is relatively good given the lack of flooding problems.

Surface and ground water strengths, Piedmont Plains
The piedmont plain areas generally have good drainage. Two rain-fed crops are possible.

6.5 WEAKNESSES — DEVELOPMENT SYSTEM (Figure 12)

6.5.1 Institutional weaknesses — development system

Government development programs and projects in the region tend to be top-down; the allocation of resources to sectors and the content of initiatives are largely donor and national government determined and driven. This condition tends to slow innovation in the design, delivery and operation of developmental programs.

6.5.2 Socioeconomic weaknesses — development system

The region exhibits poor achievement, relative to Bangladesh as a whole, in human resource development, particularly in terms of literacy and basic education. This situation is a reflection of too low investment in human resources in the region and cultural factors. Poor human resource development performance is probably the biggest single obstacle to improving human well-being and generating faster economic growth in the region.

There is a high association between gender and various occupational roles in the region, especially in more traditional fields such as agriculture. This situation contributes to lesser economic growth than would otherwise be the case and may result in men and women not realising their full potential.

Malnutrition is a problem in the region, particularly in the distressed areas in the northwest area of the region. This situation is particularly serious in the case of pregnant and lactating women.

Landlessness in the region is high (approximately 50% of the rural population) and growing rapidly, although not as high as for Bangladesh as a whole. Although landlessness is not necessarily a problem, it is in the region because most landless people are severely under-employed. Furthermore, the vast majority (perhaps 70 or 80%) of any incremental population added to the region's rural areas is likely to be added to the landless category.

One of the most important problems in the Northeast is that settlement in many areas is already above reasonable carrying capacity for an agriculturally based economy. For example, the *haor* areas may require considerable infrastructural investment because so many people live there (although densities are still only about half those for the region as a whole; they are very high given the biophysical environment).

The geographic distribution of population in the region, although a given in the short run, and something which will change through driving forces in the longer run, is clearly a weakness in developmental terms.

The extremely complex tenurial system is a major weakness, in part because occupancy does not necessarily match legal rights. In some parts of the region, much of the *khas* land, which in theory belongs to the government, has been occupied; and in some cases occupancy rights have been sold several times resulting in conflicts which are difficult to untangle.

In parts of the region, for example the *haor* areas, communities have for generations enjoyed usufructuary rights over pasture land, *beels*, or forest near their homes, but these rights have not been protected by the legal system set in place when the zamindars were abolished. When such *khas* land is leased to outsiders by the government to raise state revenue, it leads to conflicts, and often to a depletion of natural resources by entrepreneurs concerned with short term benefits.

The region's economy is still, to too large an extent, focused on production of primary products faced with declining national and world prices. In particular, this is the case with rice. The region's economy is more weighted to declining commodities than Bangladesh as a whole.

Although the transportation and communications systems are relatively good along the two corridors, remoter areas of the region, particularly the deeply flooded *haor* areas, are much less well served, particularly by communications. The large central *haor* area is relatively

inaccessible; furthermore, it serves as a transportation and communications barrier between the northeast and northwest parts of the region.

Urban areas are growing quickly: in order of percentage growth rates, Moulvibazar, Habiganj, Sherpur, and Sylhet are growing fastest. Because Sylhet is by far the largest urban area in the region (excluding the Dhaka peri-urban area), it accounts for the highest annual urban growth increments in absolute terms.

The region's urban areas are suffering from inadequately serviced sites for housing, inadequate water supply and waste systems, and a general lack of effective urban management and planning.

6.5.3 Biophysical weaknesses — development system

The adoption of high yielding varieties in the central Sylhet basin and in the northeast of the region is limited.

There is a shortage of draught animals in the region; to a large extent this is a product of the health (and related, size) of draught animals rather than the number. More generally, the health (weight) of livestock in the region tends to vary significantly by season, primarily as a result of fodder availability.

Current institutional and information system arrangements for decentralised natural resource and environmental management are inadequate.

Information on natural resources, landscapes, and environmental systems is often inadequate for good stewardship.

6.6 WEAKNESSES — WATER SYSTEM (Figure 11)

6.6.1 Institutional weaknesses — water system

The considerable importance of the fisheries sector was often not adequately recognised by government.

Fishermen in the region are not as organised as in some other parts of Bangladesh.

As is the case for Bangladesh as a whole, no protected freshwater wetland areas exist in the region. Some of the remaining wetland species and habitats are threatened.

In the past, water development and management in the region has been biased toward flood protection for rice rather than toward integrated multi-purpose water management and development.

BWDB, by its nature, always exhibits an engineering or structural bias in addressing water system needs, opportunities, and threats.

Most past water management projects have not been completed as designed because funds have run out. In addition, allocation of operations and maintenance funds are often insufficient for projects to operate as designed.

Many, if not most, FCDI projects have deficiencies which related to planning, design, construction, management and minimum cost consciousness. Meaningful public participation has generally been lacking in defining local needs and too little attention has been given to potential fisheries and navigation losses in designing projects.

Since the upstream reaches of the region's rivers are located outside the borders of Bangladesh, there has been little design data available to analysts involved in the planning and design of water management interventions. This has had a significant impact on the operational characteristics of many projects in the region.

Very limited monitoring and evaluation of water management projects occurs.

6.6.2 Biophysical weaknesses — water system

Surface and ground water weaknesses, non-spatial
Surface water shortages occur during the dry season when only about 3% of run off occurs. This shortage of water creates the following problems:

- Inland water transportation is restricted to the lower reaches of main river channels for many types of boats.
- Fish migration is often impeded.
- Sediments left behind by receding floods of the preceding wet season accumulate on the river beds causing drainage congestion, and further aggravate the problems of inland water transportation and fisheries by lack of sufficient water.
- Pollution brought into the region from India, or generated locally, is poorly diluted and tends to accumulate in dead water zones within the rivers and *haors* during the dry season.
- Supplies of water for irrigation from surface water sources are limited.

Management of water through use of dams located in the region is virtually impossible because there are no dam sites.

Upstream territory in India supplies 60% of the region's water. Control of water and sediment problems at their source, or even monitoring, would require greatly improved bilateral cooperation.

The region's rivers are not extraordinarily unstable; however, the perception of river instability, and real problems, are created by the fact that a large percentage of the region's population lives in very close proximity to active river channels since river levees are typically the highest land available for residential purposes. These people are exposed to high risk from even minor erosion or channel changes. Thus water hazards are as much a product of the settlement systems as of river processes.

Adequate materials for constructing erosion control works such as revetments and river training structures are often not available. Often stones are undersized and inadequate volumes of stones are available. Also, suitable soil for constructing embankments is in short supply in some areas. Portions of many rivers are not navigable during the dry season due to siltation and the total length of year-round navigable rivers is decreasing.

Surface and ground water weaknesses, Sylhet Basin
Maintenance costs for infrastructure (including platforms on which homesteads are built) within the basin are abnormally high because the infrastructure is subjected to wave action, partial or total submergence, and extreme rainfall.

The construction season within the Sylhet basin is very short and when coupled with bureaucratic delays (for public sector interventions), construction programs either become protracted leading to cost increases (since flood damage repair is required for uncompleted infrastructure), construction quality is affected or construction is not completed.

Since many homesteads in the Sylhet basin are constructed on river banks, they restrict optimum placement of flood control infrastructure.

The unique environment of the basin (deeply flooded in summer, dry in winter) and the relative uncertainty of when and how rapidly the hydrological regime will change, leads to conflicts between production sectors (agriculture and fisheries) as each tries to maximize their yields.

The Sylhet basin has very poor accessibility during the winter season when water transport is not an option; because this period coincides with the construction season, the impact on construction is compounded.

The flood carrying capacity of the major rivers within the Sylhet basin is well below the magnitude of the incoming floods. At times, the flood carrying capacity of these rivers is also controlled by water levels in the lower Meghna River.

Major river aggradation has taken place on the Kushiyara and Baulai.

Surface and ground water weaknesses, Seasonally Inundated Areas
This subregion is not homogenous which makes planning more difficult. There are numerous localized drainage problems and surface water for irrigation is scarce.

Where this subregion borders the Indian hills, it is subject to flash floods. Some of these areas are morphologically unstable.

In the western portion of the area, the shallow aquifer is inadequate to irrigate a substantial percentage of the area.

In the eastern portion of the Seasonally Inundated Area, the following weaknesses exist:

- Existing projects are not performing well which reflects negatively on development possibilities.

- The lower Meghna controls the drainage in some of this area which limits what can be done for F2 type lands.

- Interventions on the rivers in this area can have far reaching effects. This was evidenced by the loop cuts undertaken on the upper Kushiyara which resulted sediment being transported into the lower Kushiyara. This reduced the navigability of the lower Kushiyara and has impeded drainage for a vast tract of land.

- The flood peaks on many of the tributaries in this area are short but they occur frequently and are very intense.

- There is considerable absentee land ownership which discourages active participation of local residents in development efforts.

Surface and ground water weaknesses, Uplands
The Uplands experience rapid rainfall runoff which contributes to a shortage of water in these areas.

Some land use management practices, such as current methods of pineapple cultivation, destabilise the hill sides creating erosion problems.

Surface and ground water weaknesses, Piedmont Plains
The base river flows are low while flood flows are high which makes irrigation development from surface water costly. Associated with the extremes in river flows, flood hazards are high in this area.

6.7 OPPORTUNITIES — DEVELOPMENT SYSTEM (Figure 14)

6.7.1 Institutional opportunities — development system

With the recent return of democratic government in Bangladesh, there is opportunity to develop decentralised regional, sectoral, and local level approaches for human, economic, and environmental improvement.

6.7.2 Socioeconomic opportunities — development system

Although an extensive road network is not feasible in much of the *haor* area; there are opportunities to build key road links in various areas of the region which would greatly improve accessibility within the region. For example, a short road link of about 6 km from Sripur to Kazirgaon would significantly decrease travel time from Sunamganj to Dhaka, and have the added benefit of reducing traffic congestion in Sylhet. There is a rough east-west road, interrupted by river crossings, along the northern boundary of the region, and road links to Sunamganj and Mohanganj. Construction of a road link between Sunamganj and Mohanganj would improve east-west accessibility considerably.

There is considerable opportunity for increased economic activity and employment in the construction, manufacturing, agro-industry, and personal and business service sectors of the region's economy. For example, manufacturing firms making such products as garments, ballpoint pens, and other consumer goods are already establishing in the region. Investment of foreign remittances could be encouraged such that employment opportunities are promoted.

Improved communication systems will result in better informed populations.

The southern area of the region is part of the Dhaka mega-urban area, over the planning period, enormous opportunities will exist to supply a city of approximately 15 million to 20 million people (by the year 2015) with food and other products which could be produced in the region.

6.7.3 Biophysical opportunities — development system

Yields of existing crops can be increased by use of high yielding varieties and irrigation and other inputs, while overall value of agricultural production can be increased through diversification into higher value crops.

Potential exists for agricultural diversification. Many fruit and vegetable crops grown in the region already command high prices if they reach market. Improved transportation infrastructure will increase the size of area in the Northeast with economic market access.

Opportunities exist to substantially improve production in the livestock sector, primarily by improving the health of animals and changing the production mix.

New technologies to produce high yielding varieties, including deep water rice varieties will provide farmers in the region with more opportunities for higher production in difficult environments. In some cases, it may be possible to substitute different agricultural systems and technologies for structural interventions.

The economic and demographic growth of local markets will increase demand for agricultural products from the region.

In Upland areas, increased production of fruit and horticultural crops, and extension of the forested area, can be achieved through improved management practices.

There is opportunity to use liquefied natural gas and rural electricity to an increased extent to remove pressure from biomass resources.

6.8 OPPORTUNITIES — WATER SYSTEM (Figure 13)

6.8.1 Institutional opportunities — water system

With better fisheries management there is potential for increases in sustainable fish production.

Natural resources, including wetland products, could generate more benefits for local residents if more value were added.

There is an opportunity for better coordination of initiatives in the region. For example, transportation corridors (roads, railroads) create embankments as do BWDB projects. Often these work at cross-purposes; in other cases needless duplication of capital expenditure occurs.

There is an opportunity to better coordinate structural and non-structural initiatives. For example, land use planning, local natural resources management, and warning systems can substitute for, or complement, structural interventions.

Better coordination might occur through regional water management authorities (such as a Haor Development Authority - suggested by people in Kishorganj) with total responsibility for planning and coordinating implementation of structural and non-structural water management initiatives within the area of jurisdiction.

There is an obvious opportunity to monitor long term project impacts on river morphology and sedimentation. Improved project monitoring and systematic documentation of river engineering problems would lead to improved design practices and better formulation of future projects.

There is an opportunity to strengthen local initiatives wherever they are already occurring. There is considerable evidence of such local initiatives within the deeply flooded areas where people locally address problems related to flood and water management.

6.8.2 Biophysical opportunities — water system

Fisheries and Wetlands
Fisheries could be improved by establishing *duar* and *beel* fish sanctuaries, by improving management, and by providing fish passes in embankments.

Wetlands and wetland biodiversity at key wetland sites could be protected and enhanced through appropriate management interventions. These interventions might include locally based management or partnerships between government and locally resource users. In either case, it would involve agreements for tenure rights and defining management responsibilities.

Surface and ground water opportunities, non-spatial
India intends to implement the Tipaimukh Dam project and the associated Cachar Plain Irrigation Project. The net effect should be beneficial to the region, creating opportunities by generating higher dry season flows and lower wet season flows. It is estimated that the volume of Barak flood water entering the Kushiyara and Surma rivers would by reduced by 5.1 km^3 during the wet season - equivalent to a 20% reduction in flow. Assuming the Cachar Plain Irrigation Project is implemented, corresponding dry season inflow would be increased by 3.5 km^3, equivalent to 60% of the present dry season inflow.

The benefits to the region of these effects would be less severe flooding in the wet season and greater availability in the dry season of river water for irrigation, navigation, and habitat for fish.

India is considering constructing dams on the Sonai and Dhaleswari rivers, tributaries of the Barak river. If these dams are constructed, opportunities will be created similar to those described above for the Tipaimukh dam, but on a lesser scale.

Considerable opportunities exist to improve drainage through:
- expanded dredging programs,
- channel re-excavation work, and
- flood relief channels.

Such channel works can: improve drainage in upstream areas, improving conditions for agriculture; improve navigation; and provide more reliable water supply for irrigation and potable uses.

Opportunities for preventative channel maintenance work are considerable. For example, if an eroding spill channel can be closed off early on, a potential avulsion may be avoided. However, if the channel is allowed to grow until it captures a significant portion of the river's main flow, a large structure will be required to prevent the river shifting its course.

It is questionable whether economic hydro-electric development opportunities exist in the region. Possibilities for hydro electric projects include:

Table 16: Ground Water Remaining for Exploitation – Northeast Region

Subregion	Mm^3/year	(%)
Northwest	37	6
West	749.5	42.8
Central	316.2	91.3
Eastern	135.8	64.2
Region	1238.5	42.4

- Surma river at Sylhet: Preliminary studies indicate that a 25 MW plant could operate from May to September and generate 110 GWH during this period

- Manu river at Moulvibazar: A 2.5 MW hydro plant built in parallel with the existing barrage could be operated for eight months of the year and generate a total of 14 GWH. This energy is twice that presently used by the Manu project pumping station.

Ground water for either domestic or irrigation purposes can be expanded to the limit of ground water recharge though caution will need to be exercised to ensure that areas such as wetlands are not adversely affected. Table 16 provides estimates of ground water remaining for extraction at sustainable levels by subregion. It is estimated that ground water will be fully utilised, at sustainable levels, by 2015.

Irrigation opportunities are of high concern in the region since significant production gains can be attributed to them. As available ground water resources are utilized, surface water sources will become relatively more important. Opportunities for additional irrigation water based on surface sources include:

- local initiative earth retention structures

- river sources based on higher dry season river flows as a result of construction of dams in India, and

- storage of residual flood waters in *haors* by closing gates before drainage is complete in autumn.

Surface and ground water opportunities, Sylhet Basin

Drainage and navigation would be benefitted by dredging and river training works on the Baulai, Kushiyara, and Kalni Rivers.

While flooding can not be eliminated from the basin, it can be mitigated by controlling spills from the Surma and Kushiyara Rivers.

Cereal production can be increased substantially in the basin by protecting existing crops from pre-monsoon flooding.

It is possible that fisheries enhancement technologies such as by-pass structures might reduce, but not totally eliminate, the conflict between agriculture and fisheries.

The opportunity exists to improve scheduling of engineering work to take full advantage of the short construction season.

Surface and ground water opportunities, seasonally inundated area
The negative impacts of flooding from the Kangsha River can be reduced through river channelisation, loop cuts, and/or diversions.

Localized drainage can be improved through the Narasunda, Showai, and Suti Nadi Rivers.

There is an opportunity for increased afforestation along the banks of the Old Brahmaputra.

Channelisation of the Kushiyara below Sherpur would improve drainage.

There are opportunities to expand flood protection along the Sarigoyain, the Surma, and Kushiyara which would reduce crop damage and facilitate an expansion of irrigated agriculture.

Improvement of navigation routes between quarrying areas and major urban centres would facilitate expansion of construction materials quarrying.

Construction of a flood relief channel running from Dilalpur to Nabinagar, around the north side of Bhairab Bazar, would increase the carrying capacity of the upper Meghna and hence help reduce the extensive flooding of the central zone of the region.

Surface and ground water opportunities, piedmont plains
The Manu-Dhalai to Hakaluki flood relief channels could be constructed. This channel would divert flood water out of the Dhalai and Manu Rivers and into Hakaluki Haor, and thus reduce flooding in the lower Manu valley. While the town of Moulvibazar would be the primary beneficiary of this flood relief, benefits would also accrue to the Manu River Irrigation Project and the lower Dhalai river.

The Khowai river flood carrying capacity could be improved by eliminating sugar cane cultivation within the flood way, by setting back embankments at strategic locations, and by reconstructing bridges at Shastaiganj with longer spans and higher decks.

There is an opportunity for increased local irrigation initiatives in the subregion similar to those found on the Bilash and Langlia *khals* and on the Conti Nadi.

Surface and ground water opportunities, alluvial fan areas
Construction of a Malijhee-Mrigi Flood Relief Channel would divert flood water out of the Kangsha river basin into the Old Brahmaputra, and thus reduce flooding along the upper and middle reaches of the Kangsha valley.

Opportunities exist to protect areas of the alluvial fans against channel erosion and avulsions. This would involve zoning parts of the fans for protection and other areas of the fans as high hazard areas where development would be discouraged. The high hazard areas would be designated for sediment storage and for use as floodways.

6.9 THREATS — DEVELOPMENT SYSTEM

6.9.1 Socioeconomic threats — development system

Social breakdown could occur as a result of landlessness. Rapid urbanization could contribute to this social breakdown. Traditional family and community organisations, such as *shalish*, will experience diminished power and respect as landlessness and urbanization increase.

Future commodity prices for rice, an important product in the region, are likely to continue to fall in real (and probably nominal) terms on national and international markets.

Sylhet's economy may be overheating. This is partially a product of an under-developed urban system in the region, resulting in too much pressure on Sylhet. Traffic problems are emerging, as well as other social and infrastructural problems noted previously.

6.9.2 Biophysical threats — development system

Removal of subsidies to agricultural production, although desirable from an economic efficiency sense, will cause disruptions to local farmers. Small farms will not be able to purchase most agricultural inputs at market prices because their production is primarily for subsistence consumption.

There will be increased pressure on marginal lands by landless or land short people who wish to farm. Since currently non-farmed lands are frequently ecologically sensitive, expansion onto these lands can cause significant ecological damage.

Biomass and certain species are being exploited at levels higher than sustainable, particularly in wetland and forest (lowland and upland) areas. Habitat destruction is occurring.

6.10 THREATS — WATER SYSTEM (Figure 15)

6.10.1 Institutional threats — water system

The increased proliferation of uncoordinated water projects and schemes represents a threat to the water regime in the region. The construction of roads and embankments by different organizations, each with their own objectives and without regard to their impact on other aspects of water management has created, or aggravated, flooding and drainage problems in the past, and will continue to do so in the future if not brought under the control of a competent authority charged with coordination of initiatives. The construction of road and railway embankments is a case in point.

6.10.2 Biophysical threats — water system

Fisheries and wetlands
Because of over-exploitation and structural impediments to migration, such as embankments, the sustainable fisheries yield could decline in the future unless mitigation measures are adopted.

Future FCDI will likely reduce still further fisheries and wetlands habitats and production.

Surface and ground water threats, non-spatial
A threat to the region is climate change. If present trends continue, greater flooding in both volume and intensity, slower drainage, and more severe future dry water deficits are likely to result. These conditions would result in a requirement for higher engineering standards for new structural water projects and possible upgrading of existing projects. The financial implications in terms of design of new projects and modification of existing projects could be significant.

As industrial activity increases in the region, industrial pollution has the potential to significantly threaten water supplies unless industries display responsible behaviour (probably resulting from enforcement of standards) by minimising the discharge of pollutants into rivers and water bodies. Processes using hazardous or toxic chemicals represent a particular threat.

The quality of water in the region is also threatened by human (sewage) and animal waste as well as by increased use of fertilisers and pesticides in agriculture.

The cutting of embankments constructed to benefit agriculture alone reflects public frustration over real or perceived adverse impacts on local flooding, drainage, fisheries, and water transport. Such cutting means that economic returns of projects primarily designed for agriculture are low. This trend is likely to continue, or become more severe, unless more sophisticated design work is done based on multiple benefits and input of local impacted populations.

If irrigation projects in India, particularly the Cachar Plain project are enlarged beyond current expected size, the advantage of higher dry season water flows into the region resulting from Tipaimukh dam are likely to be lost.

Natural hazards in catchment areas, such as an earthquake in one of the Indian catchments, could lead to greater sediment supply to the region in the future. This would produce channel instability on the Meghalaya fans and on piedmont streams.

As noted above, incremental ground water supplies are likely to be exhausted by 2015. Over exploitation of ground water is a real threat. In fact, in some *thanas* in the north west area of the region, over exploitation is already occurring.

In addition to deterioration of ground water quality through over exploitation, there is also a threat of ground water quality deterioration through increased use of fertilizers, pesticides, and through industrial processes. The threat is especially strong in enclosed *haors*.

If ground water deterioration reaches unacceptable levels, the use of ground water for activities such as domestic supply and agriculture would need to be abandoned.

Surface and ground water threats, Sylhet Basin
Ongoing water regime changes from past developments on the Kalni and Kushiyara river will cause aggradation and increased water levels in pre-monsoon and post-monsoon periods downstream of Sherpur. Ongoing siltation will further worsen navigation conditions along this reach. Increased over bank spills and channel widening can also be anticipated downstream of Markuli. These regime changes will adversely affect submersible embankment projects situated in the Central Basin lowlands between the Baulai and Kalni rivers.

Surface and ground water threats, Seasonally Inundated Area
Changes in the flow regime from construction of dams on the Barak river will modify the sediment transport regime of the Surma and Kushiyara rivers. If the river's capacity to transport sediment is reduced, additional sedimentation will occur along the lower reaches of these systems.

Surface and ground water threats, Alluvial Fan Areas
Attempts to channelise the steeper piedmont rivers and alluvial fans which carry high sediment loads could produce substantial downstream impacts. For example, channelising these streams would flush sediment that was normally deposited onto the fans or piedmont floodplains into the mainstream rivers which could lead to rapid channel aggradation.

6.11 SUMMARY AND CONCLUSIONS

6.11.1 Summary
The information presented above is summarized in a balance sheet format in Tables 17 through 20.

6.11.2 Conclusions
The preceding regional analysis identifies a large number of elements of the development and water systems in terms of strengths, weaknesses, opportunities, and threats to the systems. Some of these elements will have a greater influence on the effectiveness of any interventions in the system than will others. To be effective, the water management strategy needs to build on key strengths and promote the foremost opportunities, while taking account of critical weaknesses and mitigating the effects of the dominant threats.

Much of the region's drainage system has changed over the last 30 years (as a result of man-made closures and shifts in the Kushiyara and Surma Rivers). Drainage courses through the central basin have been disrupted. This has had an impact on food production systems and on navigation. The effect of various other water management interventions on the floodplain would be substantially discounted if the need for an improved and well defined drainage system is not addressed.

Overall fish catch and fish biodiversity have been declining. The strategy needs to take account of biological management practices oriented to medium- and long-term returns. At the same time, it is necessary to identify and define structural measures to avert continued deterioration of fisheries productivity and diversity.

The need to feed an ever-growing population has resulted in encroachment on wetlands throughout the region. Natural habitats continue to be destroyed to accommodate expanding agriculture and the growing demand for natural products. Nevertheless, the region still contains

a number of large fresh wetlands in a semi-natural condition and the strategy must endorse measures to preserve and utilize these wetlands in a sustainable manner while simultaneously developing and promoting improved farming systems to ensure a food supply that keeps pace with requirements and provides protection from flood and wave erosion to the homesteads of people living in this environment.

The region's economy is still, to a large extent, focused on production of primary products faced with declining national and world prices such as rice. Numerous important factors such as the state of human resource development are responsible for the slow rate of economic diversification but also key among them are inadequate flood protection to urban infrastructure and the flood vulnerability of transportation and communication systems. The strategy must address the need to manage floods in a manner which allows economic diversification and urbanization to occur without floods acting as an impediment.

As population densities increase, water hazards to human health are magnified. To improve the quality of life and reduce the incidence of water borne diseases among the growing urban population, waste water systems and the safe potable water systems need to be developed.

The importance of external controls on the water system such as the proposed dam at Tipaimukh and the barrage at Fulerthal must be implicitly recognized in the strategy. This affects the nature and timing of any proposed interventions and spatially impacts on the eastern seasonally flooded areas and the central deeply flooded basins.

Finally, BWDB exhibits an engineering or structural bias in addressing water system needs, opportunities, and threats. This in combination with various other difficulties institutional difficulties would indicate that BWDB as presently structured can not efficiently nor effectively undertake a major water management program which is comprised of an inter-dependant mix of structural and non-structural measures which require significant inputs from non-engineering disciplines. This weakness needs to be addressed at a national level (outside the scope of the regional strategy) but the strategy must acknowledge the need for a restructured implementing agency.

Table 17: Strengths

Development System	Water System
•Farmers and families strong and resilient •Large, flexible labour force •Sylhet is an important growth centre •Dhaka-Sylhet, Dhaka-Mymensingh growth corridors •Reasonable arterial roads •Eastern part of region receives remittances from the UK •Economic restructuring already underway •National policy changes favour the region •Local rice cultivars well-suited to subsistence farming in this environment •High hyv adoption in the western subregion •Quarrying and gravel mining •Significant natural gas reserves •Increasing policy emphasis on environmental values	•Experience with existing projects •GOB commitment to address water problems •Extensive water transport system •Most rivers are still natural alluvial systems •Abundant fish habitat •Wetlands with considerable biodiversity •GOB legally owns large fisheries and wetlands •Flood levels relatively insensitive to large sediment inputs •Availability of construction materials •Capacity for increased ground water extraction in parts of the region •Generally good ground water quality •Sylhet Basin: -Homogeneity facilitates planning -Residual moisture available for winter irrigation -Acts as giant desilting and storage basin •Seasonally Inundated Areas: -Improved water management is an option -West side: three crops/year possible without costly flood protection •Uplands: -Well drained with little erosion -Areas of forest and unused land exist •Piedmont Plains: -Good drainage -Two rain-fed crops are possible annually

Table 18: Weaknesses

Development System	Water System
•Top down development programs •Poor human resource development •High association between gender and occupational roles •Malnutrition, especially in the northwest part of the region •High and rapidly increasing landlessness •Complex tenurial system •Economy focused to a large extent on rice which is facing declining prices •Relatively inaccessible central *haor* area •Urban infrastructural, social, and management needs unmet •Low adoption of hyv rice varieties in the Sylhet basin •Agricultural inputs and post-harvest services limited •Lack of draught animals •Current natural resources management institutions and information are weak and overly centralized	•No protected wetlands exist – habitats are threatened •Over-focused on flood protection, instead of integrated water development and management •Over-focused on agriculture (rice) rather than development system as a whole •Many projects not completed as designed •Poor operation and maintenance •Meaningful public participation absent in projects •Inadequate regard to fisheries, navigation losses •Dry season surface water shortages results in problems with: -Inland water transport -Fish migration -Pollution concentration -Irrigation •Most flow originates outside the region •Flood management options are constrained by settlements along rivers, whose own flood risk is high and hard to reduce •Sylhet Basin: - no organized internal drainage -Infrastructure maintenance costs high -Construction season is short -Conflicts between agriculture and fisheries -Poor land transportation affects construction -Flood conveyance capacity of major rivers is well below requirements •Seasonally Inundated Areas: -Numerous localized drainage problems -Surface water for irrigation is scarce -Western area: shallow aquifer -Northern portion: flash floods -Eastern portion: interventions on rivers can have far reaching negative effects •Uplands: - no scope for reservoirs -Erosion from poor land use practices •Piedmont Plains: -Surface irrigation is not cost effective since benefits are determined by base flows and costs are a function of flood discharges -Flood hazard is high

Table 19: Opportunities

Development System	Water System
•Democratic government provides opportunity for decentralized development programming •Construction of key road links •Economic and agricultural diversification •Improved communications •Southern part of region is adjacent to the Dhaka mega-urban area with enormous future markets •Increased value added to primary products •Crop varieties are continually being developed for difficult environmental conditions •Growth of local markets will increase demand for agricultural products •Increased use of natural gas and electricity in the rural areas •Improved management practices in the upland areas •Improved production in the livestock sector	•Improved planning •Need for a better mix of structural and non-structural initiatives •Improved project monitoring •Improved fisheries through better management and engineering mitigation measures •Protection of key wetland sites •Tipaimukh Dam in India would: -increase base flows providing opportunities for irrigation, navigation, and fish habitat -reduce monsoon season river levels and moderate flood peaks providing opportunities for agriculture; reduced need for flood protection, drainage improvement, flood damage repairs •Expanded channel re-excavation program •Possible hydro-power development •Agricultural production and effective water management synergistically related •Additional ground water for domestic and irrigation uses in parts of the region •Additional irrigation from surface sources •Sylhet Basin: -Improved drainage by excavating lower reaches of drainage system -Flood mitigation by controlling primary inflows from Surma and Kushiyara -Protect cereals from pre-monsoon flooding -Reducing agriculture and fisheries conflicts through structural means •Improve scheduling of engineering work •Seasonally Inundated Areas: -Channelization -Localized drainage improvements -Afforestation -Full flood protection to Surma-Kushiyara inter-basin area -Improve navigation from quarries to markets -Flood relief channels •Piedmont Plains -Flood relief channels -Improve Khowai River capacity -Develop local irrigation initiatives •Alluvial Fans: -Malijhee-Mrigi flood relief channels -Use of fans for sediment storage, floodway

Table 20: Threats

Development System	Water System
•Social breakdown through landlessness and rapid urbanization •Rice prices may fall •Sylhet economy may overheat •Disruption to rural economy due to removal of subsidies •Increased pressure on marginal lands by landless people •Unsustainable exploitation of biomass and certain species, particularly in wetland and forest areas •Negative environmental impacts, including siltation, from structural interventions	•Projects developed in an uncoordinated manner •Reduced wetlands and fisheries habitat •Over-exploitation and structural impediments may reduce fisheries yield •Climate change — particularly increased rainfall •More pollution through increased industrialization, agricultural activity, and human settlement •Public cuts in embankments •Increased use of surface water in India •Natural hazards such as earthquakes in catchment areas •Over-exploitation of ground water •Sylhet Basin: -Siltation will affect water regime and hence effectiveness of structural projects •Seasonally Inundated Areas: -Flow regime changes due to construction on the Barak River will modify sediment transport regime of Surma and Kushiyara •Alluvial Fans: -Channelizing rivers could produce substantial downstream impacts

7. FUTURE REGIONAL DEVELOPMENT CONTEXT

7.1 INTRODUCTION

Water management and development should be consistent with and serve the needs of overall development. It follows that rational regional water planning should take place with reference to and in the context of regional development plans. When such plans are not available, as is the case for the Northeast Region - and NERP lacks the mandate and resources to produce such plans - the need remains for a consensus as to the likely future of the region in terms of key variables such as demography, economic structure, urbanization, infrastructure, communications, and biophysical characteristics.

Thus, the purpose of this chapter is briefly to describe the likely future characteristics of the region, focusing on important trends which will affect the region over the 1991 to 2015 period. The scenario presented here is "future without plan" (FWO), that is, characterizes the region as it would appear without the implementation of the strategy and initiatives proposed in Chapters 8 and 9.

Future gazing is an inherently speculative activity, and is often inaccurate. Nevertheless, informed, explicit conjecture based on the best judgements of project analysts is preferable to proceeding blindly or on the basis of models known to be inadequate (inappropriate straight-line trend extrapolation, rear-view mirror projections).

7.2 FUTURE DEMOGRAPHY AND HUMAN RESOURCES DEVELOPMENT

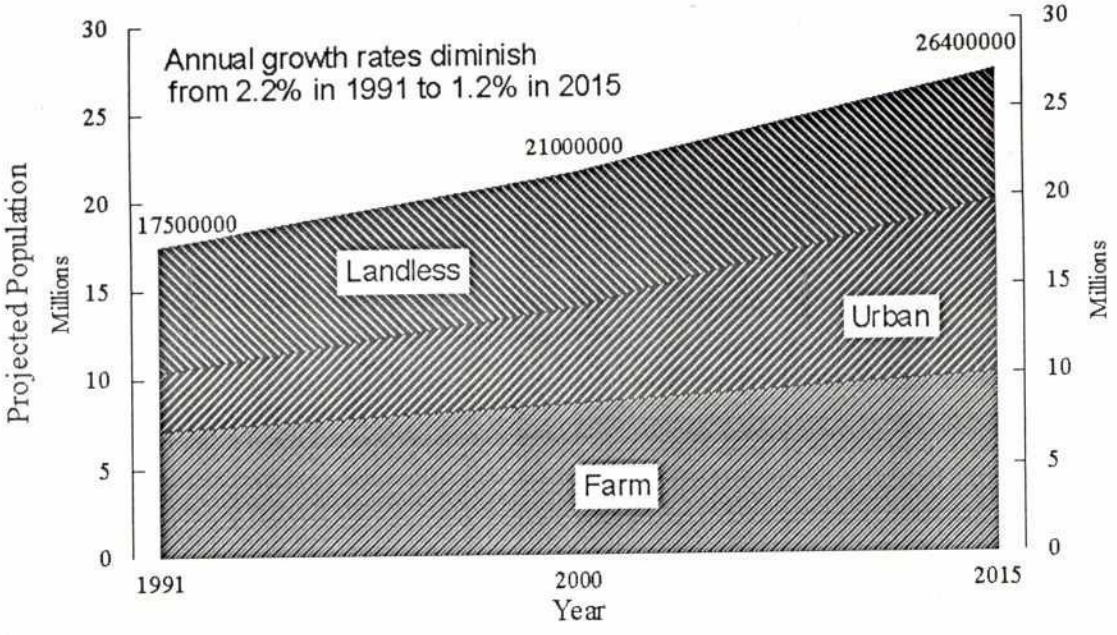
7.2.1 Regional population

Developmental planners tend to commence analysis with demographic analysis because demography drives consumption (private and public) and production to a large extent as well as being closely linked with environmental conditions.

The 1991 population of Bangladesh was estimated to be 109.9 million, and that of the region is estimated by the NERP team to have been 17.5 million. Population density for all of Bangladesh is 763 persons per km^2, while that of the region is 723 persons per km^2.

Population growth in Bangladesh during the period 1981-91 averaged 2.0% per annum, and in the region averaged 2.2% per annum. Government has set a target to achieve a growth rate of 1.8% during the Fourth Five Year Plan period (1990-95), and to achieve replacement level fertility by year 2005. In that population growth in the region is relatively higher than for the nation, it would take longer, probably an additional five years, to attain replacement level fertility in the Northeast Region. Hence, it is assumed that the population growth rate in the region will be 1.8% in the year 2000, and 1.2% in 2015. Based on these assumptions, the regional population would increase from 17.5 million in 1991, to 21.0 million in year 2000, and 26.4 million in 2015 (see Graph 7.1). It is the judgment of NERP that this projection is optimistic, that is, possibly on the low side.

Graph 7.1: Regional Population Estimates



7.2.2 Urban population

Urban population was 3.3 million in 1991 and is expected to increase to 4.8 million in 2000, and to 9.0 million in 2015.

This forecast is based on reasoning as follows. The annual rate of urbanization in Bangladesh, one of the highest in the world, was about 6% from 1981 to 1991. Although urban growth is expected to slow during the planning period, it would still proceed at relatively fast rates of 4% in 2010 and 3.6% in 2015. The level of urbanization in the Northeast Region (in 1981, 11% of regional population) lags behind the country as a whole (in 1981, 15% of national population), and slowing of regional urban growth is expected to lag behind the country as a whole. On this basis alone, regional urbanization would be expected to be 19% in 1991 (3.3 million), 26% in 2000 (5.4 million), and 37% in 2015 (9.8 million). Constraints on development in the industrial and service sectors and expected advances in agriculture dictated a downward adjustment to the future urban population estimates, yielding the forecast given in the previous paragraph.

An estimated 0.7 million of the 1991 urban population of 3.3 million resided in the eight major centres. This would increase to 1.6 million by the year 2015. The remaining urban population, located in the 74 *thana* headquarters and other smaller towns, would increase from 2.5 million in 1991 to 7.4 million in 2015. Many of the currently small towns will become significant in size, with many having populations over 50,000 in their functional areas, and some over 100,000. The mean size of the smaller urban centres may almost 100,000. If this pattern emerges, the region will have a diverse and well-balanced urban hierarchy, although Sylhet and Moulvibazar in the east of the region will play dominant roles.

7.2.3 Implications of urbanization

A possible consequence of rapid urbanization could be a shortage of affordable land and housing for many of the people, and may lead to the development of slum areas. This form of unplanned development is typically associated with inadequate shelter, poor public health, water stagnation and impeded drainage, lack of sanitary and garbage facilities, contaminated water and air, and a general shortage of public utilities, services, and transportation. An associated characteristic frequently is increases in violence and crime. The urban poor, particularly slum dwellers, often are unable to obtain adequate food, and children are the main victims. On the positive side, urban areas generally have higher rates of literacy and per capita income than do rural areas.

Rapid urbanization will likely be accompanied by a growing trend towards public programmes to improve public health and the public environment which will become increasingly feasible as the economy grows. Such initiatives are likely to be in areas such as public health, neighbourhood nutrition programmes, sites and services projects, and neighbourhood improvement projects.

The most important consideration in urbanization is the availability of opportunities for earnings, and the need to create an additional 2.0 to 2.5 million jobs in urban areas of the region will be a major challenge. However, people have been more reluctant to urbanize in the Bangladesh context and in South Asia as a whole, as compared to other areas of the developing world, unless there is a reasonable opportunity to obtain income opportunities. As long as this reluctance persists, urban slums in the region are not expected to become a problem of the same magnitude as experienced in some other parts of the world. However, the flip side of the coin is that rural landlessness is likely to remain high throughout the planning period in the region.

7.2.4 Landless population

The landless population (owning $\leq$0.2 ha of cultivable land) was 7.1 million in 1991 and is expected to increase to 7.7 million in 2000, and then decrease back to 7.1 million in 2015.

The reasoning is as follows. Landlessness nationally and in the region in 1983 was 50% of the rural population, according to the 1983-4 census of agriculture and livestock. Assuming in the absence of newer data that landless population as a proportion of rural population stays at this level through the planning period, regional landless population would be 7.1 million in 1991, 7.8 million in 2000, and 8.3 million in 2015.

The extent of landlessness is primarily a function of economic growth relative to population growth. Based on the estimates of these two parameters, it is estimated that the landless population will increase from 7.1 million in 1991, to 7.7 million in 2000, and then start to decline as people are absorbed into the secondary and service sectors, and, to a much lesser extent, agriculture.

7.2.5 Farm population

The regional farm population (rural population residing on holdings of more than 0.2 ha) is estimated to have been 7.1 million in 1991, or 40% of regional population. This is expected to grow to 10.3 million in 2015, still at 40% of regional population. Most newcomers to agriculture will be the children of existing farmers rather than persons from outside the sector buying farmland. Other offspring of current farmers will become landless or move to non-agricultural income earning roles. The major change in land tenure would be a reduction in average size of medium- and large-scale farms as these are divided up among inheriting sons. The average

medium-size farm would reduce from 1.5 ha to an estimated 1.2 ha, and the average large farm would reduce from 4.5 ha to 3.3 ha. Small farms essentially cannot become any smaller without losing their ability to support farm families.

The proportion of the increase in population which will be absorbed by family farms will be partially determined by the development of market opportunities for agricultural outputs which will be heavily influenced by developments in the non-agricultural sectors. If the regional economy grows at 5% to 6% annually creating increased demand for agricultural products, particularly higher-value product, farms would probably be able to absorb an additional 4 million people during the planning period without any loss in real income per person dependent upon agriculture. Given the competition for employment in other sectors, and the continued existence of landlessness, these factors will act as a brake on per capita income gains to farmers. Realistically, farms could absorb about an additional 1.5 million people by 2000, and a further 1.5 million by 2015, with a 2% per annum increase in real earnings per capita.

A frequently expressed concern in and about Bangladesh is the present and anticipated future population density, and the shortage of available cropland per capita. While clearly a matter of concern, it is important that the statistics be kept in context as related to other nations in Asia. Bangladesh has 0.09 ha of cropland per capita, but half of the people of Asia have less, for example, Java and China have 0.08 ha. What is likely a greater concern in the Bangladesh context is the amount of cropland per person in agriculture, which is 0.12 ha. This is about the same as China (0.13 ha), and only slightly less than Vietnam (0.16 ha). The implication is that the population density *per se* is not the issue so much as how the land and other resources are used.

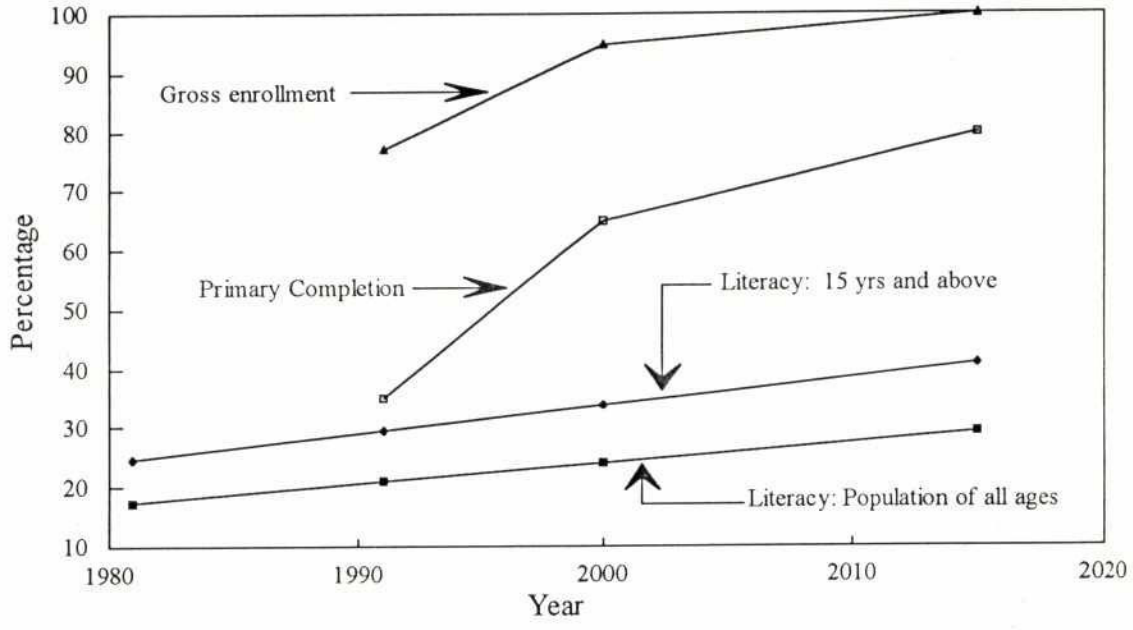
7.2.6 Literacy

The importance of literacy and education in the development process can not be over-emphasised; this is especially true in the Northeast region where levels of human resource development are currently generally very low. Human resource development is almost certainly the most important factor to be addressed and financially supported if development is to occur in the Northeast region.

The adult literacy rate for the region in 1991 was 29%, compared to 34% for the nation. The rate of literacy has been increasing slowly in both the country and the region, increasing by about 0.5% per year during last ten years. Assuming the same rate of increase in the future, the region would attain an adult literacy rate of 34% in 2000, and 41% in 2015.

The national target for gross enrolment for primary education has been set at 95% by the year 2000, and 65% for primary school completion. Assuming the same proportional increases as in the past few years, a primary completion rate of 90% would be achieved in the Northeast region by the year 2005.

Graph 7.2: Literacy

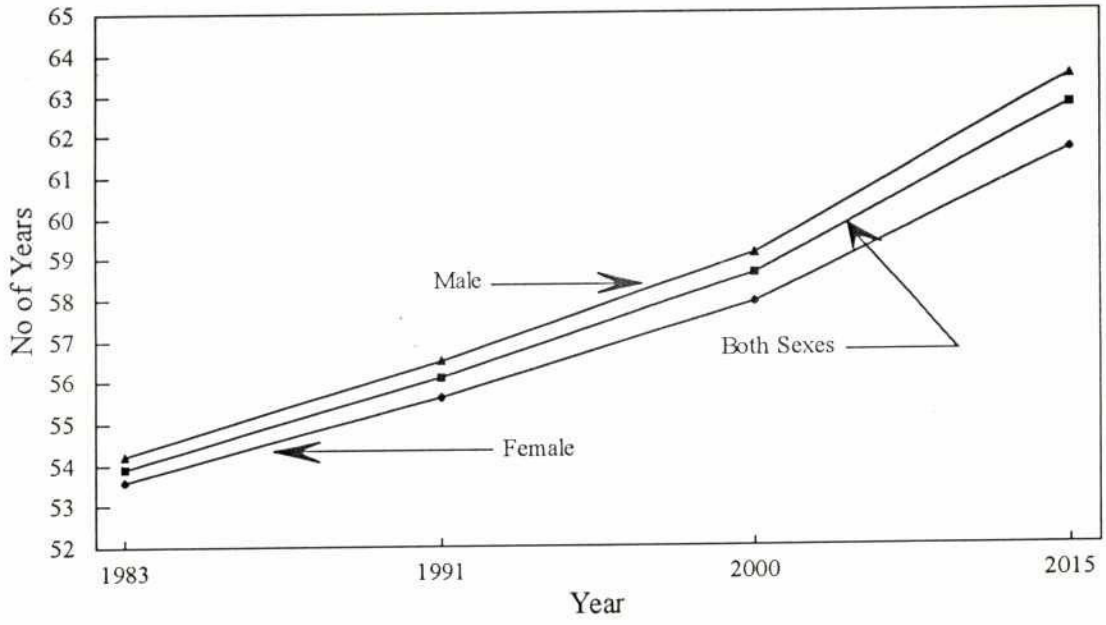


7.2.7 Life expectancy

Life expectancy data is not available for the Northeast region; hence, the data which follows is national. In 1991, life expectancy at birth in Bangladesh was 56 years. The increase in life expectancy during 1983-91 was slightly more than three months per year. Assuming similar trends in the future, life expectancy at birth would increase to 58 years by the year 2000, and 63 years by 2015.

Life expectancy is greatly influenced by infant and child mortality. In 1990, the infant mortality rate (IMR) was 110 per 1000 live births, and the child death rate (under 5 years of age) was 184. The national goals for these rates in the year 2000 are 50 and 70 respectively. Reduction of child mortality would greatly affect the statistic on life expectancy at birth; for example, at present the life expectancy of a 5 year old child is about 68 years. The apparent success of the *Expanded Program of Immunization* would suggest that life expectancy in future will increase significantly, and it is expected that life expectancy by the year 2015 will be at least 65 years.

Graph 7.3: Life Expectancy at Birth



7.3 FUTURE ECONOMIC STRUCTURE

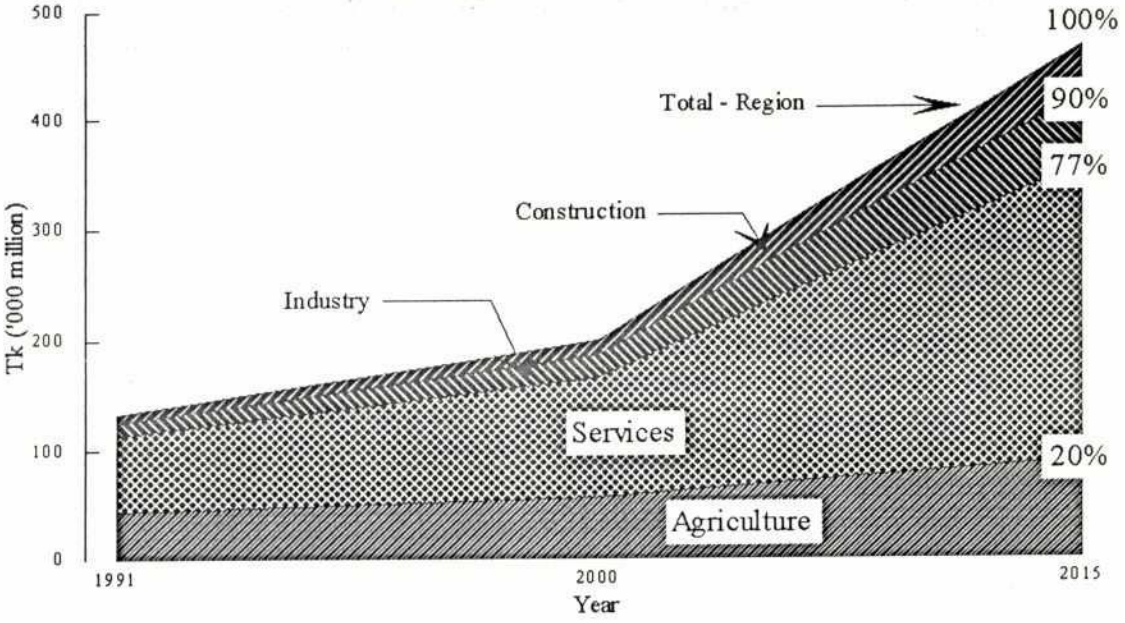
7.3.1 Regional and subregional economies

Economics is concerned with measuring the real earnings of labour and property employed in the production of goods and services. Economic performance is usually measured by Gross Domestic Product (GDP), or Gross Regional Product (GRP) as applied to the region[1]. It reflects both earnings, and the value of output which is available for consumption or savings. It does not however provide information on who receives the benefits, and this is discussed and qualified in the following as appropriate.

The regional economy is dominated by agriculture (30%) and services (52%). About 70% of the value of agriculture output is rice, and it is estimated that more than half of this is for home consumption. The service industry largely relates to transportation, communication, trade, public services, administration, professional, and business services. Industry (manufacturing) accounts for 8% of regional output, with about half of this from large scale industry and most of the balance coming from small scale industry serving agriculture such as rice mills. Construction contributes about 6% of the GRP. The regional economy differs from the national economy only in that the region has a higher dependence on rice, and a proportionately smaller industrial base.

[1] An associated measure is Gross National Product (GNP), which also considers foreign transactions. For the regional analysis, the foreign transactions are dealt with explicitly.

Graph 7.4: Regional Economic Development



The GDP of Bangladesh grew by 5.8% in FY90, and 3.6% in FY91, the major increases being in large scale industry (over 6% growth), and crops (over 5% growth).[1] During the same period, the economy of the region grew by 7% and 4.8%, more than 1% faster than the national economy. A large part of the regional increase was due to the excellent rice harvest of FY90. However, other sectors also performed well.

On a subregional basis, the economic performance for FY90 and FY91 were as follows (the regions referred to below were formerly termed districts; in most cases, only part of the region is in the Northeast region although data presented is for the regions as a whole):

- Dhaka region grew by an average of 5.5% per year. The largest gains were in crops (over 11% per year), and large scale industry (over 6% per year).

- Sylhet region had the highest growth rate of any of the subregions, averaging 7% per year, with the major expansion being in the crop sector (12% per year) and trade and services (8% per year). The construction sector expanded by only 4% per year, the same as the national average, which is somewhat at odds with perceptions about the impact of remittances on the region.

- Mymensingh region grew by an average of less than 4% per year, largely reflecting the performance of the crops sector. The other significant sectors in Mymensingh expanded well below the national average.

[1] Subsequent growth rates were 3.9% in FY92, and 5.1% in FY93.

- Jamalpur region grew by slightly over 5% per year, again mostly reflecting expansion in the crops sector. As in Mymensingh region, the other significant sectors experienced little growth.

- Rangpur grew by 5% per year, mostly reflecting expansion in the service sector.

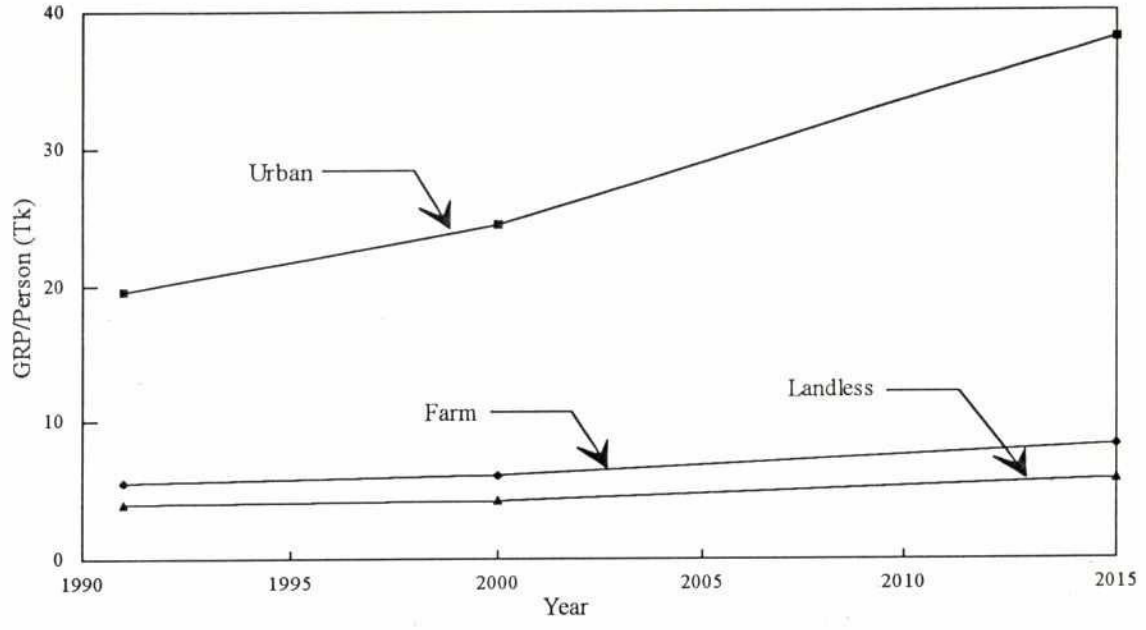
In terms of future trends, it is envisaged that economic growth will be the priority as the means to improving the quality of life of the people. This has been stated in the New Development Perspective, and in the budget speeches for FY93 and FY94. Part of the process will necessarily entail measures to increase investment, particularly in higher value activities and in value-added industries. It is unlikely that increased taxation will play a major role as a means of obtaining the required capital investment, and a consequence may be increased inequities in the distribution of earnings and wealth. Local participation in raising and directing investment funds is expected to grow substantially as a means of contributing to distributional equity in the system.

7.3.2 Primary production sectors

It is anticipated that the agricultural share of the regional economy will decline from the present 30% to less than 20% by the year 2015 – due to the higher anticipated growth rates in the non-agricultural sectors. This is a reflection on the availability of a market for the agricultural output, particularly higher value agricultural products; for example, the value of agricultural output could possibly grow by 5% to 10% per annum if there were an effective market for the output. This pattern could be altered if the region could serve as an agricultural basket for other parts of Bangladesh. However, other regions have their own problems and needs, and there is no reason to assume that they will decrease their reliance on agriculture. The Dhaka market is the exception, and it could serve as a major target market for the southern part of region, and for selected products such as fish, fruit, vegetables, and specialty rice. In total, the trends would suggest that agriculture will continue to diversify and grow at about 3% per year through to the year 2000, and between 3.5% and 4.0% thereafter as the balance of the regional economy grows providing improved marketing prospects for agriculture.

All evidence suggests that Bangladesh will be self-sufficient in rice production in the future (though the hunger gap associated with lack of purchasing power of the poor will persist), and that rice policy is likely to focus on managing and stabilizing the rice supply, and ensuring adequate supplies of rice in times of crisis. From an economic perspective, this will have a negative impact on the region, which produces more rice than it consumes, and it seems unlikely that there will be any significant opportunity for exporting rice as a way of alleviating this problem (gluts are expected on international rice markets over much of the planning period). However, as incomes rise there will be a substantial shifts in consumer demand, particularly for additional vegetables, pulses, fruits and meats, all of which have high income elasticities. It is expected that the regional producers will respond to the changes, and the future is expected to include a substantially diversified agriculture, and major improvements in the quality and sophistication of marketing of non-rice crops. If this happens, there will be an increasing demand for improved rural marketing systems and infrastructure.

Graph 7.5: Gross Regional Product Per Person



The only significant advances envisaged for the livestock sector relate to increased production of ducks and duck eggs, dual purpose cattle (milk and meat), and poultry - all targeted on the expanding middle class. There is an associated potential of using livestock as a means of utilizing potential surpluses in rice production. There may be some lesser potential for increased sheep and goat production, particularly as related to using the milk for products produced by cottage industry.

The impacts of the anticipated shifts in consumer demand would affect the subregions differently. The comparative advantage of the eastern part of the region would be in fruits, vegetables, specialty crops and livestock. The central deeply flooded area would have the advantage in specialty rices and other high value crops related to wetlands, as well as high value fish. The western part of the region would maintain a heavy dependence on rice, pulses and vegetables.

Subsistence fisheries are an essential component of the rural economy, largely for their social (in distributional terms) and nutritional benefits. There is a growing trend to give this sector explicit consideration in economic and development planning. There is also a trend towards increased commercial fisheries in the deeply flooded areas, serving regional, national, and export markets. This is of particular importance to the region because of the depressed state of the economy in the deeply flooded areas. The fisheries export industry is heavily dependent on maintaining a regular supply of raw material and this is threatened by declining production per person with resultant rapid increases in prices. The industry is also threatened by sedimentation of the water courses and resultant impacts on transportation, which is a growing concern for all sectors and one which will likely receive increasing attention over time.

Continued trade in timber from India will serve the wood products industry well, but will also result in relatively low prices for locally produced timber. This, however, is not viewed as a

serious situation in that there is very limited production of trees for timber in the region. The advantages of low timber prices would seem to far offset the negative impacts on the production of trees for timber. As such, it is expected that the major opportunities for increased tree production will relate to tree crops, fuel, associated benefits to fisheries, and other environmental benefits.

7.3.3 Industry and service sectors

The industrial (secondary) sector is likely to provide an additional 1.0 to 1.2 million jobs in the region by the year 2015. In 1993, 1.0 million jobs existed in the Bangladesh garment industry alone. It is estimated that almost an equal number of jobs will be created in the service sector.

To achieve the above employment creation in the secondary sector, and to a lesser extent in the tertiary sector, will require development of firms servicing both the Bangladesh and export markets. In population terms, the Bangladeshi market is large; the growth of the urban middle class in Bangladesh will considerably increase demand for products.

Natural resource input based industries will continue to play a significant role in the non-agricultural sector of the region's economy, for example, quarrying, cement plants, pulp mill, fisheries processing, agricultural processing, and fertilizer plants. However, many, if not most, of such industries will be constrained by biophysical limits to increased input production, particularly natural gas, fish, and wood for pulp. Small scale and cottage industries, including rice milling and weaving, will continue to provide employment opportunities. Agro-industries, in addition to rice milling, are likely to arise as agriculture becomes more diversified. Although demand is good for leather products, activity will be limited by the availability of hides.

There is potential for other industrial development along the Dhaka-Sylhet corridor, especially if the various problems associated with governance are rectified to the point where Bangladesh can compete with other Asian countries in attracting either local or foreign capital. Export oriented industrial development is likely to include extruded plastics, mass production manufacturing such as electronics, garments (which is well established already in Dhaka), and textiles.

Wage rates in Sylhet are significantly above those in other urban centres in the region, and in Dhaka itself. Thus there is likely to be growth of non-agricultural employment in other urban centres of the region where wage rates are lower. This is a factor contributing to the expected rapid rate of growth of smaller urban centres. However, most non-agricultural employment growth is expected to take place in urban centres because rural infrastructure (roads, telecommunications, electricity) is very poor in much of the rural Northeast and there will still be significant, although lessening, constraints in this regard throughout the planning period.

Much of the export oriented manufacturing activity will locate in the Dhaka urban field portion of the region. This activity, which could be very significant in terms of employment and investment will essentially represent spill over from the Dhaka metropolis. Physically, industrialised parts of this area are likely to be characterised by large single floor factories; these firms will often be grouped in industrial estates.

The service sector will continue to grow through local trading, personal services, and governmental functions. As the non-agricultural sector increases in importance, there will be a significantly increased growth in employment in business and professional services. There is

some potential for tourism in the Sylhet area. The middle and upper classes of Bangladesh (largely based in Dhaka) might spend some of their income in that area, given nearby tea estates, hill areas, tribal groups, and important cultural sites and artifacts. The Parjatan Motel which will open shortly at Sylhet may be an important market indicator in this regard.

The Sylhet connection to foreign remittances is important to the region, but somewhat over-estimated in terms of its impact on the average person. To date, much of this money has been invested outside the region, while most of the associated investments in the region have been in land and housing, neither of which have a significant multiplier impact on the regional economy. In fact, some of the land investment has had the effect of decreasing agricultural output because those receiving remittances can afford to forego agricultural earnings, especially given the fact that land taxes are very low. The remittances are expected to continue (although East and Southeast Asia may become more important in terms of source), the challenge will be to have more of these funds invested in the region, particularly in productive investments.

7.3.4 Transportation and communications sectors

Water transportation is, and likely will continue to be, the most important transportation mode in the region, particularly for agricultural products and other low value by weight commodities. The rail system is relatively insignificant compared to either the water or road systems although it plays an important role in terms of passenger transportation in the Sylhet corridor. Road transportation will become more important as the need to move manufactured products to the Dhaka market or to Chittagong port increases. However, the road transportation system is hampered by the high costs of road construction and maintenance. The main emphasis will be on road maintenance and improvement, including greater provision for cross-drainage in existing roads. There may be some opportunities for combining roads with flood control measures to achieve improved cost efficiencies. The recent decision to increase the length of the runway at Sylhet airport and improve airport facilities will improve the environment for tourism and for export oriented manufacturing which often requires air transportation for movement of critical inputs (including spares), key personnel, and shipment of high value products to time sensitive markets.

Given the past and existing traffic patterns, it is expected that the major road transportation corridors in the region will extend from Dhaka to the Indian border via Sylhet, and from Dhaka to the Indian border via Sherpur. From a purely regional perspective, it would be favourable to visualize a transportation corridor connecting the eastern and western portions of the region. The Joykalash-Mohanganj segment of a road to link sylhet to Netrokona, has been proposed by an RHD Road Master Plan. However, the interaction patterns of inhabitants of the region are likely to be more with neighbouring regions.

Communications in the region are rapidly becoming more sophisticated, including the widespread availability of radio, telephone and television reception from national and international centres. As communication equipment becomes relatively more affordable, and as more of the regional population are exposed to improved information, this trend is expected to continue. During the planning period, it is expected that all of the population will have access to at least some source of current national and international news plus a variety of national and international entertainment programmes.

7.4 FUTURE BIOPHYSICAL ENVIRONMENT

Changes to the biophysical environment during the period 1991-2015 will depend on the modifications that develop to the key driving forces such as climate, hydrology, sediment supply, land-use and water-use. Interpretive assessments were made about future changes to climate, future upstream flow regulation in India, and future morphologic changes that are expected in the region. The cumulative effect of these changes to water levels and discharges in the region was simulated by using a hydrodynamic model developed by the Surface Water Modelling Centre (SWMC) and FAP-6. Data from the 1991 water year was used to compare present-day and predicted future conditions. The return period of the 1991 floods generally ranged from 2 years to 25 years in the region and conditions were particularly severe during the pre-monsoon flood.

This analysis indicates that the region's biophysical environment will undergo significant change during the period 1991-2015. The main factors that will govern these changes are described below.

7.4.1 Possible rainfall and flooding trends and impacts

Future rainfall and rainfall variability cannot be predicted, not even as to whether they would increase or decrease. Observed trends over the past few decades are disturbingly large, however, and future increases or decreases could be similar in magnitude. Over the period 1901 to 1991, the shape of the regional rainfall pattern was remarkably stable, but annual rainfall increased moderately (10%), and its variability from year to year increased markedly (50%).[1] Also, over the period 1964 to 1989, one-day rainfalls increased rapidly (70%).

Increases in rainfall and rainfall variability are consistent with predictions that monsoon circulations intensify with global warming (specifically, with increasing longitudinal temperature gradient). This is somewhat academic, however, as the current and future status of global warming is still a matter of substantial uncertainty and controversy, and its potential impacts on this particular region unknown. It must be borne in mind that climate varies on all timescales for a variety of reasons, complicating any search for causes.

Rainfall and flooding influence regional morphology, in their influence on sediment supply and runoff characteristics. The most sensitive subregions are the Meghalaya fans in the north and the Tripura piedmont streams in the south. The main lowland rivers such as the Upper Kushiyara River (upstream of Manu River) Upper Surma (upstream of Sylhet) and Meghna River will be less sensitive.

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[1]Annual rainfall data at 51 stations for the years 1901-1991 was used. To investigate the variation over time of the rainfall pattern, each station's data was averaged in three 30-year bins (1901-1930, 1931-1960, 1961-1991) and three maps generated. The rainfall trend is estimated by a three point time series of the 30-year and 51-station annual rainfall mean. The variability trend was calculated by taking the standard deviation of each year's 51-station mean from the relevant 30-year 51-station mean.

If rainfall and rainfall variability:

- Stay at present levels, then conditions such as those experienced in the late 1980s and 1990s would prevail. Morphologic processes in the fans, piedmont streams, and elsewhere would continue at current rates.

- Continue to increase, then existing structures would be overwhelmed with increasing frequency and with ever more disastrous results. Pre-monsoon flood damage to winter crops would increase, though wetter winter seasons could also directly benefit the boro crop and crop diversification. Fisheries and wetlands would benefit, particularly from wetter conditions in the critical low period. As peak flow magnitudes increase, sediment yields to the region will also increase. Higher rates of lateral channel instability and aggradation are also likely to be experienced on alluvial fans and the lower portions of piedmont rivers.

- Decrease back towards historic (pre-1960s) levels, then the flooding situation would improve and structural failures would be less frequent. Drier winter seasons would decrease base flows, constraining boro production and crop diversification. Fisheries and wetlands would be adversely affected. As flood flows decrease, channels will tend to be more stable and the rate and magnitude of morphologic processes will be less.

7.4.2 Hydrologic impacts of Tipaimukh Project in India

India has recognized the potential for constructing a major dam on the Barak River at Tipaimukh gorge for many years. In recent years a proposal has been advanced for a multi-purpose project that would provide hydro-power and flood control (see page 37 for a project description). Information obtained through the Joint Rivers Commission provides a minimally adequate description of the project which has been used to make preliminary assessments of impacts on the region. Construction was proposed to start by 1993 but has been delayed pending resolution of various issues including the effects of flow regulation on Bangladesh. Regulation of the Barak's flow by Tipaimukh Dam would provide India with the opportunity to irrigate the Cachar Plain; this India proposes to do. Since this will involve a loss of water from the Barak, it is a matter of concern to the northeast region of Bangladesh. No statement is available as to how much water India proposes to take from this scheme. For the purposes of this study it has been assumed that the total depth of irrigation water to be applied is 1 m and that the water is diverted on a continuous basis during the six dry months (November through April).

Based on this information it is clear that significant impacts on the region will result from implementation of the Tipaimukh Dam and Cachar Plain Irrigation scheme. During an average flow year these impacts would include:

- Flood flows on the Barak River will be moderated, with peak flows at Amalshid being reduced by about 25 % and flood water volumes being reduced by 20 %. The corresponding water levels at Amalshid would be reduced by about 1.6 m. Similar changes would be expected along the Kushiyara River and upper Surma River. This should reduce the frequency of spills from the Kushiyara and Surma Rivers, reduces the extent of inundation in the Sylhet Basin and reduce channel erosion and sediment transport rates along the two rivers.

- Dry season flows will be increased substantially (for example, average flows of the Barak River at Amalshid would be 4.2 times larger in February and overall dry season flow volumes would increase by 60 %). This would increase water levels by 1.7 m at Amalshid. Increases in dry season water levels would also occur on the Kushiyara and Surma Rivers (for example, water levels during March should increase by 1.5 m at Sherpur. These increased dry season flows will provide benefits for navigation, irrigation, and fisheries, but could also reduce drainage from some areas.

Proposals for other dams on the Sonai and Dhaleswari Rivers (tributaries of the Barak) are not thought likely to be taken up before 2015. Therefore, no discussion of these proposals has been included in this study.

7.4.3 Morphologic changes

Construction of flood control embankments, loop cuts, channel closures as well as ongoing channel changes over the last 20 years are responsible for a number of morphological adjustments that are currently underway. These adjustments may take several decades to run their course, with impacts propagating long distances from the original point of disturbance. The most serious impacts will result from ongoing aggradation of the lower Kushiyara/Kalni River which is occurring as a result of the several factors including upstream channel shifts, impacts of past loop cutting and alteration of the river's flow regime. Future developments would include:

- Increased spills into the Baulai River and eventually a partial avulsion from the Kalni River near Ajmiriganj towards the Baulai River;

- Increased pre-monsoon flood levels between Madna and Sherpur, affecting 5,000 km^2 of the central Sylhet Depression, including fourteen existing submersible embankment projects.

- Increased overbank spills, causing greater floodplain sedimentation and infilling of beels adjacent to the channel in a zone 40 km long by 1 km wide, with negative impacts to fisheries.

- Elimination of existing duars in the aggrading reach between Markuli and Madna, with additional negative impact to fisheries;

- Reduced navigation along the Kushiyara River during the dry season and eventual isolation of ports such as Ajmiriganj.

Similar, channel changes also appear to be occurring on the Baulai River near Kaliajuri. However, aggradation rates appear to be lower than on the Kalni and have only occurred during the last 5 - 10 years.

The future sediment loads supplied to the region will depend primarily on future climatic conditions and the extent of land-use disturbances in the catchments. There is evidence from satellite photos that sediment yields from the Tripura Hills and Meghalaya Hills have increased in the last few decades. The main impacts from increased sediment yields would be reduction of land area suitable for agriculture, increased hazards to infrastructure and further reduction of fish habitat such as duars and beels. Increased sediment yields from Tripura will affect Piedmont streams such as the Juri, Manu, Dhalai, Karangi, Sutang and Lungla Rivers. Increased sediment

yields could accelerate ongoing sediment aggradation within flood control embankments on rivers such as the Khowai River and Chillikhali River. The overall affected area amounts to about 960 km^2 or about 4% of the region.

Increased sediment yields from Meghalaya, on the northern boundary of the region, will increase channel shifting and sedimentation on the alluvial fans which extend from the Dauki/Piyain River in the east to the Someswari River in the west. The total affected area is about 1,400 km^2 or about 6% of the region. Naturally occurring patterns of instability on alluvial fans will result in abandonment of some existing channels and development of new channels over time spans of ten to 20 years. For example, major avulsions appear to be either in-progress or imminent on the Dauki/Piyain, Dhalai Gang, Jadukata and Someswari Rivers. However, channel avulsions could occur on any of the fans in the region over the time period considered in this planning study.

In most cases, the impact of avulsions will be largely restricted to the fan areas. However, in the case of the Someswari River, an avulsion down the Atrikhali River would impact over much of the Kangsha River basin. For example, math model simulations indicated the avulsion would decrease discharges in the Kangsha River at Jaria by 250 m^3/s, or 20% of the monsoon peak and reduce flood levels on the Kangsha River by 0.3 to 0.5 m. This reduction would be offset by an increase in the eastward spills via the Atrikhali and Old Someswari Rivers. In other words, flood conditions will be reduced in one area but will be intensified in other areas.

A somewhat similar change is occurring on the fan of the Jadukata River, where an avulsion is causing peak flows to spill westwards into Matian Haor and Tangua Haor. The math model simulations indicated that two thirds of the peak flows and virtually all of the low flows will pass down the avulsion channel, so that the Jadukata River would become essentially a dry channel most of the time. Important wetland habitat, such as Tangua Haor will decrease in size as a result of the rapid sediment infilling that will occur after the channel shift is completed.

The net effects of such changes will result in both positive and negative societal impacts. Infrastructure, agriculture, and local residents near the newly developed channels will be seriously affected by increased flooding, erosion and overbank sediment deposition. Near the site of the abandoned channels, flood levels will be decreased while navigation will be impaired.

7.4.4 Cumulative Effects on Water Levels and Discharges

The cumulative effects of flow regulation and channel aggradation on the Kushiyara/Kalni River and Surma/Baulai River were estimated from the mathematical model simulations. These computations indicated that increased winter discharges and siltation along the Kalni River have the potential for raising the pre- and post-monsoon water levels by as much as 1.5 m at Markuli. During the monsoon season the effects of channel aggradation are largely offset by the flow regulation from Tipaimukh dam, so that the peak water levels were increased by about 0.3 m. The impacts from such changes would include greater depth and extent of flooding during the monsoon season, retarded drainage during the post-monsoon season and earlier and more severe pre-monsoon flooding of unprotected areas adjacent to the river.

Changes along the Surma/Baulai River were found to be similar in nature but smaller in magnitude than on the Kushiyara/Kalni. For example, at Sukdevpur on the Baulai River, water levels during the monsoon season were found to be virtually unchanged from existing conditions. During the post-monsoon season, water levels were raised by about 0.8 m. At Bhairab Bazar,

on the Meghna River, water levels and discharges were found to be only slightly affected by upstream changes in a year similar to 1991, but may be more significant during drier years.

7.4.5 Overall biophysical trends

Land use will change only slightly. Total cultivated land will decrease by some 40,000 ha (2.5%), due to urbanization and development of infrastructure. Within the cultivated area, the non-rice area will increase at the expense of rice. Overall, the rice area will start to decline during 2000-2015.

Agriculture will continue to evolve slowly. Crop yields are expected to increase by 1 or 2% per year, mainly due to minor irrigation expansion and increased use of fertilizers and pesticides, with continuing secondary impacts on water quality, fisheries, and biodiversity (see below). Cropping intensity will increase slightly and cropping patterns will shift towards higher-value crops; production of particular crops could grow as fast as 5% per year. Overall, crop production is expected to increase 3% per year by value. The region will remain self-sufficient in rice production.

The leading factors for *fisheries* trends will be future hydrology and sedimentation. Both are subject to a high degree of uncertainty, but it appears that their fisheries impacts would tend to be opposite in sign in the long term: increasing rainfall, rainfall variability, and inflow from outside the region would all favour fish production directly and also indirectly through increased risk and damage to crops, but would be accompanied by higher sedimentation rates which tends to destroy particularly valuable habitat elements such as *duars*, the deeper parts of *beels*, and so on. Conversely, less water is overall less favourable for fish but would not have the negative sediment effects on fish habitat. In either case, a growing population of rural households dependent at least in part on subsistence fishing, the growth of urban markets for fish, and deterioration of water quality (see below) will all increase the pressure on fish stocks.

Water quality will generally deteriorate, as rural and urban sewage effluent, pesticide and fertilizer contaminated run-off, and industrial discharges increase, accompanied by increasing irrigation surface water withdrawals. Waste treatment is not likely to improve in the absence of strong intervention. The result will be increased damage to public health, fisheries, and biodiversity.

Biodiversity will be lost, in particular key wetlands will lose much of their ecologic character and international significance through encroachment, over-harvesting, and increasing disturbance; reed lands will continue to be degraded, eliminated, and may be lost as a habitat/community; the status of currently threatened animals and plants will decline and some may become extinct in the region and perhaps (Pallas's Fish Eagle and possibly others) globally. Additional species will become threatened or commercially threatened. Swamp forest will likely fare better, for reasons of tenure and perceived economic and fish habitat value, but the few stands currently having value as habitats and ecologic communities will lose these characteristics; hijal gardens will continue to suffer from poor yields due to poor management.

7.4.6 Likelihood and possible impacts of hazards

The region is known to be vulnerable to earthquakes. These events, though relatively rare are extreme in intensity, and can reverse existing morphologic trends and even induce systemic reconfiguration. The likelihood that during 1991-2015 the region would experience an earthquake of magnitude 7.6 (similar to the 1918 event, return period of 30 to 50 years) is between 40 and 60%; of magnitude 8.7 (similar to the 1897 event, the largest on record, return period of 300 to 1000 years) is perhaps 2 to 5%.

7.5 SUBREGIONAL SPATIAL PATTERNS

The Northeast Region, given its size and population, varies considerably in terms of characteristics. Various spatial subunits have been used in this plan depending on the subject matter being addressed. For example, economic data is organised by administrative regions (formerly old districts); water regime analysis and planning are best addressed using ecological subregions; and major characteristics of spatial differentiation likely to develop during the planning period are best described using socioeconomic subregions. These later units are described here.

The ***Dhaka urban field area*** will likely contain a large industrial presence based on spill over from the current Dhaka metropolis. It is likely that flood protected industrial estates will exist.

Agriculture will likely become less important in this area in terms of land use but will become significantly more important in terms of value of output as significant growth of market gardening (fruits, vegetables) and livestock, such as intensive poultry production, develops. In summary, an ex-urban or edge city type of landscape is likely to emerge in this subregion.

The ***Sylhet corridor***, as noted previously, will continue to attract heavy industry, such as thermal electricity, cement, fertiliser, gas processing, construction materials (aggregates). Some of these activities could be supportive of industrial complexes and might include natural gas based industries such as petro chemicals and plastics including extruded plastics industries such as toys, and household utensils. As noted previously, mass production manufacturing might locate in the corridor; an increase in natural resource based processing is also expected.

The service sector is expected to grow quickly based on governmental, personal, and business services. A small, but significant, tourist industry could emerge in the Sylhet area.

Transportation and communications in the corridor will be the best in the region, supporting the growth of activities noted above.

Because of good transportation, there is likely to be continued diversification of agriculture in the corridor area toward higher value products which can be sold in urban areas, particularly Dhaka.

The ***Haor Area*** are likely to be slower growing in terms of population and related biophysical carrying capacity constraints. Agriculture is likely to evolve toward emphasis on activities that are consistent with the wetland environment such as specialty rices, ducks and other aquatic animals (as an example, crocodile farming is carried out in similar areas in many parts of the world), and increased emphasis on fisheries. The future of the area will be sensitive to whether appropriate integrated resource management mechanisms are developed. Protected areas are

likely to be identified and protected in the *haor* areas consistent with the growing emphasis on conservation in Bangladesh. The area may serve as a site of selective ecological tourism, although much of the value added may accrue to urban areas outside the region.

The ***Eastern Hill Area*** is likely to continue to exhibit growth of higher value agriculture, such as tea and pineapples. The rate of this growth will depend on the extent of irrigation, drainage, feeder road, and marketing initiatives in the area.

Conservation measures, if implemented, could improve the environment in the area, improve the area's economic prospects, and make it more attractive for recreation.

The ***Western High Population Density Area***, if current trends continue, could increasingly become a lagging, underdeveloped subregion. High population densities and, relative to the rest of Bangladesh, inequitable land distribution, have increasingly resulted in poor nutrition, high levels of absolute poverty, and low levels of human health and human education.

Actions such as increased irrigation, more equitable access to the land, nutritional education, out-migration and urbanization, better food storage, could contribute to improved human well-being in this subregion and hence less disparity with the remainder of the region.

The ***Alluvial Fan Areas*** are of limited direct developmental value. Mining of aggregates will continue to increase throughout the planning period. However, it is likely that if carefully managed, their main value will be to contribute to environmental quality in downstream areas that will increase the value of agriculture, fisheries, and navigation in these downstream areas.

7.6 SCENARIO SUMMARY

The Northeast Region in 2015 will contain approximately 26.4 million people of which about 10.1 million will be farmers (farming plots larger than 0.2 ha). The 26.4 million value assumes there will be increasingly effective delivery of family planning services, and increasing acceptance, in the region. The remainder of the population will be rural landless or urban. The breakdown between these two latter categories will be influenced by the health of the secondary and tertiary sectors. If the secondary and tertiary sectors grow faster than expected, the urban value will be higher relative to the rural landless value; conversely, if the non-agricultural sectors perform more poorly than expected, the rural landless value is likely to be higher than indicated relative to the urban value.

This reasonably optimistic scenario indicates that the urban population will be approximately 9 million in 2015 meaning that rural landless people will total approximately 7.3 million. Most of the urban population will be engaged in productive employment, in both the formal and non-formal sectors. Similarly, most of the rural landless will have income although likely of lower value than their urban equivalents.

The amount of land in agricultural use will decline slightly because of increased use of land for urbanisation, infrastructure, and protection and conservation. However, production per unit of agricultural land will increase significantly. These production increases, based on diversification and intensification will enable the agricultural land base to accommodate 3 million more farmers while increasing per capita income in agriculture by approximately 2%.

The overall economy of the region will become considerably more diversified. In particular, the relative importance of agriculture in GRP (gross regional product) terms will decline dramatically while the secondary (industry) and service sectors will increase in relative importance. By 2015, it is expected that the non-agricultural sectors (services, construction, and industry) which are significantly urban-based, will account for 80% of the region's economy as compared with 67% in 1991. Within the non-agricultural sectors group, the service sector will be characterised by a growth in education, business and professional, and possibly tourism and hospitality services. Within manufacturing, growth is likely to occur in heavy, mass production, and resource based subsectors; the mass production subsector is likely to show the largest relative gains within this subsector. It is expected that the manufacturing sector will become somewhat more export oriented over the course of the planning period.

The human resource base of the region is likely to change significantly during the planning period. The most significant change will be a much better educated populace. For example, 41% of adults are likely to be literate in 2015 compared with 29% in 1991. In relative terms, the biggest literacy and education gains are likely to be made by girls and women because of their current lower levels of literacy and education. The population of the region is also likely to be healthier and live longer as a result of improved nutrition, smaller families, improved immunization programmes, and improved health services.

One of the biggest changes in the region during the planning period will be the fact that virtually all of the region's residents will have access, on a daily basis, to national and international news and entertainment programmes. This will contribute to social change, increased economic efficiency, urbanization, and modernisation.

Despite increased environmental awareness amongst decision makers, the quality of the environment in the region is likely to decrease. This will primarily be the result of population pressures inducing deforestation; sedimentation; over-harvesting of biomass in wetland areas; depletion of gas reserves; extraction of ground water beyond sustainable levels; and pollution of water from industrial, human, and agricultural sources.

The region is likely to be a much more entrepreneurial culture in the future. Already, of course, most of the region's residents are private entrepreneurs such as farmers and traders. However, it is likely that this entrepreneurial culture will spread to larger enterprises, especially if local capital, such as funds from migrants to London, can be tapped.

Infrastructure in the region is likely to remain oriented to urban centres and corridors. However, it is likely that rural electricity and telecommunications services will become increasingly diffuse in the region over the course of the planning period. It is unlikely that the region will become highly spatially integrated - the *haor* area in the centre of the region is likely to remain a barrier. There is a strong likelihood that intra-regional disparities will increase between a relatively affluent area composed of the Dhaka urban field, the Dhaka-Sylhet corridor and the Eastern Hilly Area compared with the central Haor Area and the Western High Density Area, particularly Sherpur in the far northwest, if measures are not taken to alleviate this trend.

7.7 IMPLICATIONS FOR REGIONAL WATER MANAGEMENT

One of the most obvious shifts is that the relative role of agriculture in the economy will become significantly less. The absolute and relative values of the secondary and service sectors will increase enormously. From an economic point of view, these sectors will have to be protected and serviced in terms of water because of their critical economic importance.

This very significant restructuring of the economy will be reflected in a very large increase in the urban population and a significant slowing of the growth of the rural population in the region. As an increasingly larger percentage of the region's population lives in urban areas, and as the population of the region becomes more spatially concentrated, this will have very significant implications in terms of water management in regard to protection and servicing. In many ways, the increased concentration of the region's population may make water management planning easier.

Urban areas will require potable and industrial water supply as well as drainage and waste water systems. If the pattern that has occurred in other developing countries reoccurs in the urban centres of the region, water supply systems are likely to be installed extensively before corresponding water waste and drainage systems. This lag phenomenon can create public health and environmental problems. Water borne human waste from urban areas will increase as a significant challenge facing water planners.

Urban areas, as they acquire additional industry, will become larger water polluters. Of particular concern will be medical, other hazardous, and toxic wastes released into water courses through urban activities.

As agriculture becomes higher value in orientation, there will be significant geographic areas of high value agriculture. Since water is a, often the, critical input in high value agriculture (most agricultural yield increases in Asia over the last fifteen years have been related to irrigation), the movement to higher value agriculture will have significant implications for the water sector. Irrigation, from both ground and surface water sources will become increasingly important. Although irrigation delivery is a private sector responsibility, water planners will need to create conditions conducive to increased irrigation effort by members of the private sector.

Ground water is being extracted at or above sustainable levels in western parts of the region. This means that other sources, namely surface, will have to be considered in some cases for irrigation and potable water.

As the region modernises and becomes more spatially and informationally integrated, transportation and communication systems which are often characterised by skeletal core infrastructure will need to be protected from adverse affects of flooding.

As an increasingly smaller percentage of the population is employed in primary activities, the population will become increasingly geographically footloose in that most secondary and tertiary activities are not bound to a specific geographic location. This means that nonstructural approaches such as avoiding settlement in flood plain areas will become a viable alternative to protect a larger percentage of the population's houses and habitats than was the case in the past. In many cases, nonstructural approaches to deal with flood risks will become the most cost effective means of addressing the risk.

Increased levels of education and literacy should also contribute to the feasibility of nonstructural approaches to water management issues. An increasingly educated populace may be more understanding and cooperative in terms of implementing nonstructural approaches which might include encouraging settlement in certain areas as opposed to facing water related problems and threats.

An increasingly well educated and well-informed populace, the product of better education and communication services, will be better able to meaningfully participate in public participation processes designed to improve the design and operation of water sector programmes and projects.

Awareness concerning the importance of fisheries in terms of nutrition, employment, and the economy is increasing very quickly in the region. At the same time, there is greater awareness concerning the fragility of aquatic eco systems supporting fish. Trade-offs between fisheries and agriculture in water sector design decisions are unlikely to be as favourable to agriculture (vis a vis fisheries) as has been the case in the past.

There is also an increased awareness of the value of water-based transportation in the region in terms of cargo and passenger transportation value, employment, and economic value. Trade-offs between navigation benefits and benefits to other sectors in terms of water sector design decisions are unlikely to be as unfavourable to navigation as has been the case in the past.

Like much of the rest of the world, there is increased concern with the quality of the environment in the region. This is likely to increasingly affect water management planning in the region; both in terms of designation of explicitly protected areas, and water planning in non explicitly protected areas. Increasingly, there is an understanding that nature cannot be totally controlled.

Increased concern with the environment, with local participation in water management planning, and with linking water management more directly to strategic developmental planning, will almost certainly result in new institutional forms and processes for water management planning. For example, these new forms may be based on integrated natural resource planning with water planning being a key component of such institutions and processes.

In summary, water management interventions in the Northeast Region of Bangladesh are likely to be considerably different in the future than they have been in the past. Conditions in the region will change rapidly during the planning period, as will Bangladesh and international thinking and technology in water sector planning, engineering, and management.

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8. WATER MANAGEMENT STRATEGY

This chapter presents development objectives for the water sector, key principles underpinning the strategy, and the regional water management strategy that would effectively contribute to the achievement of the development objectives. The strategy is based on eight key thrusts. Six of the thrusts (Thrusts 1 through 5 and Thrust 7) are shown on Figures 16 to 19; Thrusts 6 and 8 are not area-specific. The strategy is wider than the set of initiatives described in Chapter 9; the latter providing more detail in regard to specific proposed programmes and projects. The thrusts were identified using an objectives-seeking methodology in the context of a year 2015 future scenario for the region (see box next page).

8.1 OBJECTIVES

The strategy presented in this chapter aims to achieve the following objectives:

- To increase food grain and non-grain production by 3.6% per year through the year 2015.
- To increase the annual capture fishery yield by 3.6% per year through the year 2015.
- To support informal-sector non-farm employment growth to diversify and increase rural household incomes and provide non-rural employment opportunities.
- To develop systems to manage soils, lowland forests, fisheries, wetlands and other key renewable natural resources of the region on a sustainable basis.
- To make best use of all wetland sites and to preserve options for future generations (preserve bio-diversity, broadly defined). Sites deserving special attention include Tangua Haor, Pasua Beel, Hakaluki Haor, Hail Haor, Kawadighi Haor, Balai Haor, Bara Haor, Companiganj reed land, and the Kaliajuri area.
- To provide a stable and protected environment for human settlements (from villages to cities) and industrial areas to function and grow as centres of economic activity and human settlement.
- To protect primary skeletal infrastructure, such as arterial roads, railroads, important public facilities, and electrical and telecommunications networks to minimize leveraged damage caused by flooding of these systems; and to enable emergency response systems to function rapidly.
- To enhance habitat conducive to higher value of output (in monetary terms and food value, for example protein) of agricultural production on an environmentally sustainable basis.
- To improve the environment for navigation in the region.

STRATEGY PREPARATION METHODOLOGY

Development of the water management strategy involved consolidating and analyzing the extensive background material which is summarized in other chapters of this document and which is presented in more detail in the various associated technical documents (see list of NERP studies pp ii). The strategy was defined by NERP analysts during a two day workshop which was held with the purpose of identifying a set of actions which would best achieve objectives within parameter constraints.

Background information was provided to all participants through briefings and notes. The background information included:

- *previously prepared documents* including all specialist studies and interim versions of the regional plan.
- *context parameters* such as likely capital facilities and O&M monetary resources that were expected to be available, new trends and ideas in terms of water management planning (national and international), establish what did and did not work in the region, set out social, economic, and biophysical parameters.
- *a review of objectives.*
- *key data and indicators for selected sectors.*
- *strategic inputs* which was a document prepared (mainly on a sectoral basis) as a starting point to identifying the types of interventions which could be considered important.

The process for developing the strategy was then a series of sessions with the following agendas:

- Establish the highest order potential development activities taking consideration of the number of people impacted, the economic value, environmental characteristics, costs, and benefits associated with each activity.
- Establish roles the water sector could play in support of key development potentials identified (the emphasis being on water sector outputs not on means).
- Identify means to achieve the roles defined above.
- Identify complementary activities.

Each session started with the team in plenary to introduce the agenda. The team then divided into subgroups where discussions and brain storming occurred followed by advocacy and anonymous polling. The plenary session was then reconvened with presentations by each subgroup followed by further discussion, anonymous polling and then a wrap up.

- Where possible, through multiple use structures, to provide land corridors for transportation, and other infrastructure.

- To increase the availability and quality of domestic water – in urban centres to 115 l per person per day by the year 2000; in rural areas to no more than 100 persons per hand tube well by the year 2000.

- To increase the number of fixed latrines – to all urban households by the year 2000; to all rural households by the year 2015.

- To develop appropriate institutional structures, that incorporate meaningful public participation, for decentralised natural resource management (including water) that will effectively manage water, soils, forests, fisheries, and wetlands.

8.2 PRINCIPLES

The strategy focuses on achieving water sector objectives based on certain key principles which are described here.

There are strict limits to the extent to which nature can be controlled; thus an effective strategy should be based on interventions in human and natural systems,

An effective strategy should be based on a mix of nonstructural and structural initiatives to achieve maximum developmental effectiveness. In many cases, rehabilitation and more effective operations and management of existing projects, programmes, and systems should be the preferred option. This notwithstanding, specific projects and programmes do not elaborate on explicit rehabilitation needs nor on operation and maintenance requirements. Feasibility studies being undertaken be the ongoing Systems Rehabilitation Project are detailing the work required to bring existing schemes into a state whereby they are suitable for the application of improved operation and maintenance techniques such that no future rehabilitation will be necessary. Financing is in place to carry out this rehabilitation work in several stages though technical and administrative problems are causing some delays. Improved operation and maintenance is sought as an integral part of all proposed structural initiatives with intervention points based on the recommendations presented as part of FAP 13[1].

Past sectoral plans, budgets, and activities in the water sector in Bangladesh have tended to take a defensive, or protective stance. Although such actions are commendable, a strategy based on a developmentally oriented stance promises higher benefits. Whereas flood protection is an important component of the strategy which follows, since key productive facilities must be protected from disruption, a developmental orientation predominates in terms of the overall vector of the strategy.

All investments need to be highly responsive to people's needs. Implicit in the strategy, therefore, is the understanding that local people will be involved in all phases of development of the investments which affect them. The approach to ensuring public participation will initially be consistent with the guidelines prepared by FPCO and, in the future, be modified in accordance with improvements to these methods.

As a general principle, the appropriate geographic intervention point in water systems is in upper catchment areas. However, because of international boundary conditions, and very limited international cooperation on watershed management amongst India, Nepal, Bangladesh, and Bhutan, catchment oriented strategies are not viable at the present time. By definition, this means that the strategy which follows is suboptimal. If markedly improved international cooperation is achieved, much of what follows would remain relevant but other higher priority thrusts would have to be developed. In particular, in some cases, it would be in Bangladesh's interest to invest

[1] Operation and Maintenance Study, 1992

in upstream catchment projects (outside Bangladesh) in return for some control over water flows from catchment areas outside Bangladesh. Because of the region's location, such actions would have a particularly high incidence of impact on regional development.

Perhaps most importantly, defining plans and actions to increase the value of water systems to humans in Bangladesh is one of the most difficult problems being faced. Despite diligence in analysis and planning, there are many unknowns in understanding the behaviour of the region's water systems and even more unknowns in understanding how human interventions will affect these systems - in many cases, technical solutions may not exist to solve problems. Thus this strategy, although presented in a positivistic style, should be acted upon with caution. The strategy cross-references initiatives though it is expected that over the planning period, other and possibly more effective initiatives will be identified and designed to better implement the underlying principles presented in this chapter. In phasing and prioritizing these initiatives, emphasis has intentionally been placed on actions where the risk of negative impacts is less and where impacts are more predictable. It is further suggested that where impacts are difficult to predict, interventions be carried out on a pilot scale and with careful monitoring to avoid big mistakes. Careful monitoring of all proposed actions is very important because of the unpredictability of many impacts and the need for learning to design better interventions in the water regime of the region in the future.

In formulating the strategy, there was also recognition of the reality that most people in the region are poor and that strategies therefore should impact large numbers of people. Secondly, strategies are based on the fact that overall productivity in the region must be significantly improved over the planning period if poverty is to be significantly reduced (redistribution alone will not suffice) and that water (both as a key input to productive purposes and as a disruptive threat) has a key role to play in improving productivity in the region.

8.3 STRATEGIC THRUSTS

Each of the key thrusts are presented in two parts; core activities and complementary activities. The core activities are those actions which are directly related to improved water management within the context of regional development. The complementary activities are those not directly related to water but are actions which would substantially improve the economic, social, or environmental effectiveness of the water sector activities described under core thrusts. Complementary activities are as important as water sector activities and should not be assumed to be of lower priority or items which can be dropped in implementing the proposed strategy[1].

The sequencing of strategy thrusts does not imply priority. Generalised phasing is presented in Section 8.4 of this chapter.

[1] Prefeasibility studies were not developed for complementary activities.

Strategic Thrust 1: Urban and Infrastructure Protection/Improved Urban Environment

Rationale

By 2015, the majority of the region's economic output as measured by GRP will be produced in the urban centres of the region. Since these centres will be growing much faster in economic terms than villages, they will be the propulsive agents in terms of economic growth and restructuring in the region. It is expected that approximately nine million people will live in these centres by the year 2015, 34% of the region's population.

Communications, electrification, and road infrastructure are becoming increasingly important and in fact a prerequisite to further development as the region's economy monetises and becomes less agriculturally oriented in relative terms.

The leading vector causing disease (80% of disease cases), and the factor accounting for the largest number of hospital beds in use, in Bangladesh and the region is water. Thus one of the key means of reducing ill health, improving human well-being, and increasing life expectancy is to improve the quality of water used by humans. Since water hazards to human health are often magnified as a result of the high population densities and economic activities associated with urbanisation and industrialisation, domestic water programmes are especially critical in urban areas. In addition, urban areas pollute waterways and sometimes ground water through industrial effluent including toxic and hazardous wastes, human waste, and solid waste disposal in waterways. If potable water systems predate improved water medium sanitation systems, urban environmental problems can be exacerbated by the disequilibrium between water input and output to the urban system (the "one generation" urban water environmental problem).

Fortunately, most major urban centres in the region are not located in areas where rivers are particularly unstable, with the exception of areas in the southern part of the region (Dhaka mega-urban area) threatened by the Meghna river. Nevertheless, a significant number of the region's urban centres do experience flood risk.

Content (Figures 16, 17, and 20)

1. Urban land use planning and enforcement to site future urban development on higher ground to reduce flood risks. It is important that any improved land use planning and development system introduced be appropriate to Bangladesh's stage of development and that it not introduce unrealistically high standards or it will be ignored. Secondly, urban planning should be based on functional urban areas, with planning for areas of expected geographic expansion, rather than municipal boundaries because many urban areas in the region have outgrown their official municipal boundaries. Emphasis should be on (1) reducing flood risk by steering development away from highly threatened areas, (2) basic transportation infrastructure, and (3) public health including water and waste infrastructure, sites and services for housing, and emergency service considerations.

   Although urban planning is needed for all major areas as a key means of reducing flood risk and improving urban livability and efficiency in general, it should be the dominant means for flood protection in many urban centres in the region such as Sylhet and Netrokona.

2. Urban flood preparedness is needed for all major urban areas in the region. Recommendations in regard to urban flood-preparedness have been developed by Flood Action Plan components 14 and 23.

3. In areas with large numbers of people and significant economic output, full flood protection utilising embankments can be justified where technically feasible. For example, the most populous urbanised area in the region will be the portion of the Dhaka mega-urban area that will spill over into the region. Much of the far southern portion of the region is not suitable for urbanization because of flood risk, and settlement should be restricted in these areas through urban planning measures based on floodplain zoning.

   Often embankments protecting urban areas are less effective than they could be because they are sited too close or too far from the river in question. For example, embankments are often sited too close to rivers to protect settlement immediately adjacent to rivers; such embankments are subjected to erosion and high maintenance costs. On the other hand, some embankments are placed too far from rivers because existing settlement prevents a more technically desirable location. In the future, it is important that embankments be sited better from an effectiveness point of view; new settlement should then be prohibited from areas between the river and the embankment. To achieve this synergy, urban plans should be produced in concert with water planners and engineers.

4. River diversions to re-route flood water away from cities are appropriate in cases where embankments cannot be sited in a city for social and settlement reasons or where river behaviour can not be controlled by embankments. For example, a diversion is proposed to protect Moulvibazar. In addition, other more localised measures to reduce flood risk to Moulvibazar have been proposed by FAP 9A.

5. Implementation of erosion protection for Bhairab Bazar as proposed by FAP 9B.

6. Development of waste water systems (drainage, storm and sewage) using appropriate technologies for Bangladesh's present and expected future stages of development in all of the region's urban centres. Drainage initiatives should include protection or rehabilitation of urban wetlands. This programme should commence in the major urban centres and then be spread to smaller urban (*thana*) centres in the region.

7. Raising embankments where needed emphasising multiple use (road, rail, telecommunications, electricity) where possible, and upgrading infrastructure, such as bridges where needed. In particular, the Dhaka-Sylhet corridor should be well protected.

8. Erosion control and afforestation to improve effectiveness of embankments.

9. Development of safe potable water systems to deliver water to enough points in the urban areas to be make clean domestic water readily accessible to all of the region's urban population. This programme should commence in the major urban centres and then be spread to smaller urban (*thana*) centres in the region.

10. Because much solid waste is currently disposed in waterways, development of low cost solid waste disposal systems which include effective recycling components. This programme should commence in the major urban centres and then be spread to smaller urban (*thana*) centres in the region.

11. Enforcement of regulations pertaining to industrial pollution and improvement of national standards and legislation pertaining to industrial pollution.

Complementary Activities

A. Development of an export processing zone in the region in the Dhaka-Sylhet corridor, near Sylhet International Airport, which is being upgraded.

B. Improved educational systems in urban areas, particularly those focusing on technical skills relevant to the region's economic restructuring.

C. An action oriented economic restructuring process for the region focusing on secondary and tertiary sector opportunities.

D. A sites and services housing programme for major urban centres.

E. Development of industrial estate areas.

F. Improvement of telecommunications, electrification, and road networks in and to key regional urban centres.

G. Development of more effective coordinated urban management processes and training and educating personnel to staff these processes.

Expected Benefits

The expected benefits would include protected and drained land for secondary and tertiary sector uses. This would include land for site and services and other types of housing development which will be required by the fast growing urban populace of the region. It would also include protected bases to mount emergency response measures to rural areas in the case of natural disasters. The implementation of this strategic component would further result in less disruption of key communications, electrical, and transportation services during flood periods mitigating human and economic losses.

There would be higher amenities in urban areas along with more attractive urban environments. This would result in healthier and longer living urban populations. It would further provide benefits to urban industries dependent on clean water such as sensitive electronic and biotechnology processes, beverage industries, food industries. It could lead to an increase in the range of locally manufactured goods and this in turn would lead to higher export earnings.

Strategic Thrust 1: Urban Infrastructure Protection/Urban Environment (continued)

Proposed Initiatives
Initiatives described in Chapter 9 consistent with the above strategic thrust are:

- Urban Potable Water
- Urban Sanitation
- Regional Water Quality Characterization (Cross-listed with Thrust 5)
- Industrial Pollution Abatement at Smaller Industrial Facilities (Cross-listed with Thrusts 5 and 6)
- Duckweed-based Domestic Waste Treatment (Cross-listed with Thrust 6)
- Habiganj-Khowai Area Development
- Manu River Improvement Project
- Bhairab Bazar Erosion Protection

Strategic Thrust 2: Intensive Agriculture for Urban Consumption

Rationale
Middle-class, mostly urban, markets are developing in Bangladesh for higher value agricultural products such as fruits, vegetables, poultry, fish. High market prices for such produce indicate they are in short supply. The potential exists for some rural households to significantly increase their standard of living by catering to the demands of these markets.

Content (Figures 17, 18, and 20)
Encourage market gardening and intensive livestock production near large markets. Drainage, and flood protection in some seasonally flooded areas is needed in support of this activity. The region enjoys comparative advantage in that the southern part of the region is part of the emerging Dhaka mega-urban region. It is estimated that the Dhaka mega-urban region will contain approximately 20 to 25 million people by the end of the planning period constituting a large market for high value agricultural produce from the region. The Dhaka mega-urban area's spatial growth is expected to be predominantly north-northwestward and thus mostly outside the Northeast region.

It is expected that market forces will create an intensive agricultural belt within the region extending from Dhaka to the north of Narsingdi; this belt would also include considerable areas of urbanisation. Also, intensive agricultural activity now occurring northwest of the current Dhaka urbanised area outside the Northeast region will be displaced over the planning period into the Northeast Region as urbanisation spreads northwestwards. This intensive agriculture area in the south of the Northeast Region should be the object of full flood control as technically feasible. A high level of protection is justified by the potential high value of agricultural production in this area, as well as the high number of people and the high level of non-agricultural economic activity.

Other areas exist with potential for market gardening and intensive livestock in the region. Many of these areas are naturally free from destructive flooding such as the corridor between Mymensingh, Netrokona and Kishorganj though they would benefit from improved localized

Strategic Thrust 2: Intensive Agriculture for Urban Consumption (continued)

drainage. There is considerable overlap between current/potential irrigated areas and market gardening areas.

Complementary Activities
The main complementary activity for these areas would be a strong focus of extension activities on improved market gardening technologies.

Expected Benefits
This thrust will result in more productive high value agriculture and improve nutrition in urban centres resulting in more balanced diets.

Proposed Initiatives
Initiatives described in Chapter 9 consistent with the above strategic thrust are:

- Narayanganj-Narsingdi Project (Cross-listed with Thrusts 1 and 3)
- Narsingdi District Development Project (Cross-listed with Thrusts 1 and 3)

Strategic Thrust 3: Enhanced Production Systems on Seasonally Flooded Areas

Rationale
Rice is essential in Bangladesh as the main food source. It is important that rice self-sufficiency, which has been achieved, be maintained as the population continues to grow. Thus, continued increases in rice production, at higher levels of output per unit of land, are desirable and likely. This production will be most intense and extensive during the monsoon season. Continued improvements in monsoon season rice production will facilitate dry season shifts on seasonally flooded land to higher value agricultural crops.

Most gains in agricultural productivity in Asia over the last two decades have been from increases in irrigated area and more intensive use of irrigated land. Although there are significant supply constraints in parts of the region to extension and intensification of irrigation, there is potential for increased ground water and surface water irrigation for high value agriculture.

A key to satisfactory growth in the agriculture sector in the region is sustained development of minor irrigation. Investments in minor irrigation are both low cost and have high profitability. While the region has substantial potential for adoption of modern minor irrigation technologies, it has been relatively poorly served by minor irrigation development. In conformity with current government policies, minor irrigation development needs to emphasize a major role for the private sector and a supportive role for the public sector.

The Eastern Seasonally Flooded, Western Seasonally Flooded, and Intensive Agriculture Areas have the highest agricultural potential. Thus both private and public investment in agriculture should focus on these geographical areas where much higher returns on investment are possible.

Content (Figures 16, 18, and 20)

1. Private sector funded, developed and managed small scale irrigation. To a large extent, this dynamic is proceeding effectively, to a significant degree as a result of government policies which have sharply reduced duties and taxes on inputs for irrigation equipment, and growth of a local irrigation equipment industry. Large scale, publicly funded irrigation projects are not desirable since cropping practices have not to date resulted which would justify the investments; plus there are negative equity (distributional) and environmental impacts.

   Two major projects have recently been initiated within the region; the ADB supported *Northeast Minor Irrigation Project* and the World Bank supported *National Minor Irrigation Development Project*. The *Northeast Minor Irrigation Project* has a cost of US$ 93.1 million focused explicitly within the region. It provides a credit facility for the procurement of minor irrigation equipment and power tillers and supports ground water exploration, tube well installation, demonstration farms and trade fairs. The *National Minor Irrigation Project* has a cost of US$ 106.6 million of which an unspecified proportion will be directed towards the region. It supports irrigation development, including new deep tube wells and the privatization of existing systems; improved drainage; surface water pump schemes; demonstration irrigation systems; environment protection measures; training; and institutional development.

   Small scale irrigation potential often exists in small pockets throughout the region, thus it is difficult to specify areas for expanded irrigation at a regional scale. In addition, the extent of the ground water potential in the Eastern Seasonally Flooded area is unknown. Ground water in the Western Seasonally Flooded area has been more extensively tapped. In terms of surface water, the hilly areas around the region's periphery have potential for small scale community built and controlled surface irrigation projects. Past attempts at larger scale, and government-funded interventions on the hill streams have generally failed and are not recommended.

2. Improved public sector monitoring of ground and surface water quality and quantity in support of sustainable irrigation and domestic water supply. Such monitoring would also provide an information base for public sector decisions about trade-offs, particularly for ground water, between domestic use and irrigation. Almost invariably, domestic potable water use should be given precedence over irrigation, in cases where such trade-offs must be made.

3. In non-flooded areas, pond aquaculture is very viable from financial and economic perspectives (flooding prevents year-round containment of the cultured stock, thereby restricting returns). Pond aquaculture should be undertaken on a private or community basis; the high-value fish produced will contribute to significantly increased standards of living for the pond owners. Government support to pond aquaculture such as technical assistance, should be strengthened.

4. Channel excavation to improve the flood carrying capacity of existing channels. Examples of these kinds of works include re-excavation of channels in the Upper Kushiyara Inter-basin, along the Barak River downstream of Habiganj, and in the Mrigi River.

5. Construct diversion channels around critical areas. Examples of diversions include the proposed Manu River flood by-pass to Hakaluki Haor and the partial diversion from Khowai River to Karangi River.

6. In the Western Seasonally Flooded Area in Mymensingh and Sherpur where ground water use is approaching rechargeable limits, increased efficiency of water use in agriculture plus increased production of high value dry land crops is needed to increase the value of agricultural output. Dry land crops with lower water requirements should be grown during the dry season. Although most of the topography in this area is relatively high, there are low lying pockets which require drainage. Also in this area, protection from Kangsha flooding would be provided through U-shaped embankments at strategic locations which would be combined with improved drainage.

7. The Jamuna Floodplain in the far northwest of the region is classified as a high distress area. There, irrigated agriculture can not be extended because current use of ground water at or beyond sustainable levels. An appropriate farming system should include *aus* rice in the monsoon season and cultivation of higher value crops, such as groundnuts, during the dry season. Flood proofing is needed in the area to protect rural infrastructure. In particular, there is a need to raise roads and other key infrastructure and protect settlements (see Strategic Thrust 6).

8. In the Eastern Seasonally Flooded Area, protection of crop land, especially where two crops per year could be grown, is desirable. These areas often have high population densities and relatively high levels of non-farm economic activity further justifying such interventions.

   In these areas, high yielding varieties of rice can be grown along with high value non-rice crops during the dry season. Interventions will result in either full or partial flood control. The infrastructure will consist variously of high embankments, submersible embankments, or U-shaped embankments[1] along with ancillary structures. Full flood protection would be provided for the 1:20 year flood. Pre-monsoon (partial) flood protection would be provided in accordance with the principles outlined under Strategic Thrust 4. Effective public participation is a prerequisite to development of these interventions.

   In the Habiganj area, drainage and channelisation using full embankments are the main means proposed to achieve pre-monsoon flood protection west of the city. East of the city, embankments are proposed for full flood protection.
   Further northeast, a major diversion scheme is proposed between the Kushiyara and Manu Rivers, both to protect the Moulvibazar urban area and to protect agricultural land along the Dhalai river and the right bank of the Manu river.

[1] U-Shaped embankment concept protects an area from upstream spills while leaving the downstream end open for drainage, fisheries, and navigation.

In the far northeast of the region, U shaped embankments, along with drainage interventions, are proposed to protect agricultural land along the Surma and Kushiyara rivers, and also in Narsingdi District.

9. In the transition between the Eastern Seasonally Flooded Area and the Deeply Flooded Area, a U-shaped embankment along the left bank of the Kushiyara river from the Manu river to Markuli, is proposed to provide flood protection to the areas south of the embankment.

10. In some highland hilly areas, improved locally managed and relatively small scale drainage and conservation measures will significantly improve agricultural output.

Complementary Activities

A. In the hilly areas of the northeast of the region, there is scope for increased plantation agriculture such as pineapples, citrus fruits, and spices. Market forces are likely to drive such development, especially if improved marketing and transportation systems are put in place.

B. Development of improved marketing systems, including storage and initial processing, in support of high value production. A large, under-served market, as indicated by high prices, already exists and is growing rapidly. The marketing systems are inadequate.

C. Agricultural extension activities in the region often lack sufficient emphasis on water management. This situation is becoming more serious as food supplies become increasingly dependant on irrigated agriculture. Current efforts such as the ADB financed Northeast Minor Irrigation Project (NEMIP) and the World Bank financed National Minor Irrigation Project (NMIP) should be supported, strengthened, and complemented.

Expected Benefits

Effective implementation of this strategic thrust is expected to provide increased standards of living for farm households since they will be involved in more productive agriculture. This will further result in improved nutrition from more balanced diets and in alleviation of severe poverty and distress in the far northwest portion of the region. It should result in management of ground and surface water resources on a sustainable basis, and higher productivity, consistent with sustainable management of highland eco systems.

Proposed Initiatives

Initiatives described in Chapter 9 consistent with the above strategic thrust are:

- Ground Water Investigation – Quantity and Quality (Cross-listed with Thrust 6)
- Jamuna Flood Plain Flood Proofing (Cross-listed with Thrust 6)
- Upper Kangsha River Basin Development
- Upper Surma-Kushiyara Project
- Mrigi River Drainage Improvement Project
- Pond Aquaculture
- Surma Right Bank Project

Strategic Thrust 4: Integrated Development of the Deeply Flooded Areas

Rationale

There are currently as many as 4.8 million people dependent on the deeply flooded *haor* areas in the region for their livelihoods. This population is likely to increase to approximately 6.1 million by 2015. These areas are flooded for five to six months each year.

The *haor* agricultural system is coming under increasing pressure. Probably the most important dynamic is that the winter *boro* season appears to be getting shorter and thus the amount of land available for such agriculture appears to be decreasing. The reason relates to increased flooding because of differentially higher silting of rivers relative to flood plains, particularly the embanked areas, and to higher rainfall in recent years. The general effect over the past decade has been to reduce drainage effectiveness and thus restrain agriculture production.

Price levels for rice are falling nationally and internationally, this trend combined with the fact that only one rice crop is produced annually in the *haor* areas means that the current economic system in the deeply flooded areas offers very limited potential in terms of poverty alleviation unless changes occur. In fact, dependence on rice production in the area will result in increased relative disparity with other parts of the region and the nation; that is, poverty will be concretized and perpetuated.

The deeply flooded area has a substantive comparative advantage in terms of fish production.

Content (Figures 16, 18, 19, and 20)

1. Increase the productivity of fisheries and the importance of fisheries in the area's economy taking the following key actions:

    - Construct structures to minimise fish losses from structural interventions such as embankments; for example, fish bypass structures should be built to improve the productivity of the capture fishery in the area. Since the effectiveness of such structures in the deeply flooded areas of the region is still uncertain, this action should be first undertaken on a priority pilot project basis.

    - Introduce a new management system for fisheries to provide for sustainable fish harvesting and to benefit local people. In particular, there is a need to reform the present system whereby the dry season fishery, consisting of 600 km^2 of rivers and *beels*, is leased out as *jalmohals* on a short-term basis to the highest bidder. The new system should emphasize longer and more secure tenure, and nominal leasing rates so that leasing would be affordable by local, nearby communities.

    - Protect key mother fisheries and fish spawning habitats.

    - The deeply flooded area is key to fisheries production; annual flooding is a requirement for high fish production. The quality and quantity of this habitat should be protected. In particular, deterioration of water quality through agricultural chemicals, waste from human settlements, and industrial effluent should be prevented.

- Construct *beel* embankments to reduce sedimentation in *beels* and create greater *beel* storage volume.

- Deploy effective, well-trained Fisheries Patrols in increased numbers to ensure implementation of the above.

2. Identify and adopt improved farming systems. Although rice is well-suited to conditions found in much of the deeply flooded areas and will continue to be a dominant crop there for the foreseeable future, programmes should be designed and implemented to improve farming systems. To facilitate diversification, improved farming systems should be encouraged through applied research and extension activities, demonstration, marketing support, which take advantage of the aquatic environment. For example, introduction of improved local *boro* rice varieties and cropping systems, more extensive homestead gardening (facilitated by Strategic Thrust 6), greater duck production, increased reliance on more productive fisheries, and identification and increased production of wetland products (medicinal plants, lowland forestry products) are all promising possibilities in terms of farming system improvements in the deeply flooded areas.

   An alternative farming system in the deeply flooded areas might involve growing deep water rice in areas flooded less than four metres in the monsoon season; cultivating non rice crops during the winter season; and placing priority on fish in areas flooded deeper than four metres.

   An applied research initiative geared to identify appropriate farming system changes and support actions to encourage adoption by farmers in deeply flooded areas is urgently needed. This activity could be based at the existing rice research station at Habiganj with a satellite station at Sunamganj.

3. Drainage improvements to distributary channels that drain *haors* and deeply flooded lowlands along the southern margin of the Meghalaya alluvial fans. Examples of such streams include the upper Baulai River, Rakti River and Dhalai gang. Many of these distributary channels have infilled with fine sediments after avulsions or channel shifts on the fans has altered the pattern of discharge and sediment transport. This has led to impaired drainage of adjacent low-lying lands and *haors*. During the dry season most of these channels carry virtually no flow so that excavation could be carried out using earth moving equipment or manually. Over the long term, distributaries adjacent to alluvial fans can be expected to experience periodic changes to the pattern of runoff and sediment deposition. Therefore, the required frequency of excavation will vary considerably from site to site.

4. Drainage improvements at outlet channels where tributaries join with larger mainstem rivers in the deeply flooded areas of the region. An example of this situation is along the western edge of the deeply flooded Central Basin where rivers such as the Someswari and Kangsha split into a maze of channels and distributaries as the river gradient flattens out. Much of the drainage is accomplished through abandoned or decaying channels that are silting up through reduced flows or other upstream channel changes. This situation creates pockets of poor drainage in areas upstream from the stream deposits. In general, the rate of

sedimentation in these areas will be substantially lower than areas near the alluvial fans. Small mechanized dredging would be required periodically, say every three to five years.

5. Rehabilitation of the mainstem rivers, the Kushiyara and Baulai, that drain the region. Bed levels in lower reaches of these rivers appear to be rising (aggrading) rapidly in response to past interventions, mainly loop cuts and changes in discharge regime due to channel closures and other basin-wide hydrologic changes. The channel aggradation is impairing navigation and inland transportation, reducing fisheries production and critical habitat and increasing channel erosion and channel instability. Trends towards higher pre-monsoon and post-monsoon water levels are contributing to impaired drainage and greater incidence of early flooding throughout the Central Basin, which affects 20% of the region.

6. Both capital dredging to restore the channels and periodic maintenance dredging to stabilize them are required. Cutter Suction Dredgers or other similar type of equipment would be required to accomplish this work. The amount of material that will need to be excavated is very large, particularly on the lower Kushiyara River where sediment aggradation has been greatest. For example, approximately 20 million m^3 of sediment would have to be removed to rehabilitate the Kushiyara River and in the order of 0.5 million m^3 of maintenance dredging would be required each year. Improving these rivers would be particularly important for navigation (see Strategic Thrust 7) so that this work should closely involve navigation interests and water transport institutions.

7. Much of the deeply flooded area requires some protection from early or pre-monsoon floods. The following principles should apply in areas where pre-monsoon flood protection is the desired objective.

   - Drainage improvements affecting the area in question should be undertaken first. In some cases, flooding problems can be remedied successfully with drainage improvements in which case other types of structural interventions, such as submersible embankments, will not be needed.

   - If it appears a structural intervention is needed beyond improved drainage, it should be preceded by a carefully and competently undertaken feasibility study which takes into account engineering, social, fisheries (including the need for fish bypasses), navigation (including the need for boat passes), and environmental factors. Such studies should include meaningful local input. All interventions, including structural interventions such as submersible embankments, should only be undertaken when they enhance integrated resource development strategies worked out with local people. The impacts of structural interventions are often not well understood and in some cases impacts could be negative. Therefore, a limited number of such interventions should be done at one time, with careful monitoring, so that large mistakes are not made.

     In the past, some NGO and Government Programmes, such as Food for Work, have constructed earthen structures without adequate analysis. Often, initial errors were compounded when further investments were made by official agencies such as BWDB to upgrade or rehabilitate inappropriate or miss-designed structures. In some cases, ill

conceived investments should be allowed to degenerate to avoid throwing good money after bad.

- Where structural interventions are needed, as a general principle, control structures should first be constructed at the off-takes of spill channels from rivers and *khals* into low areas such as *beels* and *haors*.

- If control structures are insufficient to meet pre-monsoon protection requirements, submersible embankments should be constructed for 1:10 year floods. If the magnitude of flooding is lower than 1:10 floods, adequate protection will be provided by hydraulic structures alone, especially if appropriate farming systems have been developed and if homestead protection has been appropriately introduced as discussed in Strategic Thrust 6.

- When structures are constructed, contracting should be undertaken professionally. In many parts of the region there are labour shortages, given the low wages paid for earthworks construction labour, which cause projects to be poorly constructed and/or never completed. Thus, often up-to-date mechanised approaches to construction should be used. Japanese and ADB funded firms in Bangladesh are increasingly using such an approach with success.

- In cases where intervention does occur, provision should be made from the outset for local involvement in the management and maintenance of water projects.

Complementary Activities

A. An important complementary activity to increase the developmental value of the above strategic thrust would be improvement of transportation and communication systems in the deeply flooded areas. In addition to the water transportation system improvements described under Strategic Thrust 7, improvements to communication systems and feeder roads to boat landings would assist in monetisation and human movement.

B. A second complementary activity would be the development of a large scale private sector dredging/excavation industry. Such support could take the form of facilitation of import of equipment, and removal of other bureaucratic barriers. Both mechanical dredging and manual excavation contracts would be let on the basis of competitive tendering. Dredging is currently a public sector activity undertaken by BWDB and BIWTA. Private sector delivery of this function would increase efficiency and reduce costs.

Expected Benefits

The main benefits would relate to increased value of agricultural, forestry, and fisheries production, and associated increased monetisation of local economies, leading to higher standards of living for *haor* residents. Improved water quality would be complemented by more environmentally sustainable utilization of resources resulting in overall higher environmental quality in the *haor* areas.

Strategic Thrust 4: Integrated Development of the Deeply Flooded Areas (continued)

Proposed Initiatives
Initiatives described in Chapter 9 consistent with the above strategic thrust are:

- Applied Research for Improved Farming Systems
- Surma-Kushiyara-Baulai Basin Project
- Kushiyara-Bijna Interbasin Development Project
- Dharmapasha-Rui Beel Project
- Fisheries Engineering Measures
- Fisheries Management Programme (Cross-listed with Thrust 5)
- Pulp and Paper Mill Effluent Treatment (Cross-listed with Thrust 6)
- Updakhali River Project
- Baulai Dredging Project
- Kushiyara Dredging
- Jadukata/Rakti Rivers Improvement Project
- Sarigoyain-Piyain Basin Development Project

Strategic Thrust 5: Biodiversity Enhancement and Sustainable Management

Rationale
Natural biological systems and the organisms of which they are composed provide many valued products and services to society. For optimal long-term benefits to be realized from natural systems, conservation, enhancement, and sustainable management of biodiversity are necessary. Biodiversity is defined as the array of populations and species, and the communities, ecosystems, and landscapes of which they are component parts (Wilson, 1988).

Freshwater wetland biodiversity of Bangladesh, which was once characteristic of much the nation's area, is concentrated now in the Northeast Region which contains all of the nation's remaining large semi-natural freshwater wetlands. Logically, then, efforts to preserve this important aspect of the nation's natural heritage should focus on the Northeast Region. The Government of Bangladesh's commitment to wetland conservation and improved management was expressed by its accession in 1992 to the Ramsar Convention, the main international agreement addressing wetland conservation and improved management.

Improved management of surface water quality is necessary to safeguard aquatic habitats. (Public health implications are discussed in Thrust 6.)

Content (Figure 19)
1. Locally-based management of internationally significant wetland sites. Improved management of wetland resources in the Northeast Region's should focus on the nine key wetland sites which have been identified as meeting one or more Ramsar Convention criteria for international significance. The emphasis should be on assisting local residents to design and implement management plans that enhance both biodiversity values and sustainable benefits flowing to local communities. This approach mobilizes local resources and

minimizes central government dependency and reduces conflicts between conservation and utilization objectives.

2. Lowland vegetation community enhancement: lowland afforestation, reed plantation, and floodplain grassland restoration. Lowland forest, reed lands, and floodplain grassland are key elements of lowland biodiversity. All three are threatened as ecological communities. In addition, these resource systems provide direct economic and other benefits to local people; enhance openwater fishery and wildlife habitat and fishery productivity; protect homesteads from wave erosion; improve water quality; and stabilize land use. These communities should be rapidly re-established over suitable areas, and sustainable management achieved, through appropriate locally-based methodologies.

3. Upland biodiversity conservation. Upland biodiversity is also an area of concern, in its own right and also for species that migrate locally between hilly areas and wetlands in the region. Most of the remaining natural and near-natural upland forest is on Forest Department-owned land and continues to be considered for clear-cutting and conversion to monoculture plantation.

4. Recovery of threatened and commercially threatened plant and animal species. Biodiversity conservation at the species level logically focuses threatened and commercially threatened plant and animal species. Action is urgently needed to prevent the irreversible loss of these populations from the region and thereby an increase in their global vulnerability. A few of these species face global extinction in the near or medium term unless action is taken. The potential ecological, societal, and economic benefits of reintroduction of species formerly inhabiting the region should also be evaluated.

5. Improved surface water quality management. This would consist of water quality characterization, industrial pollution abatement, and waste water treatment systems mainly based on aquatic plants. These aquatic treatment systems are man-made wetlands and are also valuable landscape elements and habitat, which reduce water contamination while producing biomass usable for fish culture and other purposes.

6. Biodiversity strategic planning exercise for the Ministry of Environment and Forests. Undertake a strategic planning exercise involving all parties with an interest in biodiversity management. The recent strengthening of national policies regarding biodiversity awaits commensurate national institutional development. In addition, overarching national policies regarding public participation, self-reliance, and so on, need to be incorporated in all national institutions, including those dealing with biodiversity. Strategic planning at the highest level is needed to identify and develop institutional arrangements to address biodiversity concerns, including necessary key changes in legislation, agency mandate and regulations, staffing and staff training, inter-agency cooperation mechanisms, arrangements for public participation, and so on. In preparation for such an exercise, there is a need for staff development activities to heighten awareness of surface water quality issues, treatment technologies, and so on, and of the value of biodiversity components.

Strategic Thrust 5: Biodiversity Enhancement and Sustainable Management (continued)

The need for management and protection of fisheries resources was described as part of Strategic Thrust 4. Institutional strengthening components related to this thrust are described as part of Strategic Thrust 8.

Complementary Activities

A. Ecotourism development. Criteria for appropriate ecotourism development would include: significant value-added retained by local people; contribution to environmental education and awareness; compatibility with sustainable management of natural resources.

B. Development of alternative non-biomass sources for fuel, building material, etc. Local people still rely heavily on biomass sources for many needs; fuel is one of the most important. Locally available biomass supplies are as a result heavily exploited, with the tendency being to drive them to zero productivity. Alternative sources of fuel, building materials, etc., would secure adequate supplies to local people and reduce pressures on natural habitats. Expansion of natural gas use in rural areas may be an option. There is a need for improved management at the national level of natural gas supplies.

Expected Benefits

Regional biodiversity (number, quality, area of ecosystems, habitats, populations, species) would be enhanced. Surface water quality would be improved. The benefits flowing to local people from natural systems - fish, fuel, building material, marketable products, employment, earnings - would increase. Socioeconomic and gender equity of these impacts would be highly positive, given that natural resource gathering is mainly an occupation of the poor, including poor women. Long term management of biodiversity and surface water quality would be strengthened.

Proposed Initiatives

Initiatives described in Chapter 9 consistent with the above strategic thrust are:

- Upland Biodiversity Conservation Studies and Implementation
- Management of Internationally Significant Wetland Sites
- Threatened Ecological Community Recovery Program
- Recovery Plans for Threatened and Commercially Threatened Lowland Plant and Animal Species

Strategic Thrust 6: Improve Liveability of Rural Settlements

Rationale

Even in 2015, the majority of the region's residents (approximately 66%) will still live in rural settlements. It is imperative that people in these settlements be protected from erosion to the extent feasible and that the protected areas be large enough to provide room for economic activity and human movement, for social and psychological reasons, during flood periods.

Most small settlements in the region are subject to increased pauperization, often through gradually selling of land leading to landlessness. Increased poverty often exacerbates conflict in

villages. Thus a strong rationale exists for a strategy thrust to improve the standard and quality of life in rural settlements.

It is not and will not be possible to protect extended areas of the region from flooding; this flooding must be accepted. Approximately 30% of the region's land area subject to deep flooding and 40% to seasonal flooding in a typical year; thus only approximately 30% of the region's land area is flood free. Cropping systems, ecosystems management and economic activities should be adjusted to this reality. Flood protection resources should focus on human settlements; such protection for most settlements is economically and technically feasible.

Content

1. Designing and designating a process to identify settlements for the following actions. Priority settlements for action should be those threatened by wave erosion and /or those in considerable distress. It is intended that this thrust would affect settlements throughout the region, not just communities in deeply flooded areas. This means that in some cases, only parts of the thrust would be implemented in a given geographic area or community, for example, only water supply and sanitation. Means to implement specific initiatives in this thrust would also have to vary between areas. For example, in some cases, flood proofing would mean building higher platforms for settlements while in other cases the emphasis would be on erosion protection.

In designated communities, implementing a mix of the following as appropriate:

2. Raising homestead platforms.

3. In many cases, extending the areal extent of homestead platforms. In some cases, spoil from dredging or excavating could be used for this purpose. However, transportation of spoil is expensive; thus movement over long distances is often uneconomic. Spoil must be protected with matting or other materials to be effective.

4. Protecting homestead platforms against erosion.

5. Afforestation at the settlement scale.

6. Programmes to increase accessibility to safe potable water.

7. Programmes to improve sanitation and drainage at the village scale.

Complementary Activities

A. Improvements in human resource development programming at the rural settlement level.

B. Programmes such as investment promotion and appropriate technical training, in support of rural industry and commerce.

C. Programmes to improve the skill levels of women and their access to income earning opportunities.

Strategic Thrust 6: Improve Liveability of Rural Settlements (continued)

Expected Benefits
Implementation of this thrust will result in the protection of human property and improvement in living conditions, particularly during flood periods. This is particularly true for women, who spend more time within settlements than men. Also protected will be areas for human resource development activities, rural industry and commerce, rice storage and drying, homestead gardens, livestock, and leisure activities. It would further lead to improvements in water quality in and around settlements.

Flood response will be improved since there would be protected base areas for storage of emergency response commodities and from which to mount emergency activities.

This thrust also would improve the productivity and quality of life for women. It would facilitate carrying out the numerous and key functions that women perform in homesteads such as drying and storing grain, preserving seeds, and keeping draught animals.

Proposed Initiatives
Initiatives described in Chapter 9 consistent with the above strategic thrust are:

- Village Water Supply and Sanitation
- Improvement of Homestead Platforms
- Village Afforestation

Strategic Thrust 7: Improve Water Transport in the Region

Rationale
Water transportation is important in the region because of the nature of the river system and the fact that so much of the region is flooded for much of the year. In many situations, water transportation is the most economic form of transportation for cargo and passengers. Improved water transportation is a precondition for development beyond subsistence local economies in the many areas of the region that are only accessible by water.

Water transportation is a major employer. Over 60% of employment in the transportation sector is in the water sector. Several hundred thousand people in the region (perhaps 320,000) gain all or part of their livelihood from work in the water transportation sector.

Content (Figure 16)
1. Incorporate water transportation needs in the design of all water management projects.

2. Selective channel improvement, often utilising dredging, for water transportation needs; above those required for drainage purposes as outlined in Strategic Thrust 1. To the extent practicable, this activity should be coordinated with overall drainage improvement programmes to avoid duplication, avoid undesirable systemic effects, and increase efficiency.

Strategic Thrust 7: Improve Water Transport in the Region (continued)

3. A navigational aids programme which would result in more and better marked navigational channels, boat passes as and where appropriate.

4. A programme to improve docking facilities, loading and unloading facilities, boat construction and repair sites, water based wholesale and retail markets, and industrial sites along navigable waterways.

5. A programme supportive of local country boat operators. This programme would focus on investment facilitation to enable boat operators to upgrade their boats, normally through motorisation, to increase efficiency and capacity.

Complementary Activity
A complementary activity to enhance the above strategic component is the incorporation of water transportation needs in natural resource, urban and regional and rural planning processes.

Expected Benefits
This thrust would result in increased efficiency in the shipment of bulky construction materials from the alluvial fans in the north of the region to markets in Dhaka and other key centres of Bangladesh. It would also facilitate shifts to monetised agriculture and higher value agriculture and increase the viability and efficiency in several manufacturing and service activities.

The livelihood of a large number of people who work in this sector would be protected. It is possible that, with mechanisation, total employment would not increase significantly in this sector; gains from mechanisation would likely result in lower tariffs, higher wages, increased speed of transportation, etc.

Proposed Initiatives
Initiatives described in Chapter 9 consistent with the above strategic thrust are:

- Dredging for Navigation (Cross-listed with Thrust 4)
- Support to Country Boats (Cross-listed with Thrust 6)

Strategic Thrust 8: Institutional Strengthening and Development

Rationale
Evaluation and assessment of water sector programmes by a variety of agencies to date have indicated that past water sector planning and management has tended to be too centralised, dominated by engineers to the exclusion of input from other disciplines, not developmental enough in orientation, and has not adequately involved local people in project development, implementation, or operation. Many existing water projects and programmes have considerable potential but are not performing or are performing considerably below potential. The GOB has indicated a desire to make developmental systems more decentralised and participatory in nature.

Strategic Thrust 8: Institutional Strengthening and Development (continued)

Content

1. Support increased public participation in the design, construction, operations, maintenance, and rehabilitation of water sector projects. This would include important roles for NGOs and the private sector, particularly small businesses, in identifying, developing, and operating water-related projects.

2. Increased range and depth of local expertise in water sector government agencies.

3. Improved systems for monitoring quantity and quality of ground water reserves and surface water quality and levels.

4. An improved system should be designed to determine which existing under performing projects and programmes in the region should be abandoned and which should be rehabilitated. Such decisions should be based on consistency with this strategy and expected economic, social equity, and environmental impacts after rehabilitation. In cases where rehabilitation is deemed appropriate, such projects should be given priority at least equal to new projects.

5. Improved systems need to be devised to improve operations and maintenance of currently operating projects. Such systems should be based on local inputs and on local people having an increased financial stake in projects in their area.

   FAP 13 has recommended several measures to improve operation and maintenance related to water projects in Bangladesh. In the case of the Northeast region, because of the need to improve technical interventions over the planning period, especially in difficult areas such as the deeply flooded *haors*, certain recommendations from FAP 13 are especially important, namely:

   - In the case of new projects, a period of approximately two years should pass during which local technical experts work closely with local people in improving operating and maintenance systems. During that period, careful and systematic monitoring of the project should occur.

   - After approximately two years, based on the monitoring and local operation and maintenance experience, the project should be adjusted if necessary. All projects should have monies set aside for possible adjustments.

   - After adjustments, local people should have increased responsibility for the operation and maintenance of the project.

6. Although the technical quality of much flood hazard forecasting is good in Bangladesh, the time horizons and timing of warnings can be improved. In the Northeast region, changes in major rivers can often be forecast and warnings issued for more than the present two day period. On the other hand, flash flooding can also occur very quickly, particularly on tributaries, so that more than a daily warning bulletin would be appropriate. Actual communication of flood warnings could be improved.

More interpretative descriptions of risks, which would be better understood by regional residents should be developed and broadcast. A forecast that a river will rise x metres is often of limited value to those potentially threatened. Secondly, reporting of risks should be more location specific.

7. Cross-drainage problems created by constructing rural infrastructure, particularly local roads on embankments, is a significant problem in terms of flooding and environmental impacts. This is true of much infrastructure developed by NGOs as well as government.

   Improved rural planning and infrastructure design is needed to reduce these problems. It is further suggested that there be vetting of all rural infrastructure projects, such as rural roads, to ensure that implementation of such infrastructure will not cause drainage or other environmental problems. In many cases, improved cross drainage or changes in network location will be required after vetting.

8. Changes in revenue systems to increase local revenue collection and mobilisation over the planning period. This should involve a variety of means, including user charges by public or private authorities to water uses, such as potable water and irrigation water. Increased revenue generation by local institutions would likely increase their autonomy and thus ability to make decisions locally. Furthermore, increased revenue collection could be used to improve water sector projects, particularly in terms of operations, maintenance, and rehabilitation.

9. Surface water quality management strategic planning exercise for the Environment Pollution Control Directorate, Department of Environment (EPC/DOE). Undertake a strategic planning exercise involving all parties with an interest in surface water quality management. Measures to be considered should include strengthening EPC/DOEs central authority functions (planning, enforcement, decision-making, data collection oversight, EIA review, permits for new industrial facilities, and so on) while off-loading execution of field data collection and information dissemination to private contractors and NGOs.

10. Creation of a regional institution for environmental management, research, and education. Improved surface water quality management and biodiversity conservation will not be achieved by unilateral central government action, nor by direct partnership between local people and central government bureaucrats. There is a need for institutional development at intermediate levels. A regional level institution would be ideally suited to fill this gap, with scale and competence to command national attention, while having a primary orientation towards the needs and views of residents and communities in the region. Such a regional institution would also provide assistance in mobilizing local and regional input to environmental planning, assessment, and management of development projects. The likely form would be a new NGO governed by a General Membership open to representatives of all interested parties.

Complementary Activities

A. Increased horizontal integration and cooperation at the national level among institutions responsible for water sector planning. This may involve creation of one or more new organisations at the national level to oversee water sector planning, implementation, and operations.

B. Development of local integrated natural resource management authorities. These organisations would focus on natural resources planning and coordination of implementation in local areas rather than implementation itself, which would be left to sectoral agencies. Such a system would require decentralised natural resource information systems.

C. Increased emphasis on literacy and education to improve the efficacy of participatory processes.

D. Education of increased numbers of people willing to work in the region in natural resources and environmental planning and management, water resources planning and management, and regional planning to improve the effectiveness of water sector and natural resources planning, management, and operations.

Expected Benefits

Improved technical quality of projects because of increased deployment of technical expertise at the local level and increased input of knowledge of local conditions by local residents is expected. There would also be increased support of local projects by local people which should lead to increased project effectiveness and a reduction in community opposition and damage to projects often associated with it (such as public cuts).

Water sector planning would have a stronger developmental focus and would also result in increased synergy in the content of local natural resource programmes which should lead to greater effectiveness. This would lead to improved drainage through reduction in cross-drainage problems and more effective flood forecasting and warning resulting in property savings and reduction of human suffering. Also expected would be increased funding to and autonomy of local water institutions.

Proposed Initiatives

Initiatives described in Chapter 9 consistent with the above strategic thrust are:

- Pilot Project to Institutionalize Public Consultation (Cross-listed with all Thrusts)
- Improved Flood Warning (Cross-listed with Thrust 6)
- Northeast Region Environmental Management, Research, and Education Centre (NEMREC) (Cross-listed with Thrusts 2 and 5)
- Surface Water Quality Management Strategic Planning Exercise for the Environmental Pollution Control Directorate, Department of Environment (Cross-listed with Thrusts 2 and 5)
- Biodiversity Strategic Planning Exercise for the Ministry of Environment and Forests (Cross-listed with Thrusts 2 and 5)
- BWDB Strengthening (Cross-listed with all Thrusts)

8.4 PHASING PRINCIPLES

Certain strategic phasing principles follow directly from the above strategy, namely:

1. Because drainage improvement is a prerequisite to most structural actions, drainage improvements recommended should be carried out on a large scale as soon as possible. As a general rule, drainage actions start downstream and work upstream. Since channel improvements for navigation are so closely related to drainage improvement for other reasons, the navigational actions proposed related to drainage should also be given phasing priority.

2. As a general rule, flood control structures should generally be implemented from the upstream end of the river system – but after prerequisite drainage improvements have been made.

3. Urban areas should be protected, either through nonstructural or structural means as soon as possible because: (1) it is much easier to implement nonstructural approaches to urban flood protection before massive in-migration occurs, and (2) because of the increasing economic value associated with urban centres.

   Improvements in protection of the Dhaka-Sylhet transportation and communications corridor should commence as soon as possible because of the key role that this corridor plays as the spine of the region.

   Because the absorptive capacity of the construction industry in the region is limited, the above phasing priority may limit construction of a large number of rural structurally oriented projects early in the planning period.

4. Because the fisheries management changes proposed: (1) require few prerequisite actions, (2) there is lag time until full production impact, and (3) expected high economic returns relative to a minor financial investment, these actions should be commenced as soon as possible.

   Many of the fisheries engineering recommendations, particularly fish bypass structures, require real world testing in the context of the region. Because such pilot project testing is prerequisite to later larger scale actions, pilot fisheries engineering projects should commence as soon as possible. Where fisheries engineering projects are known to be effective on a replicable basis, they should be implemented as soon as possible in support of the fisheries sector with its expected large nutritional and economic returns.

5. The recommended applied research programme for the deeply flooded area should be started as soon as possible because research takes time to bear fruit and because farming systems adjustments which may be identified by such a programme are critical to the strategy for the deeply flooded areas.

6. The nine wetland areas recommended for protection should be legally protected as soon as possible. Irreversible damages can occur; the more time that is lost in protecting these areas, the more they will be threatened.

7. Local water sector institutions and processes should be strengthened as soon as possible. If these actions are designed and implemented effectively, significant positive impacts will be generated.

8. The actions recommended related to homestead platforms should be implemented early in the planning period to provide flood protection to the large number of families in the region living in small settlements. This will require initial work to identify target settlements based on consistent application of predetermined village selection criteria.

9. As a general rule, area programmes in the seasonally flooded areas should be implemented earlier than those in the deeply flooded areas. Area programmes in the deeply flooded areas should be implemented slowly and carefully because better approaches for tackling the challenges of these areas are still evolving. Care must be taken to avoid damage to the fragile ecological systems in the area; in some cases, no action will be in order.

   Area programmes in the seasonally flooded areas are likely to yield high economic returns, primarily though higher value agriculture, especially in the south of the region near Dhaka and thus should receive phasing priority.

8.5 STRATEGY SUMMARY

The priority structural intervention is drainage improvement. Strategic drainage improvement would yield significant, highly leveraged impacts over a much of the region.

Water is the most important vector influencing human health in the region. Hence, the strategy affords considerable priority to domestic water supply, sanitation, and overall water quality.

The strategy focuses on protecting urban areas and rural villages and improving the quality and standard of life in these areas. Flood protection is focused on these areas because protection of the whole region from flooding is not desirable (for example, the floodplain fishery would be eliminated) and in any case is technically impossible.

The strategy reflects the fact that the region requires considerable economic development if the 26 million people who will live in the region in 2015 are to experience better lives than current residents. Hence, the strategy recognises:

- The agricultural potential of the eastern, western, and southern areas of the region to generate higher value agriculture based on irrigation, drainage, and flood protection of seasonally flooded areas.

- The increasingly important role of industrialisation, a modernising service sector, and urbanisation in economic and employment growth in the region; and consequently the important protective and supportive role of the water sector in relation to these economic restructuring processes.

- The significant potential value of fisheries production, particularly in the deeply flooded area where fisheries enjoys comparative advantage.

In support of the above, the importance of enhancing navigation and protecting corridor and rural servicing infrastructure is emphasised.

The strategy recognises the fact that the region contains significant areas of international environmental significance and thus advocates actions to protect these key areas while, at the same time, not displacing those whose livelihoods depend on these areas. It is expected that innovative natural resource management practices and economic activities developed in the protected wetland areas can be diffused, in many cases, to the deeply flooded areas as a whole.

The strategy reflects the fact that the deeply flooded areas are unique areas having comparative advantage in fisheries, *boro* and deep water rice production, and lowland forestry. The appropriate strategy to develop these areas should be to encourage adoption of farming systems that reflect the dynamic and unique ecological conditions of the deeply flooded areas. Sustainable development systems for the deeply flooded areas can be developed based on their unique characteristics.

Lastly, the strategy reflects recent constructive recommendations that water resource sector planning, design, and operations be more decentralised and participatory in Bangladesh.

9. INITIATIVES

This chapter provides summary descriptions (in a one page standard format) of the individual project initiatives that have been developed from the regional strategy described in Chapter 8. An index for the initiatives is provided in the text box (next page). Additional supporting documentation for the initiatives is provided in a series of pre-feasibility studies. An overview of the portfolio is provided in a summary (Section 9.2) and the priority and phasing of initiatives is provided in Section 9.3.

9.1 INITIATIVES

The initiatives conform to the water management strategy proposed for the region and have been subjected to the multi-criteria analysis specified by FPCO. The proposed initiatives fall into two broad categories: flood control drainage, and non flood control drainage.

Non-flood control drainage initiatives were identified by following a process which began with the preparation of sectoral (specialist) studies. The list of initiatives was refined further during subsequent steps in the planning process, which included the development of an interpretive description of the region, identification of driving forces, regional analysis, and most importantly, strategy formulation.

The flood control drainage initiatives generally followed a similar approach to that described above, but in addition required the identification of geographical boundaries to ensure that water management concerns were addressed throughout the Region. Boundaries were established on the basis of class parameters such as physiography, depth of flooding, agriculture, and soils. The areas within these boundaries were then examined in some detail to define major water management problems existing within each one. Areas having similar problems were then established and these were reviewed to ensure they were in conformity with what were considered "appropriate" hydrological boundaries[1]. The analysis of initiatives was undertaken in sequence leading from upstream to downstream to ensure that downstream impacts of water management interventions were not overlooked. The list of initiatives was then finalized in conformity with the strategy.

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[1] FAP 6 basin boundaries did not necessarily conform to the planning areas identified by the Master Planning Organization(MPO). While FAP 6 was concerned with identifying and studying all manner of water resource projects, MPO was focusing more extensively on dry season surface water resource estimates. For example, while estimating resources in Planning Area 26, MPO correctly included both banks of the Kushiyara River; FAP 6, in formulating interventions dealt with the left and right banks separately. Further, FAP 6 integrated Planning Area 25 and the Kushiyara left bank portion of Planning Area 26 since any intervention impacts on both areas.

INDEX OF INITIATIVES

INDEX OF INITIATIVES (cont'd)

THRUST: **URBAN/INFRASTRUCTURE PROTECTION AND DEVELOPMENT**

Initiative: **Urban Potable Water**

Location Regional urban centres including district headquarters and *thana* headquarters.

Area Urban

Population Impacted 7.3 million (2015)

Objectives To supply potable water to urban dwellers including 115 litres of piped water per person per day in core areas by the year 2015.

Description The supply of piped water is perceived to be one of the most essential urban services in today's context and will become increasingly important as urban populations increase through the planning period. In most urban centres of the region, only a fraction of the population is served with piped potable water (extracted from deep tube wells). According to BBS data, only 16% of the population of Sylhet (1981), and 7% of the population of Narsingdi (1985) were so served.

This initiative has two components: to supply piped water in core urban areas of the district and *thana* headquarters and to increase hand tube well coverage in urban fringes. The component on piped water supply is an endorsement of the program defined within the *Structure Plans* prepared under the auspices of the *Urban Development Directorate* in 1987. These plans were prepared for various district headquarters and major urban centres in the region including Netrokona, Sherpur, Kishorganj, Bhairab Bazar, Moulvibazar, Habiganj, Narsingdi, and Sunamganj. However, specific reference to provision of urban potable water was included in only the plans for Sylhet and Narsingdi (two of the largest urban centres). As yet, no action has been taken on these plans.

This initiative would expand the program to provide piped potable water to centres which include district and *thana* headquarters. It is proposed to cover 50 % of the population in eight major urban centres and 20 % of the population in smaller towns by the year 2015. The potable water would be supplied by deep tube wells to be installed at the various urban centres by the Department of Public Health Engineering and that the quality of water so provided be in accordance with the specifications provided in the referenced plans. The rest of the urban population will be served by hand tube wells with the population/public hand tube well ratio coming down to 100 from the present regional ratio of 134. The HTW programme also includes training/motivation for tube well maintenance and supply of maintenance equipment to caretaker groups.

Institution Department of Public Health Engineering

Cost US $232 million

THRUST: URBAN/INFRASTRUCTURE PROTECTION AND DEVELOPMENT

Initiative: **Urban Sanitation**

Location Regional urban centres including district headquarters and *thana* headquarters.

Area not applicable

Population Impacted 8.5 million (2015)

Objectives To improve solid waste disposal, provide a piped sewer system in the urban core areas, and place fixed latrines in all urban households in the region by the year 2015.

Description At present, sanitation facilities appear to be less developed in the region than in much of the rest of Bangladesh with only about 40% of urban dwellers having access to sanitary latrines. At present, a 53% subsidy is provided to the purchase and installation of latrines. The current joint action program of UNICEF and DPHE is scheduled through 1995. As the urban population continues to expand, the need for improved waste disposal facilities will become ever more pressing.

Solid waste disposal would be improved for the urban areas of the district and thana headquarters. The initiative would include construction of solid waste collection points and the provision for trucks, and support facilities.

This initiative would provide a piped sewer system to cover 25% of the population in the eight major urban centres by the year 2015. The proposed works would include gravity sewer mains, pumping stations, and treatment works. It endorses the on-going joint action program of UNICEF and DPHE which promotes the use of fixed latrines by supplying reinforced concrete slabs and rings and by providing training and motivation.

This initiative supports continuation of the subsidy (which in 1991 prices amounts to US $3 per latrine) and the provision of vigorous social mobilization to create more demand for the latrines and to provide training on installation (this is estimated to cost US $2 per latrine).

Institution Department of Public Health Engineering and Non-government Organizations

Cost US $150 million

THRUST: **URBAN/INFRASTRUCTURE PROTECTION AND DEVELOPMENT**

Initiative: **Regional Water Quality Characterization**

Location Throughout the region

Area Regional

Population Impacted Regional

Objectives To provide information needed to make decisions about structural and non-structural water quality management measures. Such measures include structural elements such as rural water seal latrine programs, urban sewage treatment systems, industrial pollution abatement systems, and non-structural elements such as educational programmes to promote tube well drinking water or improved factory housekeeping in selected industries.

Description Existing data on surface water quality in the region is very limited. Department of Environment (DOE) data for the region consists of:

- River water quality monitoring of six parameters (biological oxygen demand, total solids, dissolved oxygen, chloride, pH, and turbidity) at five sampling sites, two within the region (on the Surma at Chhatak and on the Meghna at Ashuganj) and three on the region's southern boundary rivers (on the Lakhya at Ghorasal and Narayanganj, and on the Meghna at the Meghna ferry ghat; DOE, 1991), plus
- Sampling of selected industrial effluent and drinking waters.

This level of information is insufficient to support analyses of the impacts of poor water quality nor, by extension, the impacts of efforts to improve it. Planning of water quality measures in the areas of domestic sanitation, urban sewage disposal, and industrial pollution abatement, should be guided by water quality observations. For example, diarrhoeal disease is known to be one of the main causes of infant and child mortality, but actual data on bacteriological contamination of surface waters used for domestic purposes is very limited.

The project would, under the ongoing guidance of water quality managers from across the range of relevant institutions, generate a baseline data set on regional water quality through the use of field-based analysis augmented with laboratory tests. Equipment and appropriately trained staff would be assembled; sampling points established and documented; river monitoring undertaken in dry (winter) and monsoon (summer) seasons; selected beels monitored (since they are an important component of fisheries and the key wetland sites); representative ponds used for aquaculture and domestic purposes monitored; data analyzed and interpreted; and an ongoing monitoring program designed.

Institution EPC/DOE with DPHE, Municipal Corporations, and other entities

Cost US $700,000

THRUST: URBAN/INFRASTRUCTURE PROTECTION AND DEVELOPMENT

Initiative: Industrial Pollution Abatement at Smaller Industrial Facilities

Location Industrial sites and nearby downstream areas

Area Regional

Population Impacted Regional

Objectives To maintain, in cooperation with DOE, an up-to-date inventory of regional industries releasing effluent into the air and water, and to characterize the most significant sources of impacts.

To work with existing industries and industrial planners, through education, technical support, demonstration projects, and the like, to implement the maximum gains achievable through, as a first step, minimal and inexpensive measures such as improved plant housekeeping and controlled discharges.

[Larger industrial facilities producing regionally significant pollution merit site-specific consideration. The only such facility at present is Sylhet Pulp and Paper Mill, which is covered by *Pulp and Paper Mill Effluent Treatment* initiative.]

Description The region is less industrialized than other parts of Bangladesh but does have its share of industrial pollution sources. Regional industrial pollution is likely to double over the next decade. Regional industrial pollution sources number about 300, estimating from the region's population share and relative industrialization/ urbanization and the >2000 industrial pollution sources nationally (DOE, 1991).

DOE past and planned industrial pollution control measures mainly focus on monitoring and enforcement activities (river water sampling, polluting industries inventory-keeping, new industrial facility registration, etc.). The agency has been successful in a number of areas, but staff and revenue have always fallen short of the requirement for effective implementation of stated programs.

There is a need for approaches based on cooperation with industry, focusing on helping industry owners and managers to move towards compliance with national pollution control standards. Means to this end would include education, technical support, demonstration projects, and the like. As a first step, the maximum gains achievable through minimal, inexpensive measures emphasizing low- and medium technology (improved plant housekeeping, controlled discharges, and the like) should be sought. Close communication with industry and development of mutual respect and trust, emphasizing gradual improvement, would be needed.

Institution Environment Pollution Control Directorate of DOE working with designated NGO(s).

Cost US $300,000

THRUST: **URBAN/INFRASTRUCTURE PROTECTION AND DEVELOPMENT**

Initiative: **Duckweed-Based Domestic Waste Treatment**

Location All regional major urban centres, some *thana*/smaller centre, some rural villages

Area Regional

Population Impacted 1.6 million, major urban centres; plus some *thana*/smaller centre and rural populations

Objectives To reduce adverse health impacts associated with inadequately treated human waste while generating fish food in support of aquaculture production.

Description Duckweed-based wastewater treatment systems are a proven technology in Bangladesh, capable of providing tertiary treatment performance equal or superior to conventional treatment methods while generating employment and cash income through production of valuable protein-rich biomass usable locally as fish meal. Both a centralized treatment facility for a community of 25,000 and a number of pond-based village systems have been implemented in Bangladesh by the NGO PRISM. The PRISM program is documented in a World Bank publication (Skillicorn et al., 1993).

A first step towards achieving acceptable treatment of regional urban domestic wastes, and the employment and economic benefits of duckweed/fish production, would be to undertake feasibility studies for the largest urban areas of the Northeast (Sylhet, Narsingdi, Bhairab, Kishorganj, Sherpur, Netrokona, Habiganj, and Moulvibazar; NERP Study on Urbanization, 1993), and for representative *thana*/smaller centres and villages. For the total projected 2015 population of the eight major centres (1.6 million), engineered wetlands on a total area of 160 to 320 ha would be required (0.1 to 0.2 ha per 1000 persons). These systems would produce duckweed at a rate of 160 to 320 T/day (yields are 1 T/ha-day), which in turn can be used to support daily aquaculture fish production of 16,000 to 32,000 kg per day (duckweed to fish conversion of 0.1; duckweed is 45% protein by dry weight; Skillicorn et al., p. 53).

Given that rates of return on investment in this type of wastewater treatment can be quite attractive, private sector involvement in implementation and operation should be emphasized. Feasibility studies would need to emphasize local consultation with regard to institutional arrangements (for example, public-private joint venture), siting, and local resource mobilization. Linkage to the Pond Aquaculture project should be developed.

Institution Municipal Corporations; DPHE; EPC/DOE

Cost US $1.0 million feasibility studies (public sector cost); US $10.0 million (private sector cost)

THRUST: **URBAN/INFRASTRUCTURE PROTECTION AND DEVELOPMENT**

Initiative: **Habiganj-Khowai Area Development**

Location Nabiganj, Baniachong, Bahubal, Habiganj, Lakhai, and Chunarughat *thanas*

Area 159,264 ha (gross); 112,115 ha (net)

Population Impacted 953,670 (1991); 1,407,930 (2015)

Objectives To protect Habiganj town, homesteads, infrastructure and agriculture from Khowai River monsoon flooding; and to protect mainly winter season crops on low-lying areas below Habiganj from Khowai River pre-monsoon flooding.

Description In five of the last ten years flooding along the Khowai has damaged or threatened urban infrastructure and dwellings, destroyed crops and damaged rural infrastructure. A solution to flooding along the Khowai River is thus considered the paramount water management issue in this area. So far, failures on the Khowai embankment have been caused not by overtopping but by breaching due to piping failures at structures, bank erosion, and scour at the toe of the embankment. Spills into the Karangi River system have originated in the unembanked reach of the Khowai River between Ballah and Chunarughat.

To improve the level of protection against Khowai River monsoon flooding in the reach between Ballah and Habiganj it is proposed to:

- Divert Nalmukh *Khal* to the Karangi River (2 km diversion) and the Isali *Chara* to the Sutang River (4.5 km), thereby reducing Khowai River flood discharges by an estimated 10%. Both the Karangi and Sutang Rivers will require channel improvements;
- Improve the Khowai River within the existing embankments (remove encroachments such as homesteads, eliminate sugar cane plantations during the flood season, raise and increase the span of all bridges and provide adequate setbacks to embankments);
- Provide a drainage channel from Habiganj town to the Sutang River (8 km);
- Extend and improve the high embankments (design for a 1:50 year return period) on both banks of the Khowai River (17 km required on the right bank and 16 km on the left bank) plus some re-sectioning.

To reduce pre-monsoon damages it is proposed to excavate the existing channel below Habiganj and shorten the channel length by 4 km through a diversion into the An Gang. Submersible embankments along the lower Khowai are not advised since they will tend to raise upstream water levels in the fully embanked reach and they will tend to concentrate sediment deposition within the channel.

Institution Bangladesh Water Development Board

Cost US $15.225 million

THRUST: **URBAN/INFRASTRUCTURE PROTECTION AND DEVELOPMENT**

Initiative: **Manu River Improvement Project**

Location Rajanagar, Moulvibazar, Kamalganj, and Kulaura *thanas*

Area 52,300 ha (gross); 40,800 ha (net)

Population Impacted 350,900 (1991); 544,400 (2015)

Objectives To reduce the risk of flooding in Moulvibazar town; to reduce damage to Manu River Project infrastructure; to provide flood relief to the 30,000 people living between the Manu River and the Manu River Project embankment; to reduce flooding in the Dhalai River basin.

Description In recent years monsoon flooding of those parts of Moulvibazar district near the Manu River has increased in both frequency and extent despite the existence of a protective dyke on the right bank of the river (this increase appears to be correlated with increases in local rainfall and confinement effects from embankments). It has resulted in increased erosion of the river bank adjacent to Moulvibazar town, damage to property and infrastructure within Moulvibazar town, severing of the Dhaka - Sylhet road (part of the Dhaka-Sylhet corridor), damage to the Manu River Irrigation Project infrastructure, and damage to crops throughout the basin. A solution to flooding along the Manu River is thus considered the paramount water management issue in this area.

The most favourable option for addressing the problems in the Manu basin involves diverting peak monsoon flood flows from the Manu River into Hakaluki Haor. The lower Manu River presently experiences 100-year floods of 1500 m^3/s. This reach can safely handle no more than 800 m^3/s. A 30 km diversion channel from Kotarkona (near Manu railway bridge) to Hakaluki Haor would, therefore, be designed to pass 700 m^3/s. Required infrastructure are: a major diversion structure, a 50 m wide embanked diversion channel (3 m high), and reconstruction of two road bridges and one railway bridge. The diversion would operate to 21 days during extreme flood years such as 1988 or 1991 and only 2 -3 days during low flood years. Impacts on Hakaluki Haor may be considerable and require further evaluation.

To eliminate overbank spills in the lower Dhalai River, a 2.5 m high embankment would be constructed for a length of 30 km on the right bank of the Dhalai upstream from the near its confluence with the Manu River.

Institution Bangladesh Water Development Board

Cost US $22.24 million

THRUST: **URBAN/INFRASTRUCTURE PROTECTION AND DEVELOPMENT**

Initiative: **Bhairab Bazar Erosion Protection**

Location Bhairab Bazar

Area Not applicable

Population Impacted 30,000 (1991); 54,300 (2015)

Objectives To protect Bhairab Bazar town (including commercial buildings, homesteads, and industrial buildings), the railway bridge, and two transmission towers from damage caused by erosion of the right bank of the Upper Meghna River.

Description Deep scouring on the right bank of the Upper Meghna River upstream and downstream of the railway bridge has resulted in steep unstable underwater slopes. The railway bridge provides the only rail link across the Upper Meghna River to the Northeast Region. Bangladesh Railway have recently carried out limited protection works around the railway bridge piers but additional work is required.

A study on erosion protection at Bhairab has been prepared as part of the Flood Action Plan (by FAP 9B). The study concluded that erosion protection of the right bank was technically feasible and economically viable (the EIRR was estimated at 36%). An advanced bank protection scheme was proposed. This includes the construction of a new bank line extending some 20 metres from the existing bank line into the river channel. The project extends from the Ferry *Ghat* just north of the railway bridge to the confluence of the Old Brahmaputra River, a distance of some two kilometres to the south-west.

To provide the necessary degree of protection (for a 1:100 year return period) the following work is proposed:

- Dredging;
- Placing hydraulic fill to form the new bank line;
- Constructing a falling apron section at the toe of the new slope;
- Underwater boulder slope protection placed on a geotextile fabric; and,
- Open stone asphalt slope protection on a geotextile fabric above the water surface.

Institution BWDB

Cost US $15.8 million

THRUST: **INTENSIVE AGRICULTURE FOR URBAN CONSUMPTION**

Initiative: **Narayanganj-Narsingdi FCD Project**

Location Kaliganj, Narsingdi, Palash, Rupganj, Bandar, Araihazar, and Baiddar Bazar *thanas*

Area 40,560 ha (gross); 34,832 ha (net)

Population Impacted 781,480 (1991); 1,413,300 (2015)

Objectives To promote the development of high value and diversified agriculture for future urban (greater Dhaka) consumption leading to improved nutrition and to protect homesteads and infratsructure from the Meghna and Lakhya Rivers.

Description Dhaka is one of the fastest growing urban centres in the world. The Dhaka mega-urban area is and will continue to expand rapidly northwards into the area which is at present producing much of the non-rice food supplies for Dhaka. This production will be displaced, some into Narayanganj and Narsingdi districts, as the city expands. This displacement effect, combined with increasing demands for food from the growing city, and some extension of the Dhaka mega-urban area into the project area will result in an enormous market potential for high value non-cereal crops and fish over the plan period.

Work on a pilot phase and on part of Phase I of the Narayanganj-Narsingdi Project has been completed. This initiative endorses continuation of Phases I and II of the Project. The development concept for Phase I appears appropriate as designed. Phase II development, however, should be considered without pumped drainage.

There is a need for development of the area bounded by the Dhaka - Chittagong highway, the Lakhya River and the Old Brahmaputra River (old channel). While this area is much smaller than Phase II, it has similar hydrological characteristics and development here could serve as a model for Phase II. The development would consist of full flood control embankments along the river banks incorporating drainage regulators as required, flushing regulators for irrigation, and an improvement of the channel network to distribute irrigation water. The flood control provided to this area would, on low land, facilitate extension of the current land use practice which involves a boro season rice being rotated with fish production (aquaculture). Higher land could then accommodate boro or other irrigated non-rice high-value crops like fruits and vegetables.

Institution Bangladesh Water Development Board

Cost US $15.16 million

THRUST: **INTENSIVE AGRICULTURE FOR URBAN CONSUMPTION**

Initiative: **Narsingdi District Development Project**

Location Narsingdi, Belabo, Shibpur, Palash, Raipura, Kapasia, Bhairab, Katiodi, Kuliarchar, Bajitpur, and Monohordi *thanas*

Area 50,600 ha (gross); 38,000 ha (net)

Population Impacted 1,255,640 (1991); 2,078,200 (2015)

Objectives To provide flood protection for crops and homesteads of the project area; to promote expansion of high yielding variety monsoon crops, and to facilitate agriculture diversification.

Description The project area is affected by flooding when the Old Brahmaputra River, flowing from the north, spills its banks. The flooding situation has been further aggravated by a locally built closure on the Old Brahmaputra downstream of its confluence with the Arial Khan, near Katiadi *thana*. This has resulted in most drainage being effected through the Arial Khan which has infilled with sediment and thus does not provide adequate drainage. The Arial Khan also spills its banks regularly. The Binabaid area is most affected. In the future, the project area will need to support an expansion of the Dhaka mega-urban area and thus an improved flood regime is important.

To improve the flood regime it is proposed that 37 km of embankments be built along the Old Brahmaputra with particular attention being given to the Binabaid area. In the vicinity of Binabaid, 17 km of full flood embankments are proposed along the Arial Khan River. Drainage would be improved by re-excavating 90 km of drainage channels and by providing regulators. The regulators would be designed for both drainage and flushing, thus providing potential for irrigated vegetables and other crops.

Institution Bangladesh Water Development Board

Cost US $3.72 million

THRUST: **ENHANCED PRODUCTION SYSTEMS ON SEASONALLY FLOODED LANDS**

Initiative: **Ground Water Investigation**

Scope Regional

Objectives To facilitate development and improved management of ground water for domestic, industrial, and agricultural use in a sustainable manner.

Description The area irrigated by ground water in the region is estimated at 213,000 ha. Groundwater is also a key source of domestic water supply. However, the occurrence of ground water varies throughout the region and its extent is not well known. While ground water development occurs mainly in the private sector, its rate of extraction is uncertain and there is a need to ensure that future development (which could fully utilize available ground water within the next 15 years) does not exceed sustainable limits. There are three main components to the proposed groundwater investigations:

Data Compilation and Analysis Output from extensive exploratory drilling and aquifer testing, to be started soon in the region (NEMIP, NMIDP), needs to be compiled and analyzed to define ground water potential and management needs. Prior assessments of the resource are based on incomplete data. A program of exploratory drilling and aquifer testing now being initiated will fill data gaps, but plan studies will not produce a resource assessment or management guidelines. Ground water dating should be attempted which would involve the application of environmental isotope techniques. The data should be used in a new, more appropriate mathematical model for simulating groundwater development and management options.

Assess the Impact of Ground Water Development: Recent planning and development is all based on assumptions that aquifers are fully recharged every year and that fairly homogeneous physical conditions prevail. Hence, the influence of previous withdrawals is not carried over and hydraulic simulation can not be realistic. These limitations need to be overcome for effective management before further development proceeds beyond the sustainable limits of the resource.

Baseline Survey of Ground Water Quality and Subsequent Monitoring: A similar data compilation and analysis program, to that described above, is required to consolidate available information in collaboration with NEMIP and NMIDP, including the British Geological Survey (1992) findings. In cooperation with the existing projects, establish continuing input into the assessment and management guidelines.

Institution BWDB and DOE

Cost US $900,000

THRUST: **ENHANCED PRODUCTION SYSTEMS ON SEASONALLY FLOODED LANDS**

Initiative: **Jamuna Floodplain Floodproofing**

Location Roumari and Rajibpur *thanas* of Kurigram district

Area 34,000 ha

Population Impacted 207,000 (1991); 372,000 (2015)

Objectives Adopt floodproofing measures on lands within the Jamuna Floodplain.

Description Settlements along the narrow strip of Jamuna floodplain including attached *char* lands suffer flood damages whenever the Jamuna River is in spate. Protection of crops does not appear to be a viable proposition, but floodproofing measures would alleviate suffering of people living in this area. This area is classified as a high distress area because of poor access, inadequate infrastructure, and a highly vulnerable agricultural regime.

Guidelines for planning flood proofing were prepared through the FAP 14 and FAP 23 studies. These guidelines form the basis for the potential structural flood proofing measures for the 530 affected villages as follows:

- Raising floor levels of homesteads;
- Improving the quality of housing construction;
- Providing flood shelters;
- Providing storage areas;
- Protecting commercial premises;
- Raising ground levels at markets, schools and other community facility areas;
- Building key infrastructure (roads, public buildings) above specified flood levels.

The non-structural flood proofing measures include the following:

- Promote public awareness programs and provide training at the community level;
- Linking government resources to individuals, communities and the private sector;
- Implementing flood preparedness programmes including flood forecasting and warning.

Institution Bangladesh Water Development Board and NGOs.

Cost US $5.0 million

THRUST: **ENHANCED PRODUCTION SYSTEMS ON SEASONALLY FLOODED LANDS**

Initiative: **Upper Kangsha River Basin Development**

Location Sherpur, Jhenaigati, Nalitabari, Nakhla, Phulpur, Haluaghat, Purbadhala, Netrokona, Barhatta, Durgapur, and Kalmakanda *thanas*

Area 87,200 ha (gross); 68,165 ha (net)

Population Impacted 615,500 (1991); 897,100 (2015)

Objectives To protect rice crops from pre- and monsoon flood damage, to provide flood relief to homesteads and infrastructure, to relieve drainage congestion and support pond aquaculture, and to reduce the risk of channel avulsions and the corresponding loss of land and property.

Description The Upper Kangsha basin extends over much of the western seasonally flooded area. There is good potential to increase productivity in both agriculture and pond aquaculture. However, flash floods from the Kangsha River damage crops, flood culturable ponds, damage roads and bridges, and submerge homesteads. The following general principles were applied in identifying interventions:

- Embankments were considered only where the protected area had alternate drainage routes;
- The protected areas are kept open on at least one side to facilitate fish migration; and,
- Major structural interventions were to be avoided on the unstable alluvial fans.

The proposed initiative identifies four strategic intervention points along the Kangsha system:

- *Improving the Malijhee River*, which involves isolating the flows of the Boghai River from the Malijhee by excavating a 4 km channel, straightening the Boghai and Malijhee Rivers;
- *Diverting the combined flows of the Bhoghai and Mailijhee Rivers* through an excavated channel into the Mogra River basin;
- *Extending the Konapara embankments* for 20 km from Bahirshimul to the present confluence of the Malijhee and Boghai Rivers.
- *Extending Kangsha right bank embankments* for 35 km from Jaria to Kharia River outfall.
- *Improving the Someswari River* by upgrading, paving and closing all bridges on the Durgapur-Jhanjail road which would then serve as an embankment. In addition, the newly avulsed Atrakhali channel would be closed and flows diverted back to the Someswari and old Someswari Rivers.

Institution BWDB

Cost US $21.44 million

THRUST: **ENHANCED PRODUCTION SYSTEMS ON SEASONALLY FLOODED LANDS**

Initiative: **Upper Surma-Kushiyara Project**

Location Beanibazar, Golapganj, Kanairghat, and Zakiganj *thanas*

Area 49,200 ha (gross); 33,600 ha (net)

Population Impacted 376,000 (1991); 560,320 (2015)

Objectives To reduce flood damage to monsoon and boro rice; to promote expansion of HYV rice onto lower lands through lower flood depths, to improve drainage, and reduced early flood risk; and to reduce homestead and infrastructure damage from river floods.

Description Flooding during the monsoon season from heavy rainfall in the Barak River basin damages agriculture (broadcast *aus*, transplanted *aman*), infrastructure, and homesteads. Pre-monsoon floods damage the *boro* crop. In this hydraulic regime, without any intervention, food grain production is not expected to increase (it has not done so in the past ten years) and it may well decline as drainage conditions worsen. Floodplain fisheries are declining and are expected to continue to decline because of current management practices. Any intervention that improves agricultural production will further aggravate fisheries production and will require mitigation measures to be provided.

The proposed project involves:

- Embanking the Surma River (left bank) and Kushiyara River (right bank) on the eastern, northern and southern side of the project area to protect against a 1:20 year monsoon flood (155 km of the required 181 km of embankments are existing);
- Leaving the lower western side of the Project area open for drainage, navigation, and fish passage;
- Improving the drainage network at the lower western side by excavating or re-excavating about 40 km of channels;
- Rehabilitating three existing regulators for drainage and constructing five new regulators on major channels to provide for fish passage and navigation; and,
- Improving road transportation within the area by constructing two bridges.

Effects of the proposed Tipaimukh dam in India need to be carefully considered during the scheduling and implementation of this initiative.

Institution BWDB

Cost US $22.21 million

THRUST: **ENHANCED PRODUCTION SYSTEMS ON SEASONALLY FLOODED LANDS**

Initiative: **Mrigi River Drainage Improvement Project**

Location Bakshiganj, Sribardi, Jhenaigati, Sherpur, Nakhla, and Jamalpur *thanas*

Area 24,400 ha (gross); 20,400 ha (net)

Population Impacted 239,800 (1991); 381,200 (2015)

Objectives To reduce agricultural damage resulting from drainage congestion without negatively affecting fisheries or navigation.

Description Rice based agriculture is the main economic output of the area and increased production is constrained because of inadequate pre- and post-monsoon drainage. On-going sediment deposition in the drainage system will result in increasing crop losses in the future, and will hamper navigation and river fish production. Production on land in adjacent areas to the north will also decline over time since sand coming from the upland hilly areas is deposited on agricultural land.

The proposed project includes:

- Re-excavating 28.2 km of the Mrigi River from Boysha Beel to Char Betmari;
- Rehabilitating the left bank of the Old Brahmaputra River from Nij Kharmarer Char to Gogra Kandi (35 km); and
- Enhancing fisheries in ten ox-bow lakes by establishing nurseries and setting in-place a weed eradication program.

A 28 km reach of the Upper Mrigi River (from Matiphata to Boysha Beel) is being re-excavated in 1993 under the *Canal Digging Program*. This excavation will increase the inundated surface area by some 300 ha. By comparison, the improved drainage will reduce inundated *beel* areas by an estimated 15 ha. Therefore, the excavation should have a positive impact on fisheries production.

Rehabilitating the left bank of the Old Brahmaputra River should be carried out prior to channel excavation so that major siltation will not occur from Old Brahmaputra River flood overflows.

It should be noted that FAP-3.1 is proposing to embank the right bank of the Old Brahmaputra River as part of the Jamalpur Priority Project. The impact of this scheme was assessed and it was determined that flood levels will be raised by up to 0.54 m at Jamalpur. Therefore, further raising and strengthening the left bank embankment should be costed and implemented simultaneously with construction of the right embankment.

Institution BWDB

Cost US $1.36 million

THRUST: **ENHANCED PRODUCTION SYSTEMS ON SEASONALLY FLOODED LANDS**

Initiative: **Pond Aquaculture**

Location Habiganj, Moulvibazar, Sylhet, Sunamganj, Kishorganj, Netrokona, Sherpur, Narsingdi, Narayanganj and Mymensingh districts.

Area An estimated 26,500 culturable ponds with a total area of about 2500 ha

Population Impacted 100,000 (1991); 179,000 (2015)

Objectives To increase fish production through concentrated and highly supervised demonstration ponds, and to improve the socio-economic situation of small and landless farmers by providing opportunities for non-agricultural employment.

Description There are about 0.25 million ponds in the region with a total area of about 18,700 ha. The ponds are classified as cultured (49% by area), culturable (23% by area) and derelict (28% by area). Ponds contribute less than 16% of overall fish production in the region and the average production is about 800 kg/ha/year — considerably less than the national average of 1100 kg/ha/year. Little support is extended to aquaculture in the region; the exception being the DANIDA-financed Aquaculture Extension Project, but even this operates only in parts of Kishorganj and Mymensingh districts.

This initiative proposes direct intervention on 500 ha of culturable ponds and indirect intervention on a further 2,000 ha of culturable ponds. This will involve providing extension support for farmers through training, supervision and credit in two stages:

- Assist 20% of culturable pond owners (who will become Result Demonstrators) in semi-intensive fish cultivation methods by providing training, follow-up and credit support leading to improved yields on their ponds; and,
- Assist the Result Demonstrators in extending these technologies through method demonstrations in their localities

Institution DOF; NGOs

Cost US $2.5 million (including a revolving loan fund of US $1.0 million to stimulate private investment).

THRUST: **ENHANCED PRODUCTION SYSTEMS ON SEASONALLY FLOODED LANDS**

Initiative: **Surma Right Bank Project**

Location Kotwali (Sylhet Sadar), Jaintiapur, Gowainghat, Kanaighat, Golabganj.

Area 40,000 ha (gross); 33,895 ha (net)

Population Impacted 269,400 (1991); 487,279 (2015)

Objectives To increase monsoon and *boro* season agricultural production without compromising the integrity of the wetlands and fisheries production systems.

Description The project evolved out of discussions with people living in the project area. They expressed concern that agriculture is being damaged by both flash and seasonal floods; that siltation appears to be filling in some boro areas, such that cropping on them will have to shift to lower-yielding b aman; and that there is little scope to expand irrigation because of limited ground and surface water supplies. The overall result is that under the present flood regime there is little scope to increase food production. In general, the solution which people favour involved protecting the boro crops while maintaining the existing drainage system into the Surma River. Therefore, navigation and fish passage between Bara *Haor* and the Surma River will not be obstructed.

The proposed initiative will provide flood protection for the project area from upper Surma and Lubha River spills. This will be achieved by constructing full embankments along the right bank of the Surma River from Kanaighat up to Lubha Tea Garden and along the Lubha right bank. Rustampur and Bagha Khals will be closed to prevent overbank spills in the area between Kanaighat and Sylhet. In addition, to mitigate displacement of Lubha spills onto areas behind its left bank, a full flood embankment along the Lubha's left bank would be provided. Project physical works are:

- Full flood embankments (13 km)
- Closure dams (2)
- Drainage regulator (1)

Institution BWDB

Cost US $1.74 million

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Applied Research for Improved Farming Systems**

Location Sunamganj, Netrokona, Kishorganj, Habiganj and Sylhet districts

Area Not applicable

Population Impacted 1.9 million (1993); 2.9 million (2015)

Objectives Development of farming systems and their components (crop, livestock, fisheries, agro-forestry and off-farm activities) to improve the quality of the diet, and increase income and employment in agriculture and related sectors.

Description The production systems of the deeply flooded areas are coming under increasing pressure as the population continues to grow and as people have easier access to these areas. Rice will continue to be the dominant crop for the foreseeable future since it is well-suited to the agro-hydraulic regime but there is a need to diversify and improve the farming systems.

The proposed project involves applied and adaptive research to design and test improved farming systems for the deeply flooded area including better crop practices, improved technologies and superior management practices for livestock (nutrition, feeding standard, health and hygiene), introduction of medium-scale cattle farming, improvement of rice-fish culture, improvement of agro-forestry, introduction of small-scale mixed farming, and extension of information on post-harvest activities, consumption, processing, storage and marketing.

The studies will utilize physical and biological scientists and socio-economists to develop systems based on the physical and biological potential of the area, and also on social and economic acceptability. The extent of adoption of improved farming systems will be determined through the evaluation of productivity, and impacts on farmers's income and on consumption patterns. A computerized farm plan will be developed from informal farmer interviews and from on-station and on-farm studies of traditional and modern farm practices. On-farm research will be the primary way of integrating the studies, and the results will be disseminated through agricultural, livestock, fisheries and forestry extension services staff.

Institution Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural Research Institute (BARI), Bangladesh Agricultural University (BAU), Department of Agricultural Extension (DAE), Bangladesh Livestock Research Institute (BLRI), Department of Livestock Services (DLS)

Cost US $800,000

379

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Surma-Kushiyara-Baulai Basin Project**

Location Balaganj, Biswanath, Golapganj, Fenchuganj, Sylhet Sadar, Chhatak, Derai, Dowarabazar, Jagannathpur, Jamalganj, Sunamganj, Sullah, Khaliajuri, and Itna *thanas*

Area 319,290 ha (gross); 254,590 ha (net)

Population Impacted 1,892,150 (1991); 2,869,650 (2015)

Objectives To protect *boro* crops grown in the low *haor* areas from winter and pre-monsoon floods; to mitigate the effect of monsoon floods on *aus* and *aman* crops; and to protect infrastructure in the higher area to the east while retaining the integrity of the wetlands and fish sanctuary in the Khaliajuri area to the west.

Description The natural resource and agricultural systems of *haors* within the project area are coming under increasing pressure as the number of people dependent on this system grows. The results of past attempts to increase productivity in the area through flood control and drainage are not satisfactory. These attempts involved construction of localized ring embankments (submersible) such as the Baram *haor*, Udgal *beel* and Shanghair *haor* projects. The embankments are breached or overtopped regularly by pre-monsoon floods, they hamper drainage and obstruct navigation, and they have strong negative impacts on the natural resource base (fisheries and wetlands).

The solution proposed for this area is the completion of flood embankments on three sides of the area (along the left bank of the Surma-Nawa-Baulai Rivers and along the right bank of the Kushiyara-Kalni Rivers) to prevent pre-monsoon flood flows from the north and east. The south and southwest side would be left open for monsoon and post-monsoon drainage, for natural monsoon flooding, for the entry of spawning and other fish, and for navigation purposes. The drainage system to the south would be improved through the excavation and re-excavation of strategic channels. Ancillary structures (including regulators, fish passes, and navigation passes) would be provided at the off-takes of major spill channels in the north and southeast.

Institution BWDB

Cost US $36.79 million

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Kushiyara-Bijna Interbasin Development Project**

Location Baniachong, Nabiganj, Ajmiriganj, Habiganj, Madna, Derai, Astagram, Jagannathpur, Mitamain, and Moulvibazar *thanas*

Area 100,000 ha (gross); 84,000 ha (net)

Population Impacted 517,000 (1991); 815,000 (2015)

Objectives To protect *boro* crops from pre-monsoon flood damage; to a lesser degree, to protect monsoon crops from flood damage; to protect homesteads and roads from flood damage; to provide supplemental irrigation, and to enhance fisheries.

Description Historically, the project area drained via the Bibyana and Old Kushiyara Rivers to the Kushiyara River. In recent years, the Bibyana River has been abandoned as a result of morphologic changes and the Old Kushiyara channel bed has in-filled with sediment, so that drainage must now be effected further downstream through the Ratna River system. Consequently, post-monsoon drainage is impeded which delays planting of the *boro* crop. In addition, pre-monsoon drainage has also become less effective. Therefore, the single *boro* crop (produced on low land) which was a risky enterprise in the past, is becoming more and more vulnerable to flood damage.

Proposed project infrastructure would consist of 48.5 km of full flood control embankments on the left bank of the Kushiyara River, 33 km of submersible embankments on the left bank of the Kalni River downstream of Markuli, nine drainage cum flushing regulators, five irrigation inlets, and 56 km of channel re-excavation. Several of the regulators would be sited explicitly to enhance fisheries production; for example, the regulators at the Bibyana off-take and the Kaiyer Dhala channel will retain water to support fisheries longer into the dry season.

The proposed project relates synergistically to the suggested "Kalni-Kushiyara River Improvement Project" described elsewhere in this chapter. Spoil earth resulting from dredging in the Kushiyara could form the basis of the submersible embankments required for this project. Implementation of this project increases the pre-monsoon discharge and thus facilitates Kushiyara bed scouring – reducing dredging requirements.

Institution BWDB

Cost US $9.61 million

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Dharmapasha-Rui Beel Project**

Location Dharmapasha, Madhayanagar, Barhatta, and Mohanganj *thanas*

Area 20,500 ha (gross), 17,000 ha (net)

Population Impacted 78,000 (1991), 124,800 (2015)

Objectives To increase *boro* rice and *rabi* crop production, while incurring the best possible outcomes for navigation and the openwater fishery.

Description Many *haor* areas are suitable for only one crop annually, and the window within which that crop (*boro*) is produced relatively short. Changes in the hydraulic regime (the result of human interventions and natural processes such as sedimentation) are further reducing the time available for this crop, with the result that the crop is damaged or destroyed in more than half the years it is planted. While efforts are needed to diversify farming systems in this flood regime, the system will be based on *boro* rice production into the foreseeable future.

The proposed project involves the construction of 2 m high submersible embankments (50 km) for protection against flash floods. The embankments would connect existing high lands and homesteads on the perimeter of *beel*. Five drainage/flushing regulators, five pipe sluices, and 20 irrigation inlets would be provided in the embankment; an additional two pipe sluices would be provided in an internal village road. Internal channels (50 km) would be re-excavated.

The negative impacts on navigation and the openwater fishery of the pre-monsoon flood protection and increased surface water irrigation withdrawals would be partially mitigated by the channel re-excavation; by retaining water in the dry season behind the regulators in the improved channels and in the *beels*; by providing boat passes in two of the regulators; and by providing fish passes (once these have been field tested in the region).

The river system within which the project is located is actively changing in a number of places. Future hydrologic conditions in the project area will depend on natural processes, and on the outcomes of several of the NERP initiatives affecting this system, including *Baulai River Improvement*, *Upper Kangsha River Basin Development*, and *Updakhali Project*.

Institution BWDB

Cost US $3.4 million

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Fisheries Engineering Measures**

Location Regional

Area Not applicable

Population Impacted Rural

Objectives Maintain and improve fisheries habitat through structural measures incorporated into new and existing FCDI projects, or built as stand-alone fisheries projects. Specifically, maintain or re-establish migration routes by providing fish pass structures in embankments; and protect selected *beels* from sedimentation and increase *beel* water storage by constructing protective embankments.

Description Traditionally, water resources infrastructure on the floodplain has been oriented solely towards improving agriculture. In the process, the openwater fishery has suffered negative impacts in the form of reduced floodplain and *beel* habitat, delay of flood onset (and therefore of spawning activity), and closure of fish migration routes at embankments, which in some cases has eliminated critical access between floodplain, *beel* and river habitats.

New and existing FCDI projects can be made less inimical to fish by providing fish passes at key points in embankments, and, where appropriate, by providing protective embankments, with structures at outfall channels, around selected *beels* to increase water volume and decrease sediment deposition. Fish passes (a vertical slot design appears most appropriate) will first require a pilot project to verify designs and impacts.

Such measures have already been incorporated in many of the new FCDI initiatives proposed under NERP, and are included in costs for those projects. For example, the Kushiyara-Bijna Interbasin Development Project contains a *beel* bunding component.

Costs shown here would cover provision of fish passes in some existing FCDI projects, and construction of *beel* embankments/structures within existing FCDI projects or as stand-alone measures.

Institution BWDB and DOF

Cost US $8.09 million

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Fisheries Management Programme**

Scope Regional

Population Impacted National

Objectives Improve biological management of the floodplain fishery through direct interventions in fisheries habitats, and indirectly through assistance to NFMP (New Fisheries Management Policy) fishermen associations and improvements in management of community fisheries (*mohalshamil jalkar*, defined as beels 1.2 ha or less in area), while improving equity of benefits. Improve marketing and processing facilities to reduce spoilage and increase the value added in processing.

Description The project consists of seven measures targeted on strategic elements of the openwater fisheries production and marketing system:

- Improve biological management of mother fisheries.
- Protect key spawning and overwintering habitats.
- Assist 120 Fishermen Associations under NFMP.
- Assist communities to improve management of *mohalshamil jalkar*.
- Establish a floodplain fisheries management and fish processing station under Fisheries Research Institute (FRI).
- Construct eight fish landing facilities and wholesale fish market halls at important fish collection centres.
- Construct six municipal retail fish markets in district towns.

Institution DOF; FRI; MOL; and NGOs

Cost US $32 million

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Pulp and Paper Mill Effluent Treatment**

Location Surma River at Chhatak

Area Surma River downstream of Chhatak

Objectives To reduce significantly negative impacts from discharge to the Surma River of the Sylhet Pulp and Paper Mill effluent. These impacts include damage to open water fisheries production, contamination of fish flesh, and other short- and long-term negative impacts to the biophysical environment and to human health. In addition, this would be a pilot project and training exercise which if successful would lead to improved effluent treatment at all other pulp and paper mills in the country.

Description In the region, the Sylhet Pulp and Paper Mill at Chhatak is currently the most significant single source of industrial pollution. The mill, which began production in 1976, uses a bleached Kraft process with a design capacity of 100 air-dried tonnes per day. Actual production is 30 to 80 ADT/d due to shortage of input materials. The annual gross value added (economic) of the Mill in 1991 was US $3.0 million.

Existing treatment facilities consist of two lagoons in series. Observed poor removal of suspended solids and no removal of BOD suggests that they are anaerobic settling basins only.

The estimated effluent flow rate is 30,000 m^3/d (0.4 m^3/s). Contaminants discharged into the river include BOD 6100 kg/d, suspended solids 6000 kg/d, mercury 1 kg/d, plus unknown amounts of AOX, dioxins, and furans which are characteristic of Kraft process effluent. Presumably, contaminant discharge would increase should the gap between actual production and design capacity close; an increase in input materials would make this possible. Dry season flow in the Surma is roughly 40 m^3/s (estimated from gauge measurements of 23 m^3/s at Sylhet plus estimated inflow from the three tributaries between Sylhet and Chhatak).

This initiative would consist of the preparation of a feasibility study for the treatment of Sylhet Pulp and Paper Mill effluent; the design and construction of appropriate treatment facilities; and the provision of training for mill staff in the proper operation and maintenance of treatment facilities provided. In addition, there would be additional studies and training using SPPM as a model, addressing the need for improved effluent treatment at other government- and private-owned pulp and paper mills in the country.

Institution Private sector companies working with the Sylhet Pulp and Paper Mill/Bangladesh Chemical Industries Corporation (BCIC)

Cost US $2.0 million plus US $50,000/year recurrent costs

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Updakhali River Project**

Location Kalmakanda and Madhayanagar *thanas*

Area 5,960 ha (gross); 4,890 ha (net)

Population Impacted 35,900 (1991); 50,840 (2015)

Objectives To protect *boro* rice from flood damage and to reduce beel sedimentation.

Description The project is in a deeply flooded area where *boro* rice is the only crop that can be grown. More than 80% of the area's population depend on this crop as their primary source of income and food. This crop is routinely damaged by pre-monsoon flooding.

It is proposed to construct 25 km of 2 m high submersible embankments around the project area. The embankment alignment would follow existing roads and river banks (*kanda*) as much as possible. Ancillary structures would include five drainage regulators, two pipe drainage sluices, and 21 irrigation inlet structures. To improve drainage in the area, the Gunai River would be induced to redevelop along its lower reach below Jatrabari, by closing Jatrabari Dhala to which most of the Gunai flow has recently shifted and excavating a 17.5 km pilot channel.

Fisheries impacts will be complex and are difficult to assess:

- Fish migration will be blocked for a significant part of the pre-monsoon migration window, until water control structures are opened and the submersible embankment overtops. Fish passes might provide some mitigation, but their incorporation has been deferred until feasibility. Also, the redevelopment of the lower Gunai could have some positive impact on fish migration.
- Pre-monsoon water quality within the project area will be reduced due to reduced flushing, but post-monsoon water quality in areas draining to the revitalized lower Gunai may improve.
- *Beel* area is currently decreasing, with some being filled in with silt brought in through Jatrabari Dhala, the new course of the Gunai flow. The impact of the project on this process is very uncertain.
- The redevelopment of the lower Gunai will increase river/channel area.

The project is not without potential significant adverse impacts and unresolved issues. Implementation of this project is recommended only after resolution of these matters.

Institution BWDB

Cost US $2.06 million

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Baulai River Improvement Project**

Location Baulai River, Itna to Tahirpur

Area 320,000 ha (gross); 261,000 ha (net)

Population Impacted 1,368,700 (1991) ; 3,482,580 (2015)

Objectives To restore effective drainage through the Central Basin. To reduce pre-monsoon and post-monsoon water levels and to improve navigation on the Baulai River and the major tributary channels that drain into it.

Description Drainage through the Central Basin has been disrupted over the last 30 years by obstructions due to channel closures, sedimentation and changes in river alignments. The proposed work would focus on improving drainage conditions on the Baulai River upstream of Kaliajuri and on six main branch channels – Old Surma River, Piyain River, Someswari River, Kangsha River, Patnaigang-Upper Baulai River and Rakti River. The main channel improvements on the Baulai River would focus on the reach between Kaliajuri and the Nawa River, where the channel cross section narrows at former loop cuts. Re-excavation along the tributary outlets would be carried out through the network of abandoned or decaying drainage channels that have silted-up due to changes in inflow conditions or upstream morphologic changes.

Carrying out the proposed works would require a substantial upgrading of the existing BWDB/BIWTA dredger fleets. Preliminary dredging volumes amount to 7 million m^3 from the main river and 8 million m^3 from the tributaries.

Benefits from the work would include reduced damage to crops in the pre-monsoon season due to lowered water levels, faster post-monsoon drainage and improved navigation throughout the Central Basin. In addition, the dredged spoil could be used to improve 27 village platforms (accommodating 18,000 persons), as described in the associated initiative "*Flood and Erosion-Affected Villages Development Project*". The initiative is intended to work synergistically with "Surma Kushiyara Baulai Basin Project","Updhakali Project" and "Dharmapasha-Rui Beel".

It is recommended that a two year Pilot Project be carried out as a first step in the work.

Institution BWDB; BIWTA

Cost US $39.00 million

THRUST: INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA

Initiative: Kalni-Kushiyara River Improvement Project

Location Kushiyara River, Madna to Markuli

Area 426,900 ha (gross); 362,000 ha (net)

Population Impacted 2,226,800 (1991); 3,482,600 (2015)

Objectives To reduce pre-monsoon and post-monsoon levels on the Kalni/Kushiyara River and to improve navigation by a program of maintenance dredging and loop cuts.

Description The Kalni-Kushiyara River has changed dramatically over the last 30 years due to both past engineering developments and natural processes. During the same period there have been trends towards rising pre-monsoon water levels and poorer drainage due to higher post-monsoon water levels throughout much of the Central Basin. These impacts have disrupted water transport, increased channel instability and adversely affected submersible embankment projects in much of the region. It is questionable whether the Kalni River can be sustained as a major drainage channel and a water transport route without carrying out channel maintenance and restoration works.

Before major channel maintenance work is initiated on the Kalni River, it is recommended that a pilot project be successfully completed to gain prototype experience on execution of channel improvement operations and to develop appropriate methods of dredged spoil disposal. On the basis of these findings, a comprehensive program of channel improvements could be designed. Based on the available information, a tentative five year program of channel improvements has been prepared for pre-feasibility level investigations. Channel restoration work includes the removal of 12.5 million m^3 of sediments from the river and construction of two further loop cuts. Benefits from the work include improved river navigation throughout the year, lower pre-monsoon water levels and faster post-monsoon drainage as far upstream as Manumukh, improved security of existing submersible embankment projects in the Central Basin and construction of new village platforms from the dredge spoil. The project is intended to work synergistically with several other major initiatives, including *Kushiyara-Bijna Inter-Basin Project*, *Surma-Kushiyara-Baulai Basin Project* and *Flood- and Erosion-Affected Villages Development Project*.

Institution BWDB; BIWTA

Cost US $39.60 million

THRUST: INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA

Initiative: **Jadukata/Rakti River Improvement Project**

Location Tahirpur, Bishwamvarpur, Jamalganj, and Sunamganj *thanas*.

Area 37,400 ha (gross); 30,300 ha (net)

Population Impacted 202,485 (1991); 317,800 (2015)

Objectives To reduce damage to agricultural land from pre-monsoon flash floods, improve post-monsoon drainage, facilitate navigation and quarrying and to reduce sedimentation in Tangua Haor, a key wetland site and "mother" fishery.

Description The project area contains plentiful natural resources but is situated in a morphologically unstable location that is subjected to high intensity floods and large sediment inflows. The centre of activity for this initiative is on the Jadukata River, which is the main influence on flow patterns in the Patnai, Upper Baulai, Nandia and Rakti Rivers. The river is currently in the process of shifting across its alluvial fan into the Maharram channel to the west. Two key wetland sites (Tangua Haor and Gurmar Haor), as well as valuable fisheries habitat and agricultural land are threatened by rapid sedimentation from this channel shift.

The Jadukata River is also the centre of activity in another sense. It is a major source of sand and stone for the construction industry in the region. In 1992 it was estimated that roughly 500,000 m^3 of aggregates was quarried from the river and over 85 million taka was introduced into the local economy from this work. However, the Rakti River, which is the main navigation route for boats transporting this material has become silted up to the point where it is completely dry during the winter. Furthermore, due to this siltation, post-monsoon drainage is deteriorating and the net cultivable area is gradually declining.

The proposed initiative emphasizes developing a management plan for the project area so that hazards from flooding and erosion can be minimized, and economic activity can be improved. Given the unstable nature of alluvial fans, it will be impractical to attempt to make the entire fan area safe from flooding and/or erosion. However, the situation can be improved through monitoring, ongoing channel maintenance and local river training. Dredging 24 km of the Jadukata/Rakti River from Dulabpur to Fazlipur would have a high priority, as this would improve drainage and facilitate navigation. Consideration would also be given to limiting further flow diversion from the Jadukata River by constructing a submersible weir across the Maharram River to prevent bed load and early and pre-monsoon flows from entering Tangua Haor.

Institution BWDB

Cost US $7.25 million

THRUST: **INTEGRATED DEVELOPMENT OF THE DEEPLY FLOODED AREA**

Initiative: **Sarigoyain-Piyain Basin Development Project**

Location Kotwali, Sylhet Sadar, Jaintiapur, Gowainghat, Chhatak, Companiganj, and Dowarabazar *thanas*

Area 126,590 ha (gross); 93,090 ha (net)

Population Impacted 604,500 (1991); 950,000 (2015)

Objectives To protect rice crops from pre-monsoon and monsoon flooding, to provide flood relief to homesteads within the area, to improve navigation, and to reduce the risk of further channel avulsions which threaten homesteads and cultivable land.

Description The project area borders the Meghalaya Hills which experience very high rainfalls and generate large quantities of sand and gravel sediment. Sediment deposition on the Dhalai Gang alluvial fan is modifying land use – the deepest areas are infilling which is destructive to fisheries and natural ecosystems, while arable higher lands are being lost to sand deposition. Under these conditions, flooding is frequent and unpredictable and the Piyain and Dhalai channels are highly unstable. The deposition has also seriously hampered river transport of stone aggregate from quarry operations at the fan apex to Companiganj.

This initiative proposes intervention at three strategic locations as follows:

- The *Rauchunni Beel Project* would include flood protection (19.5 km full embankment with two regulators). The embankment would provide protection from inflows to the north but the southern side would remain open for drainage. Drainage improvement would involve re-excavation mainly of the Lain Khal (24 km), and low embankments around Raua and Kurundi *Beels* (about 6 km) to increase *beel* storage for fisheries.
- The *Nainda Haor Project* would provide pre-monsoon flood protection using 15 km of submersible embankments with 4 regulators, improved management of accumulated rainfall and inflows by constructing 15 km of embankments configured as compartmental bunds, and drainage improvement by excavating the Kaliurigang, Mirza, Shaheb, and Holakar Hoar channels (31 km).
- The *Dhalai Gang Project* infrastructure consists of a low-height closure dam across a recently formed distributary channel of the Dhalai Gang; bank revetments on the main channel left bank upstream and downstream of the present avulsion site; partial re-excavation of 4 km of the main channel up- and down-stream of the avulsion site; 4 km submersible embankment along the right bank of the Piyain River to the south with a regulator at the Rautir Khara channel; one fish pass structure; one pipe sluice; and re-excavation of 2 km of Rautir Khara.

Institution BWDB

Cost US $6.40 million

THRUST: **BIODIVERSITY ENHANCEMENT AND SUSTAINABLE MANAGEMENT**

Initiative: **Upland Biodiversity Conservation Studies and Implementation**

Location Uplands of the Sylhet and Mymensingh Forest Department Ranges

Area Regional

Population Impacted National

Objectives To characterize and undertake necessary measures to conserve the biodiversity of the region's upland areas, taking into account the needs of local people dependent on these areas

Description Some parts of the region's upland areas, principally those on Forest Department land, have some ecological character as natural forest ecosystems. As such, they are important national biodiversity havens, for purely upland species and for some species which migrate locally between upland and lowland/wetland areas. The Rema-Kalenga Wildlife Sanctuary, established in 1981, contains the last remaining patch (1,036 ha) of primary forest in the Sylhet region (IUCN, 1990).

In keeping with a traditional perspective on tropical forest resource management, virtually all Forest Department land is still carried on Department books as suitable for economic forestry activities, in some cases clear-cutting and conversion to plantation monoculture. Despite the major shift in attitudes towards logging and the growing recognition of the value of tropical forest biodiversity which have occurred over the past decade, the recent Forestry Master Plan did not, as had been hoped by conservationists, definitely set aside any additional forest areas in the region for biodiversity conservation in combination with other compatible objectives (ecotourism etc.), despite thematic recognition in Plan documents of this option.

Under the proposed project, the region's remaining natural forest areas would be protected under a logging moratorium until they were properly surveyed. The information collected, plus inter-agency and public consultations, would provide the basis for informed decisions on the best use of these areas. The project would then support the feasibility study/detailed design and initial set-up of improved management systems. Rema-Kalenga Sanctuary would be carefully surveyed and management upgraded to a level in keeping with its national significance.

Institution Ministry of Environment and Forests

Cost US $500,000

THRUST: **BIODIVERSITY ENHANCEMENT AND SUSTAINABLE MANAGEMENT**

Initiative: **Locally Based Management of Internationally Significant Wetland Sites**

Location Nine key wetland sites (Hail Haor, Hakaluki Haor, Tangua Haor, Pashua Beel, Baulai Haor, Kawadighi Haor, Bara Haor, Companiganj Area, Khaliajuri Area)

Area 83,800 ha

Population Impacted 29,000 (1991); 36,000 (2015)

Objectives General: conserve biodiversity at the ecosystem level and wetlands of international significance, by stabilizing the ecological character of the nine most important remaining semi-natural wetland sites. Site specific: objectives for each site will need to be formulated based on consultations with stakeholders.

Description Efforts to preserve the freshwater wetland biodiversity of Bangladesh, an important aspect of the nation's natural heritage and once characteristic of much the nation's area, should focus on the Northeast Region which contains all of the nation's remaining large semi-natural freshwater wetlands. The Government's commitment to wetland conservation and improved management was expressed by its accession in 1992 to the Ramsar Convention.

Improved management of wetland resources in the region should focus on the nine wetland sites which have been identified as meeting one or more Ramsar Convention criteria for international significance. The emphasis should be on assisting local residents to design and implement management plans that enhance both biodiversity values and sustainable benefits flowing to local communities. This approach mobilizes local resources, minimizes central government dependency, and reduces conflicts between conservation and utilization objectives. A methodology to create locally-based natural resource management systems has been developed by the NGO Nature Conservation Movement through its work at several sites (Kapasia, Munshiganj, and Teknaf). The approach is built around a network of volunteers who are identified based on direct involvement with and dependence on resource utilization, residence near the resource, with an expressed interest in protecting their natural and cultural heritage, and other criteria. Activities of the volunteer network are coordinated through a Conservation Center established in each area and staffed by a core group of local people who are given necessary training and technical support. Activities for men, women, young people, and children are used to create community awareness, exchange information, and address community concerns such as resource management, income generation from natural resources, and so on.

Institution NGOs in partnership with Ministry of Environment and Forests

Cost US $3.0 million

THRUST: **BIODIVERSITY ENHANCEMENT AND SUSTAINABLE MANAGEMENT**

Initiative: **Threatened Ecological Community Recovery Programme**

Location Swampforest, floodplain grassland, and Forest Department reedland areas plus suitable other areas

Area About 30,000 ha known, plus unknown extent of other suitable areas

Population Impacted National

Objectives General: rehabilitate, extend, and sustainably manage lowland ecological communities once characteristic of the region that have all but disappeared. Specific: Reeds - Social afforestation and sustainable social management of 19,000 ha of unencroached Forest Department reed land, plus suitable areas (yet to be identified) under other ownership. Swamp forest - Sustainable social management of afforested areas. Floodplain grassland - Sustainable social management of the remaining 500 ha of floodplain grassland, plus habitat restoration in any areas found to be suitable.

Description Lowland forest, reed lands, and floodplain grassland are key elements of lowland biodiversity. All three are threatened as ecological communities. In addition, these resource systems provide direct economic and other benefits to local people; enhance openwater fishery and wildlife habitat and fishery productivity; protect homesteads from wave erosion; improve water quality; and stabilize land use.

The proposed intervention is to use appropriate locally-based methodologies to re-establish these communities over suitable areas. The techniques used for each community will differ, reflecting the different strengths, weaknesses, opportunities and threats applicable to each. Sustainably-managed swamp forest seems to offer attractive economic returns to land owners and fisheries lessees, who are undertaking some afforestation on their own. There is a need to investigate where and how it would be feasible to promote it as an economically viable alternative to other land use activities, and to determine how it could be incorporated into social forestry schemes. Reeds are of value as input to the Pulp and Paper Mill, but previous management schemes focusing on this use alone were unsuccessful. Past experience needs to be evaluated, and new multi-purpose models developed, for social forestry on Forest Department reed land, and for private land owners and fisheries lessees. Finally, floodplain grassland area is extremely limited and little studied, but of importance as habitat for a number of bird and other species some of which may have already disappeared from the region but could perhaps be reintroduced. More study of this community is needed, along with preservation of the small fragments that remain.

Institution NGOs in partnership with MOEF

Cost US $2.0 million

THRUST: **BIODIVERSITY ENHANCEMENT AND SUSTAINABLE MANAGEMENT**

Initiative: **Recovery Plans for Threatened and Commercially Threatened Lowland Plant and Animal Species**

Location Regional

Area Regional

Population Impacted National

Objectives Ensure the survival of viable populations of extant animal and plant species. Specific objectives must be formulated for each threatened or commercially threatened species.

Description Biodiversity at the species level logically focuses on threatened and commercially threatened plant and animal species. Action is urgently needed to prevent the irreversible loss of these populations from the region and thereby an increase in their global vulnerability. A few of these species face global extinction in the near or medium term unless action is taken. The potential ecological, societal, and economic benefits of re-introduction of species formerly inhabiting the region should also be evaluated. Currently threatened species include:

- A total of three mammal, two bird, and four reptile species thought to be extant in and dependent upon the lowlands of the Northeast Region are classified as globally threatened (IUCN, 1990). At least one and possibly three fish species and one plant species may be globally threatened but are not listed in this reference.
- An additional five mammal, five reptile, and one amphibian species are classified as commercially threatened (CITES, 1991).

Targets for each species should be established based on consultations among local people, technical experts, landowners (principally GOB), and government; and taking into current strengths and weaknesses and future opportunities and threats in the areas of technical means, ecological and social considerations, and so on. Recovery of threatened/commercially threatened upland species (see the initiative *Upland Biodiversity Conservation*) and any other lowland taxa subsequently identified should also be undertaken.

Institution NGOs in partnership with MOEF, and with established international species recovery programmes and researchers

Cost US $400,000

THRUST: **IMPROVE LIVEABILITY OF RURAL SETTLEMENTS**

Initiative: **Village Water Supply and Sanitation**

Location Villages throughout the region

Area Regional

Population Impacted 14,280,000 (1991); 16,610,000 (2015)

Objectives To provide sufficient hand tube wells such that one tube well services on average no more than 100 persons (down from the present 134 persons per tube well); to provide fixed latrines in all rural households in the region.

Description The provision of safe supply of domestic water combined with effective sanitation facilities is universally considered as a prerequisite for human wellbeing. In the strategy document entitled "*Achieving the Goals for Children and Development in the 1990s — National Programme of Action*" the government targets universal access to drinking water by the year 2000 (up from the present 80%); and 80% sanitation coverage (up from the present 6%). Access to hand tube wells for domestic water supply in the region is slightly below the national average of 131 persons per tube well.

This initiative is an endorsement of the on-going program of DPHE and UNICEF to extend tube wells and sanitary latrines. It also proposes that access to safe water be provided for a broader range of domestic purposes than only drinking water — hence the target of 100 persons per tube well which makes them more accessible to the people. It is proposed that the existing subsidy (53%) on sanitary latrines be continued and that the extension of both domestic water supply and sanitation facilities be accompanied by:

- A social mobilization program to enhance social awareness of the need for clean drinking water and the use of sanitation facilities;
- Training in installation of the slab and ring latrines (for 80% of the households); and,
- Training in construction of pit latrines (20%) of households.

Institution DPHE, UNICEF, NGOs working with local institutions and cooperatives.

Cost US $64.5 million (tube wells US $42.5 million; latrines US $22 million)

THRUST: IMPROVE LIVEABILITY OF RURAL SETTLEMENTS

Initiative: Improvement of Homestead Platforms

Location Villages in the region severely affected by flooding and wave erosion.

Area Deeply Flooded Areas

Population Impacted 3.8 million (1991); 5.6 million (2015)

Objectives To raise 700,000 homesteads in 4,600 villages (typically by 1.5 m) to reduce flood impacts; to enlarge 345,000 partially eroded homestead platforms in 2,300 villages to improve their liveability; and to construct 23,000 new homestead platforms in the deeply flooded area with dredging/re-excavation spoil material to resettle the most affected victims of flooding and wave erosion.

Description About 25% of the region is deeply flooded during the monsoon months with flood depths varying from three to eight metres. Settlements in these small areas are organized into small villages located on higher ground such as river levees and *kanda* (raised land within the *haor* basin area). Raised platforms three to five metres in height are constructed on these higher lands and homes are clustered on these platforms. Historically, people had the resources (access to earth and labour time away from paid or other directly productive employment) to undertake annual earthwork maintenance of their homesteads. Homesteads were on average larger and located on higher land than today, because village populations were smaller. The area had significant swamp forest cover which served to lessen the rate of wave erosion.

As people gradually occupied lower lands and the swamp forest disappeared, village margins have come to be composed of small, low homesteads, exposed to increasing wave activity. These homesteads are typically occupied by the poorest people, who, in the face of increasing economic and environmental pressures, are unable to undertake maintenance homestead earthwork. Without this maintenance, they find themselves in a downward spiral of increasing flood and wave damage contributing to increasing poverty.

The project described here would finance:

- earthwork to enlarge previously wave-eroded homesteads and to raise homesteads above the danger of flooding;
- (re)-establishment of strategic stands of swamp forest, and grass land habitats to protect against wave erosion and to provide sustainable biomass harvests;
- settlement of new villages on spoil platforms created by the dredging and channel re-excavation projects proposed in this plan document.

Institution Local Government (Union Parishad) and NGOs working with village based institutions

Cost US $158.1 million (capital cost); US $11.6 million (line of credit)

THRUST: **IMPROVE LIVEABILITY OF RURAL SETTLEMENTS**

Initiative: **Village Afforestation**

Location Villages subjected to severe erosion by monsoon wave action.

Area Deeply Flooded Areas

Population Impacted 2.0 million (1991); 2.8 million (2015)

Objectives The primary objective is to improve protection against wave erosion during the monsoon season at an estimated 2,300 existing and 150 future villages ; the secondary objective is to create employment and sustainable income for villagers.

Description About 25% of the region is deeply flooded during the monsoon months with flood depths varying from 3 - 8 m. Settlements in these deeply flooded areas are organized into small villages located on higher ground such as river levees and *kanda* (interior elevated areas). Raised platforms (3 - 5 m high) are constructed on these higher lands and the homes are clustered on these platforms. Historically, the area had significant forest cover and these trees served to lessen waves which erode the platforms. More recently, these forests have all but disappeared because of indiscriminate felling of trees and homesteads are being subjected to severe erosion. It is estimated that 2,300 villages (on an area of about 6,900 ha) have lost up to 25% of the surface area of the mounds on which they are situated.

The proposed initiative involves setting up a mechanism to enable villagers to reforest around homesteads and other identified strategic locations (along embankments and rural roads). The project would consist of several steps:

- Identify villages where erosion is most serious;
- Initiate an awareness/motivation campaign which would describe the benefits and the operational mechanics of the program and generally encourage villagers to participate as a group since not all people in the community would have access to land on which to plant trees;
- Develop nursery beds with flood resistant trees and reed plants through village based organizations (necessary training will be imported);
- Provide trees to the villagers at no cost from the nurseries and transplant them in critical locations; and,
- Assign caretakers from amongst the villagers to look after the seedlings for up to three years.

Institution NGOs (IDEA and others)

Cost US $4 million

THRUST: NAVIGATION IMPROVEMENT

Initiative: Dredging for Navigation

Scope Regional

Objectives To improve water transport in selected waterways by increasing navigable depths.

Description Inland water transport is responsible for conveying an estimated 80 per cent of the 30 million tonnes of produce and commodities carried annually to and from the 19 major markets in the region. Water transport is also used extensively by local inhabitants for personal travel, for getting produce and livestock to market and for fishing. Navigation conditions in many waterways have deteriorated over the last ten to 20 years as a result of ongoing siltation, upstream channel changes, alteration to discharges and hydraulic conditions, obstruction from FCDI works or lack of maintenance. There has been very little systematic channel maintenance work carried out in the region to-date. Substantial improvements could be made to the existing system by localized dredging at shoals and other trouble spots, removal of obstructions and channel constrictions and by provision of better navigation aids.

The proposed project envisages providing support in the form of:

- systematically cataloguing important navigation routes and maintaining an updated inventory of country boat routes;
- marking obstacles and providing beacons along main channels;
- making pilotage services available on main routes;
- providing draft forecasts on key channels;
- conducting mechanical dredging at shoals and local "trouble spots" on rivers such as the Rakti, Kangsha and Someswari and by manual dredging on smaller channels and khals.

Aside from improving navigation, regular maintenance dredging can be used as a means of increasing the stability of river channels by controlling sedimentation patterns as they develop. If potential problems are managed early on before serious erosion or scour is initiated, the need for much more expensive interventions (such as bank protection works) may be eliminated. Therefore, dredging for navigation needs to be closely coordinated with other measures for managing river engineering problems in the region.

Institution BIWTA, BWDB, Local Government, Bangladesh Country Boat Owners Association

Cost US $14.9 million

THRUST: **NAVIGATION IMPROVEMENT**

Initiative: **Support to Country Boats**

Scope Regional

Objectives To integrate the role of country boats into the overall development of the region to improve the efficiency of this mode of transport and communication.

Description Country boats carry 50% of all cargo and provide 60% of all employment in the transport sector in the region. This important role in the economic and social development of the region is not reflected in the manner in which the sub-sector is supported. At present there is very little coordination among the agencies which impact on this sector, including BIWTA, BWDB, LGED, Roads and Highways, and NGOs. As a result, country boats are faced with inadequate services such as mooring facilities, boat repair facilities, and improved engines and related technologies. They are also experiencing operational problems related to the construction of roads, bridges, regulators, and river closures. Furthermore, the use of engines on country boats can double earnings of operators and installing a gear box increases speed and safety while reducing fuel consumption by one-third.

The proposed project involves:

- Establishing and enforcing policies to ensure that, along identified navigation routes, any interventions (such as bridges and regulators) be designed and constructed to accommodate specified navigation requirements;
- Improving opportunities to install boat engines and gear boxes;
- Researching possible improvements in boat construction materials and boat designs;
- Establishing boat centres with mooring facilities, repair shops, and depots for spare parts, lubricants and fuel; and,
- Institutional support to handle registration, licensing, credit security, insurance and training. Training would focus on socio-economic and technical issues such as group formation, credit, insurance, boat crews, carpenters, and mechanics.

Institution BIWTA, Ministry of Shipping, Bangladesh Country Boat Owners Association

Cost US $10 million (Public); US $ 70 million – boat improvements, services and supply, businesses (Private)

Initiative: **Pilot Project to Institutionalize Public Consultation**

Scope Regional

Objectives Primary objective: to recommend a framework within which public consultations would be organized as a mandatory component of project planning and development; Secondary objective: to provide a forum for public input into the feasibility and design activities which would constitute subsequent phases of project development within the Northeast Regional Project.

Description There are various government institutions (such as BWDB, LGED, DOF, Roads and Highways, BIWTA, and DOA) working on behalf of the people of the region to provide a development system that can stimulate economic and social growth. The activities of these institutions all affect or are affected by the regions water resources. While in the past most of the related programmes and infrastructure have had considerable potential, many have under-performed; in part due to centralized planning (and the corresponding absence of community involvement), and in part due to the absence of coordination of programmes. The GOB has indicated a desire to make development systems more decentralized and participatory in nature. As a response, while preparing the Northeast Regional Water Management Plan, a series of seminars were undertaken to ensure that the Plan is consistent with perceived needs and problems expressed by the various communities on whom the plan is to impact. There is a need to identify an institutional framework through which the public and the various agencies can formally respond to development plans which impact on them, and through which concerns with regard to on-going programmes can be expressed.

The proposed project would reside within the Northeast Regional Project through its second phase. It would involve financing a programme of on-going public consultation associated with specific investment initiatives. Efforts would be directed (through consultation) towards identifying an appropriate institutional structure through which these meetings would be organized and financed - various options would need to be tested. In addition to providing input for NERP Phase II initiatives, the outcome of this exercise would be a recommendation for a permanent institutional structure for such a process.

Institution Northeast Regional Water Management Project.

Cost US $500,000

THRUST: INSTITUTIONAL STRENGTHENING AND DEVELOPMENT

Initiative: **Improved Flood Warning**

Location Regional areas adjacent to Meghalaya and Tripura

Area 5000 km^2 north of the Kangsha-Surma Rivers alignment; 4000 km^2 south of the Kushiyara River

Population Impacted 2.3 million north of the Kangsha-Surma Rivers alignment; 2.9 million south of the Kushiyara River

Objectives To provide timely, readily understood, warnings to villagers in flash flood-prone areas of flash floods imminent in their locality and posing danger to them, and to promote their appropriate response to the warnings.

Description Storms over Meghalaya and Tripura are often severe, are increasing in severity, and are not restricted to the monsoon season. These storms produce severe flash floods in two areas, one between the border with Meghalaya and the Kangsha and Surma Rivers, the other between the border with Tripura and the Kushiyara River. Such floods impact riverside villages so endangering the lives of the villagers and their livestock, their homes, food stocks, belongings, and crops.

The water management strategy supports ongoing development of FAP 10's forecasting effort but recognises that it is unlikely to be able to produce timely warnings of flash floods and disseminate them to village people; hence this initiative.

The initiative proposed involves: 1) detection, at the Indo-Bangladesh border, of rising river water levels reaching, successively, three danger levels selected to correspond to "moderate", "very", and "extremely" dangerous conditions for villagers; 2) activation, in response to these detections, of recognizably different audio and visual warning signals every 5 km along the flood's path; 3) appropriate protective/evasive actions by villagers in response to each level of danger signal. Details of appropriate technology remain to be worked out but it is expected to feature simple electrode detectors, radio signalling, small sirens and flashing lamps, all battery-powered with recharge by photo-voltaic cells because of the lack of mains electricity and mounting of these components on guyed masts to maximise audibility, visibility, and security of equipment. Details of actions to be taken by villagers also remain to be worked out in consultation with them.

Institution BWDB, and local administrations

Cost US $260,000 for Pilot Project on one river; US $2.4 million for extension to 8 other rivers

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THRUST: **INSTITUTIONAL STRENGTHENING AND DEVELOPMENT**

Initiative: **Northeast Region Environmental Management, Research, and Education Centre (NEMREC)**

Scope Regional

Objectives General: Create a regional institution capable of addressing biodiversity, surface water quality, and related concerns; which is sustainable, transparent, and efficient, responsive to changing opportunities and threats, and has proper accountability. Specific: Establish an autonomous regional environmental non-governmental organization (NGO) with the technical and community organization capabilities needed for ongoing support to a broad range of ongoing and self-initiated actions in environmental management, research, and education, in particular as these relate to lowland biodiversity and surface water quality.

Description Improved surface water quality management and biodiversity conservation will not be achieved by unilateral central government action, nor by direct partnership between local people and central government bureaucrats. There is a need for institutional development at intermediate levels. A regional-level institution is ideally suited to fill this gap, with the scale and competence to command national attention, while keeping a primary orientation towards the needs and views of residents and communities in the region. Such a regional institution would also provide assistance in mobilizing local and regional input to environmental planning, assessment, and management of development projects.

The functions and needed qualities of this institution suggest that it should be private rather than governmental, and specifically should follow the NGO model, which is widely understood and successful in Bangladesh, and recognized and governed by specific national legislation. The first step in creating a new NGO is to establish a Convening Committee. This group prepares a draft organizational plan following a standard format established by the Ministry of Social Welfare. This document includes a draft constitution identifying goals, objectives, and areas of activity. Then the Committee would organize and convene meetings of a General Membership. In the case of NEMREC, this would be open to all interested parties or their representatives. The General Membership then elects a Executive Committee of eleven or more members. The Executive Committee finalizes the constitution (which must define *inter alia* regular meeting and election intervals, membership categories and criteria) and registers with the Government. The Executive Committee is responsible to meet legal requirements for proper accounting and other types of records. Once established, NEMREC would take over ongoing surface water quality and biodiversity actions, and assist to mobilize local and regional input to environmental, planning, assessment, and management of development projects.

Institution An established NGO with broad environmental interests to set up Convening Body.

Cost US $700,000

THRUST: **INSTITUTIONAL STRENGTHENING AND DEVELOPMENT**

Initiative: **Surface Water Quality Management Strategic Planning Exercise**

Scope National

Objectives General: Improve the institutional framework for water quality improvement and management. Specific: Prepare and begin implementation of a strategic plan and action programme for water quality improvement and management, reflecting input from all interested parties

Description All aspects of water quality management – industrial pollution control, sewage treatment, access to safe domestic water and fixed latrines, water quality characterization and monitoring, public health education related to water – need to be strengthened. This is complicated by the fact that responsibility for water quality management is divided among a large number of entities.

A strategic planning exercise would allow a cross-cutting examination of water quality management issues, and would provide a venue for discussion among the various interested parties. The aim would be to develop and begin implementation of a strategy and programme to reduce pollution from industrial and domestic waste by deploying resources more efficiently, increasing the amount and effectiveness of private sector and people's participation, and by improving the coordination and integration of functions between entities.

The institutions involved in water quality management include the following. The Environment Pollution Control Directorate of the Department of Environment is responsible for water quality monitoring. The Municipal Corporations in each major urban center are responsible for urban infrastructure, which includes urban water supply and sewage conveyance and treatment systems, development zoning, and so on. The Department of Public Health Engineering is responsible for rural water supply and sanitation. The Bangladesh Chemical Industries Corporation, under the Ministry of Industries, is by far the largest public sector industry, with 22 enterprises, including the four pulp and paper mills, and employing over 30,000 people to produce a wide range of products. There are a number of laboratories, within and outside of Government, which perform water quality analyses of various types. The Bangladesh Chemical Society, the professional society of chemists and chemical engineers, has taken a strong interest in pollution abatement technology. In addition, nationally there are 2000 private industrial concerns classified as pollution sources — the owners and managers of which would be the ones to implement actual pollution abatement measures.

Institution MOEF, with participation of other agencies and NGOs as appropriate

Cost US $300,000

Initiative: **Biodiversity Strategic Planning Exercise for the Ministry of Environment and Forests**

Scope Regional

Objectives General: Develop national institutions in the area of biodiversity conservation. Specific: Prepare and begin implementation of a strategic plan and action programme for institutional development, reflecting input from all interested parties, to create adequate mechanisms to support the Government's stated policy commitments to biodiversity and wetland conservation, and to public participation in natural resource management.

Description The recent strengthening of national policies regarding biodiversity awaits commensurate national institutional development. In addition, overarching national policies regarding public participation, self-reliance, and so on, need to be incorporated in all national institutions, including those in these two areas.

Strategic planning at the highest level is needed to identify and develop programmes for the necessary key changes in legislation, agency mandate and regulations, staffing and staff training, inter-agency cooperation mechanisms, arrangements for public participation, and so on. In preparation for such an exercise, there is a need for staff development activities to heighten awareness of biodiversity issues, treatment technologies, and so on, and of the value of biodiversity components.

The role of the project would be to identify key biodiversity issues and develop an acceptable institutional framework for dealing with these, based on dialogue with and among the interested parties - those within and outside government, and from the grassroots, intermediate, and national levels. The project would provide technical assistance, training, support for conferences, and similar inputs, in support of this activity. An initial effort in this area was made by CIDA/IUCN in sponsoring a conference entitled "Conservation and Sustainable Management of Freshwater Wetlands" in December 1992.

Institution MOEF, with participation of other agencies and NGOs as appropriate

Cost US $300,000

THRUST: **INSTITUTIONAL STRENGTHENING AND DEVELOPMENT**

Initiative: **BWDB Strengthening**

Scope Regional

Objectives Make the BWDB a genuine partner in the region's development; instill community partnership and effective management and operation of water management infrastructure as priority BWDB goals; and improve BWDB capabilities to effectively manage operate and maintain their inventory of infrastructure.

Description In the thrust toward making water management systems more decentralized and participatory BWDB regions will have a changed role in development with responsibilities in planning, design, management and O&M of water control infrastructure. Implicit in this role is the need for change within BWDB to become a genuine partner of the community and to be more perceptive in addressing emerging development needs including protection of the environment, enhancing fisheries and integration with other development sectors.

If the projected benefits of existing and proposed new structural projects are to be realized and sustained, the capabilities and performance of BWDB in managing, operating and maintaining its inventory of infrastructure unquestionably needs to improve.

The proposed project will reside within the Northeast Regional Project through its second phase. It will involve field work within BWDB O&M Divisions at the Executive Engineer level and below. Activities will include:

- Education and training to develop among all levels within the regional O&M divisions a thorough understanding of and commitment to the regional development plan;
- Identifying opportunities for social change within BWDB which could be exploited to provide a more responsive management commitment to infrastructure management;
- Training programs to provide for negotiation and establishment of partnerships between BWDB with initiation of pilot partnerships as opportunities appear;
- Traditional training and institutional strengthening at the appropriate field level on capabilities needed to effectively manage, operate and maintain BWDB infrastructure.

Institution

Cost US $250,000

9.2 SUMMARY

9.2.1 Characterization of Initiative Costs by Strategic Thrust

The strategic thrust entitled "Urban and Infrastructure Protection and Improvement" accounts for the largest (44%) financial component of the strategy. The two largest initiatives in this thrust are *Urban Potable Water* and *Urban Sanitation*, which are both infrastructure improvement projects.

The three initiatives in the strategic thrust "Improved Liveability of Rural Settlements" account for the second largest financial component (23%) of the strategy. The non-structural flood control initiative *Improvement of Homestead Platforms*, which focuses on raising and improving village homestead platforms to prevent flooding and erosion in the deeply flooded Central Basin, is the single largest project in this category.

The twelve initiatives in the strategic thrust "Integrated Development of the Deeply Flooded Area" make up the third largest financial component of the strategy. These initiatives, which account for 20% of total Plan costs, are geographically focused on the low-lying Central Basin in the middle of the region. The primary focus of these initiatives is to improve agricultural production through drainage improvement, which would be achieved by channel rehabilitation and re-excavation, regulation of pre-monsoon flash floods at key offtake sites and spill channels, and where necessary, by upgrading and/or constructing submersible embankments. A major component in this strategic thrust is also related to fisheries management and provision of fish pass structures at FCD works.

The seven initiatives in the strategic thrust "Enhanced Production Systems on Seasonally Flooded Areas" account for 7% of total Plan costs. These initiatives are located in the Eastern Seasonally Flooded Area (primarily the Upper Surma-Kushiyara floodplain) and the Western Seasonally Flooded Area (lands in the Kangsha basin and on the Jamuna floodplain).

The remaining 14 initiatives are components of the four strategic thrusts "Intensive Agriculture for Urban Consumption", "Biodiversity Enhancement and Sustainable Management", "Navigation Improvement", and "Institution Strengthening and Development". These initiatives, which include a mix of structural and non-structural projects account for about 5.5% of the total Plan costs.

9.2.2 Characterization of Initiatives by Type

Infrastructure improvement initiatives represent the largest Plan component (43%), followed by structural FCD initiatives (26%) and non-structural floodplain management (18%).

Table 21 compares the present-day regional characteristics of FCD developments along with the proposed FCD initiatives to illustrate how the strategy will change the region. Compared to the existing situation, the proposed FCD initiatives provide a much greater emphasis on drainage over flood control; on multi-function over single-purpose projects; and on innovative technical solutions. *Manu River Improvement Project, Upper Kangsha Project, Mrigi River Improvement Project, Surma-Kushiyara-Baulai Project, Kalni-Kushiyara River Improvement Project, Baulai River Improvement Project*, and *Jadukata-Rakti River Improvement* are in the latter category.

Table 21: FCD Initiatives by Type

FCD Project Description	Present		Proposed Initiatives		
	Number	Net area (ha)	Number	With Drainage Improvement	Net area (ha)
Full flood control	27	96,000	3	3	138,000
Partial flood control	33	172,000	4	2	282,000
Drainage only	5	18,100	5	5	50,000
Mixed (both full and partial flood control areas)	-	-	4	4	274,000
Irrigation distribution	2	6,000	0	0	-
Erosion Protection only	-	-	1	0	-
TOTAL	66	292,100	18	14	744,000

The increase in net area under controlled flooding/full flood control, partial flood control, drainage improvement, major surface water irrigation, and other development would be as follows:

- Controlled flooding/full flood control projects: increase by 263,672 ha or 275%, including 100,226 ha within mixed-type projects;
- Partial flood control: increase by 456,520 ha or 265%, including 173,890 ha within mixed-type projects; and
- Drainage improvement: increase by 408,360 ha or 2,256%, excluding drainage improvement within flood control projects.

The individual FCD projects that have been proposed tend to be larger (greater net area) than existing projects. There are several reasons for this. Three of the proposed projects consist of two or more schemes within a single basin (*Narayanganj-Narsingdi, Upper Kangsha,* and *Sarigoyain-Piyain Basin*). Also, the *Surma-Kushiyara-Baulai Project*, the largest project at 254,600 ha net area and over twice the size of the next largest project, represents an alternative to numerous small partial flood control schemes based on a ring dyke approach. The analysis of existing projects found little correlation between size and project performance.

The three primarily non-structural floodplain management projects (*Improvement of Homestead Platforms, Jamuna Floodproofing,* and *Improved Flood Warning*) focus on reducing hazards from flooding by improving flood warning systems, by floodproofing homesteads and infrastructure, and by controlling erosion and raising homesteads above expected flood levels. These initiatives account for 18% of the total cost of all proposed initiatives.

The infrastructure improvement projects primarily focus on provision of other types of structure or hardware (*Urban Potable Water, Urban Sanitation, Duckweed Wastewater Treatment, Pulp and Paper Mill Effluent Treatment, Fisheries Engineering, Dredging for Navigation*). These projects account for approximately 43% of the total cost of all initiatives.

Fifteen non-structural initiatives primarily focus on improving resource management; (*Regional Ground Water Monitoring, Water Quality Characterization, Industrial Pollution Abatement at Smaller Industrial Facilities, Pond Aquaculture, Applied Research for Improved Farming Systems, Fisheries Management, Upland Biodiversity, Locally-Based Management of Key Wetland Sites, Threatened Ecological Community Recovery*, and the six institutional initiatives). These initiatives amount to 6% of the total cost of all proposed initiatives.

Three initiatives do or could make significant use of both structural and non-structural elements (*Threatened Species Recovery, Village Water Supply and Sanitation, Support to Country Boats*). These mixed initiatives account for 8% of the total cost of all initiatives.

9.2.3 Geographical Distribution of FCD Initiatives

Most of the initiatives that are classified as "Infrastructure Improvement" or "Resource Management" are intended to be applied at a regional scale rather in specific localized parts of the region. On the other hand, the various structural and non-structural FCD initiatives vary spatially across the region. This section describes these spatial variations and illustrates how the different hydrological, geological, and topographic features in the region affect the kinds of FCD initiatives that can be utilized. It should be noted that some initiatives include several different components and extend over more than a single sub-region.

Eastern Seasonally Flooded Sub-Region

Structural Flood Control Projects in the ***Eastern Seasonally Flooded*** sub-region include:

Upper Surma-Kushiyara River Project
Surma Right Bank Project
Sarigoyain-Piyain Project (also extends into the Meghalaya Fans)

These projects will control flooding by eliminating spills from rivers during both the pre-monsoon and monsoon season by rehabilitating existing embankments, by regulating major spill channels and where necessary, by constructing new embankments.

Northern Alluvial Fan Sub-Region

Structural flood control projects in the ***Northern Alluvial Fan*** sub-region include:

Dhalaiganj Improvement component of *Sarigoyain-Piyain Project*
Jadukata-Rakti River Improvement Project
Someswari River component of the *Upper Kangsha River Basin Project*

The Plan recognizes the inherent instability and high risks that are associated with developments on fans. Therefore, the Plan has avoided initiatives that would attempt to confine the fan channels by narrow embankments. Instead, it is recommended that the fans be allowed to occupy a wide active floodway, which will be used for storing sediment and conveying flood flows. Initiatives have been restricted to stabilizing inactive or less active portions of the fan so they will be safe from future avulsion hazards, or preventing new avulsions from developing by closing spill channels that threaten to capture the main river flows.

In view of the high hazards from flash flooding in the fan areas, a non-structural hazard management approach has been included as part of the initiative "Improved Flood Warning Systems".

Central Basin

Structural FCD projects primarily focused on the ***Central Basin*** include:

Surma-Kushiyara-Baulai Basin Project
Baulai River Improvement Project
Kalni/Kushiyara River Improvement Project
Kushiyara-Bijna Inter-Basin Project
Jadukata-Rakti River Improvement Project
Updhakali Project
Dharmapasha-Rui Beel Project

Projects in the Central Basin will be aimed at altering pre-monsoon and post-monsoon season flow conditions. Project impacts are expected to be minor during the monsoon season when the sub-region, and the initiatives will be inundated. The primary focus of these projects includes:

- Reducing spills of pre-monsoon floods from main river courses into the low-lying haor basins by regulating of spill channels and completion of new submersible embankments along the major rivers. Consequently, during the pre-monsoon season, drainage requirements will be primarily determined from local runoff rather than from externally generated flood inflows. The key project that accomplishes this regulation of spills into the Central Basin is the Surma-Kushiyara-Baulai Basin Project. In addition, the Upper Surma-Kushiyara River Project, although located outside the sub-region, also plays an important role in reducing flood flows from the Upper Kushiyara River.

- Improving drainage in the Central Basin by re-excavating and re-organizing the internal network khals and channels. At present, much of the existing drainage system has been obstructed by past channel closures, channel changes due to morphologic processes or local siltation. These initiatives will aim to restore the drainage capacity of the basin through a programme of channel re-excavation and re-alignment. Key initiatives addressing this component include the Baulai River Improvement Project and the Surma-Kushiyara-Baulai Basin Project.

- Rehabilitating the Kalni and Baulai Rivers by channel dredging and removal of local constrictions to lower pre-monsoon water levels (to reduce spills into the Basin) and post-monsoon water levels (to hasten post-monsoon drainage). The key initiatives for this component are the Kalni River Improvement Project and the Baulai River Improvement Project.

The non-structural floodplain management initiative *Flood and Erosion Affected Villages Development Project* (FEAVDEP) is the largest single initiative (in terms of costs) in the Central Basin. This initiative is closely associated with several of the drainage improvement projects described above, since spoil from the channel re-excavation work would be utilized for the improvement of the village platforms.

Western Seasonally Flooded Sub-Region

Structural FCD projects in the ***Western Seasonally Flooded*** sub-region include:

Upper Kangsha Basin Project
Mrigi River Drainage Improvement Project

The proposed *Mrigi River* works involve channel re-excavation and drainage improvements while *Upper Kangsha* works involve construction of full flood control embankments, a flow diversion to Mogra River and a major program of channel straightening and loop cutting.

The non-structural floodplain management initiative *Jamuna Floodplain Floodproofing Project* is intended to reduce hazards from periodic spills from the Jamuna River by controlling erosion and raising homesteads above expected flood levels.

Southern Piedmont Sub-Region

Structural FCD initiatives in the ***Southern Piedmont*** sub-region include:

Manu River Improvement Project (Manu River and Dhalai River)
Habiganj-Khowai Improvement Project (Khowai River, Karangi River, and Sutang River)

The primary effect of these projects will be to reduce monsoon season flooding by either confining main channel flows and preventing spills (*Habiganj-Khowai Project*) or by reducing flood magnitudes by diverting flows into an adjacent basin (*Manu River Improvement Project*). 9.4

Peri-Urban Sub-Region

Projects in the ***Peri-Urban area*** (the extreme south-west corner of the region) include:

Narayanganj-Narsingdi Project
Narsingdi District Development Project

These projects are intended to promote the development of high value and diversified agriculture for future urban (Greater Dhaka) consumption.

9.3 PLAN IMPLEMENTATION CAPACITY

Implementation responsibility for the proposed initiatives broadly fall under the jurisdiction of agencies within six ministries of GOB: Bangladesh Water Development Board under the Ministry of Irrigation, Water Development, and Flood Control; Department of Environment under the Ministry of Environment and Forests; Department of Fisheries under the Ministry of Livestock and Fisheries; Department of Public Health Engineering under the Ministry of Local Government, Rural Development, and Cooperatives; Bangladesh Inland Water Transport under the Ministry of Shipping; and Department of Agricultural Extension under the Ministry of Agriculture. FY91 and FY93 Annual Development Plan allocations for the region by sector compare with the disbursement profile (Figure 23) as follows:

- Regional FY91 and FY93 allocations to flood control and drainage were estimated at Tk 1.06 thousand million and Tk 1.41 thousand million respectively. Plan initiatives are expected to comprise all future investments in this sector and have a disbursement profile which ranges from Tk 0.78 thousand million in the first year of Plan implementation to a peak of Tk 1.92 thousand million at the end of the fifth year, gradually falling back to Tk 0.53 thousand million. Given that the Plan disbursement

profile calls for peak implementation rates at only 35% above FY93, it is not expected that the proposed volume of work will present a problem.

- At present, regional allocations to environmental initiatives through DOE are negligible. Plan disbursement would begin at Tk 0.02 thousand million and peak at Tk 0.08 thousand million. Much of the proposed work would be carried out by DOE in conjunction with NGOs. Some increase in institutional implementation capacity would be a prerequisite to implementing environmental components of the Plan.

- Regional FY91 and FY93 allocations to agriculture and fisheries amounted to Tk 0.7 thousand million and Tk 0.9 thousand million respectively. Plan initiatives, peaking at Tk 0.2 thousand million represent about 20% of this level of disbursement.

- Regional FY91 and FY93 allocations to rural development are Tk 0.5 thousand million and Tk 0.7 thousand million respectively. Plan initiatives represent annual disbursements of Tk 1.06 thousand million or about 40% higher than FY93 values. Some expansion of institutional capacity would be required to implement these Plan components.

9.4 PRIORITIZATION AND SCHEDULING

The prioritization of the recommended initiatives shown in Tables 22 through 25 is based on the general prioritization of strategic thrusts (Section 8.5) and on considerations related to rational sequencing of initiatives (for example, upstream to downstream for flood control, downstream to upstream for drainage interventions). The results of the multi-criteria analysis were not used to determine phasing, because the proper basis for phasing relates to the considerations noted above, not to slight differences in indicators such as the Economic Rate of Return.

For the purpose of establishing a tentative scheduling of projects, the initiatives have been grouped into the following four categories:

Non-structural initiatives of a remedial nature (Group N). Generally, these are initiatives for which the implementation is overdue; for which implementation is independent of other internal or external actions being carried out; and for which processing has some urgency. The initiatives in this class are presented in Table 22.

Structural initiatives that are independent of other structural plan initiatives and of external developments (Group SI). Implementation of these initiatives will not be affected by other Plan initiatives or upstream developments. These include drainage improvement schemes having a large impact on the region and on subsequent initiatives; initiatives not substantially affected by Tipaimukh dam; projects in the upper catchments that are isolated from other recommended initiatives; and projects requiring immediate action to avoid further deterioration of existing infrastructure. The initiatives in this class are presented in Table 23.

Structural initiatives that are internally dependent (Group SID). Structural projects that are highly dependant on other Plan initiatives and that cannot be implemented in isolation,

but need to consider the impacts of these other initiatives during feasibility analysis, planning, and design. The initiatives in this group are presented in Table 24.

Structural initiatives that are externally dependant (Group SED). These initiatives (Table 25) will be strongly affected by future developments outside the Region which are largely beyond the control of the Government of Bangladesh (such as Tipaimukh Dam in India). Ideally, these initiatives should incorporate the expected impacts from Tipaimukh Dam into their planning, design, and schedule for implementation. However, given the present level of uncertainty associated with Tipaimukh, this can only be done in a very preliminary fashion. Therefore, in the implementation schedule for the initiatives (Figure 22), this group of projects has been shown as commencing in year four of the plan, to allow additional time for resolution of the Tipaimukh Dam issue.

Table 22: Group N Initiatives

Initiative	Rationale
Urban and Infrastructure Protection	
Urban Potable Water	Essential services for urban development.
Urban Sanitation	
Regional Water Quality Characterization	Immediate attention is required to obtain information on water quality.
Industrial Pollution Abatement at Smaller Industrial Facilities	Immediate action is required. Regional industrial pollution is likely to double over the next decade.
Duckweed-Based Domestic Waste Treatment	Immediate attention required for the enhancement of health standards.
Enhanced Production Systems on Seasonally Flooded Areas	
Ground Water Investigation	Immediate attention required to avoid over-extraction of ground water.
Jamuna Flood Plain Floodproofing	This area is subjected to regular Brahmaputra River inundation resulting in greatly reduced quality of life.
Pond Aquaculture	Improved socio-economic conditions for small and landless farmers.
Integrated Development of Deeply Flooded Areas	
Applied Research for Improved Farming Systems	Immediate attention required so that mixed farming systems can be introduced into the deeply flooded area.
Fisheries Management Program	Immediate attention required to increase open water fish production and to ensure the long-term sustainability of fish production.
Pulp and Paper Mill Effluent Treatment	Immediate attention required to arrest environmental degradation.

Table 22: Group N Initiatives

Initiative	Rationale
Biodiversity Enhancement and Sustainable Management	
Upland Biodiversity Conservation Studies	Immediate attention required to arrest environmental degradation.
Locally Based Management of Internationally Significant Wetland Sites	
Threatened Ecological Community Recovery Programme	
Recovery Plans for Threatened and Commercially Threatened Lowland Plant and Animal Species	
Improved Liveability of Rural Settlements	
Village Water Supply and Sanitation	Immediate attention required for the provision of essential services.
Village Afforestation	Immediate attention required to arrest environmental degradation.
Institutional Strengthening and Development	
Pilot Project to Institutionalize Public Consultation	Immediate attention required to improve the planning process.
NE Regional Environmental Management, Research, and Education Centre (NEMREC)	Immediate attention required to arrest environmental degradation. This initiative linked to other environmental initiatives.
Surface Water Quality Management Strategic Planning Exercise	Immediate attention required to arrest environmental degradation. This initiative linked to other environmental initiatives.
Biodiversity Strategic Planning Exercise	Immediate attention required to arrest environmental degradation. This initiative linked to other environmental initiatives.
BWDB Strengthening	

Table 23: Group SI Initiatives

Initiative	Rationale
Urban and Infrastructure Protection	
Habiganj-Khowai Area Development	Project includes urban protection for Habiganj town and the reduction in flood damages to homesteads, infrastructure, and crops.
Manu River Improvement Project	Project includes urban protection for Moulvibazar town, rehabilitation of Manu River Irrigation Project, and the protection of adjacent road and rail links.
Bhairab Bazar Erosion Protection	Immediate action required to avoid further damage to Bhairab Bazar town, railway bridge, and electrical line.
Intensive Agriculture for Urban Consumption	
Narayanganj-Narsingdi Project	Future plans need to focus more on agriculture for consumption by the Dhaka mega urban area.
Enhanced Production Systems on Seasonally Flooded Areas	
Upper Kangsha River Basin Development	Consists of several sub-projects in the upper catchment. Benefits include improved operation of the existing downstream Kangsha-Thakurakona Project.
Integrated Development of Deeply Flooded Areas	
Fisheries Engineering Measures	Immediate attention required to arrest the deterioration of fish habitats and to restore open water fish production.
Baulai River Improvement Project	Drainage improvement scheme having a large potential impact on the region. Incorporates drainage improvement component of *Surma-Kushiyara-Baulai Basin Project.*
Kalni-Kushiyara Improvement Project	Drainage improvement scheme to rehabilitate lower Kalni-Kushiyara River.
Improved Liveability of Rural Settlements	
Improvement of Homestead Platforms	Homestead conditions are deteriorating rapidly and population is increasing.
Institutional Strengthening and Development	
Improved Flood Warning	Better warning systems are critical to reducing loss of life, damage to crops and property. A pilot project is proposed to determine an appropriate solution.

Table 24: Group SID Initiatives

Initiative	Rationale
Enhanced Production Systems on Seasonally Flooded Areas	
Mrigi River Drainage Improvement Project	Project affected by upstream work on the Karnajhora River.
Integrated Development of Deeply Flooded Areas	
Jadukata-Rakti River Improvement Project	Project affected by *Baulai River Improvement Project.*
Sarigoyain-Piyain Basin Development Project	Located in the upper catchment area but not affecting existing projects or urban centres.
Dharmapasha-Rui Beel Project	Affected by *Baulai River Improvement Project*
Updakhali River Project	Affected by *Upper Kangsha Basin Project* and *Baulai River Improvement Project*. Lead time for testing fish pass structures also needed.
Intensive Agriculture for Urban Consumption	
Narsingdi District Development Project	Project affected by upstream development on the Old Brahmaputra channel.
Navigation Improvement	
Dredging for Navigation	Project affected by *Baulai River Improvement* and *Kalni-Kushiyara River Improvement.*
Support to Country Boats	Other action is needed before implementation as project is partly linked with water resource projects.

Table 25: Group SED Initiatives

Initiative	Rationale
Enhanced Production Systems on Seasonally Flooded Areas	
Surma Right Bank	Project is located upstream of other initiatives on Surma River. The project will be affected by Tipaimukh Dam if constructed.
Upper Surma-Kushiyara Project	Project is located in the upper catchment area and will affect flood discharges in the downstream reaches of the Surma and Kushiyara channels. The project area will be affected by the Tipaimukh Dam if constructed.
Integrated Development of Deeply Flooded Areas	
Kushiyara-Bijna Interbasin Project	Project affected by *Kalni-Kushiyara River Improvement*, by other upstream initiatives, particularly *Upper Surma Kushiyara Project*, as well as by Tipaimukh Dam if constructed.
Surma-Kushiyara-Baulai Basin Project	Project affected by *Baulai River Improvement*, by other upstream initiatives (*Surma Kushiyara Project* and *Surma Right Bank Project*) and by Tipaimukh Dam if constructed.

10. ASSESSMENT OF REGIONAL PLAN IMPACTS

10.1 INTRODUCTION

10.1.1 Organization

This chapter is organized as follows:

- Introduction
- Biophysical impacts
  - Interpretive description of regional physical impacts of Plan FCD initiatives
  - Biophysical impacts of Plan FCD and non-FCD initiatives by environmental components
- Socioeconomic impacts
  - Regional economic impacts
  - Other socioeconomic impacts
- Cumulative impact of Plan + other processes
- Sustainability analysis
- Environmental Management Plan issues

Additional information is provided in a separate report entitled *Initial Environmental Evaluation* (IEE). Additional information on the impacts of individual potential initiatives is provided in the project pre-feasibility study reports.

10.1.2 Orientation

The purpose of this chapter is to provide an overview of the impacts of strategy implementation; the sustainability of the strategy and its impacts; and environmental management issues.

Readers should bear in mind a number of considerations. Projects which physically alter floodplain hydraulics (FCD) projects can profoundly alter the spatial and temporal distribution of water and are well-known for their potential to produce a mixture of beneficial and adverse impacts across the range of water-linked systems. For this reason, the potential beneficial and adverse impacts of the FCD projects (including the effects of built-in mitigation measures) are given special attention here. The few adverse impacts of the non-FCD projects are also noted.

Impact is here defined as the difference between the future-with-Plan (FW) situation in 2015 and the future-without-Plan (FWO) situation in 2015. The FWO situation is characterized in Chapter 7 (Future Regional Development Context). Further developments outside/upstream (such as Tipaimukh) are, by definition, part of the FWO scenario. Those that affect the FW scenario directly, through environment-on-project impacts or other means, are mentioned here.

The net (i.e. residual) impacts of Plan initiatives described here result from:

A. Direct impacts of flood control and drainage measures

B. Mitigating/compensating impacts of mitigation/compensation measures incorporated into individual FCD projects

C. Direct impacts of non-FCD projects

D. Cumulative impacts of FCD projects

E. Interactions among FCD projects (project-on-project impacts)

F. Environment-on-project impacts

G. Mitigation and compensation of adverse FCD impacts by non-FCD projects

10.2

10.2.1

Impacts in categories *A*, *B*, and *C* are documented in individual project pre-feasibility studies, and quantifiable impact indicators from these studies are tabulated and totalled in IEE Table 9.1 and IEE Figure 13. Impacts in categories *D* through *G*, are documented in IEE Sections 9.2 to 9.5; additional information on category *G* impacts is provided by IEE Sections 11.2 and 11.4. Impacts are characterized for each subregion in Section 9.2.3 of this report, with additional detail provided in IEE Section 9.8.

Assessment methodologies are documented in IEE Chapter 7 (Assessment Methodologies, Data Sources, Assumptions, and Information Deficiencies). The information underlying the estimates of impact presented here is pre-feasibility level. Estimates of impact are conservative. Qualifying words ("estimated", "approximately", "about", and so forth) are omitted from the text for reasons of brevity. Proposed initiatives are assessed here on the basis of the draft final pre-feasibility studies. As the initiatives continue to evolve, the impacts will also, perforce, evolve. In some cases, impacts will depend on the timing and phasing of particular initiatives (see IEE Section 9.7).

An important characteristic of the portfolio of Plan initiatives is mitigation, compensation, and enhancement of FCD impacts by non-FCD initiatives:

- *Fisheries Engineering Project*. Mitigate fish migration impacts of embankments, closures, and water control structures by developing and providing fish passes. Other fisheries engineering structural measures would protect *beels* from sedimentation and increase dry season water storage.

- *Fisheries Management Programme*. Compensate for FCD fisheries impacts and enhance fish habitat and production, through biological management of the floodplain fishery which would be improved through interventions in fisheries habitats, assistance to New Fisheries Management Policy (NFMP) fishermen associations, and improvements in management of small community fisheries (*mohalshamil jalkar*, < 1.2 ha in area).

- *Biodiversity and surface water quality management initiatives*. Eleven of the 44 initiatives proposed in the Plan undertake to preserve and enhance regional biodiversity and to improve the management of regional surface water quality, through measures in the field and through institutional strengthening. These measures compensate in part for adverse impacts of Plan FCD projects in these areas.

- *Ground Water Investigation*. Addresses ground water management issues. The direct impacts of Plan FCD projects on ground water abstraction are small, but they may contribute to over-exploitation in some areas.

- *Dredging for Navigation* and *Support to Country Boats* would act synergistically with the major river improvement (drainage improvement) projects to enhance navigation.

In addition, mitigation, compensation, and enhancement measures were integrated into the design of individual Plan FCD projects; and there is mitigation between and among FCD projects (for example, of flood control and loop cut impacts by drainage improvement).

10.2 BIOPHYSICAL IMPACTS

10.2.1 Interpretive Description of Regional Physical Impacts of Plan FCD Initiatives

The initiatives which will produce the greatest physical impacts in the region fall into three broad categories:

- Controlled flooding (full flood control with controlled flushing) and partial flood control projects along the Surma-Baulai and Kushiyara-Kalni Rivers which extend from Amalshid on the east to near the outlet of the Central Basin in the southwest (*Upper Surma-Kushiyara Project, Surma Right Bank Project, Surma-Kushiyara-Baulai Basin Project*).

- Major drainage improvement schemes along the lower reaches of the Kalni and Baulai River systems (*Kalni-Kushiyara River Improvement Project, Baulai River Improvement Project*).

- Controlled flooding projects on the piedmont rivers (Manu, Bhogai-Kangsha) which involve either flood control embankments or flow diversions (*Manu River Improvement Project, Upper Kangsha River Basin Development Project, Habiganj-Khowai Area Development Project*).

Spills of water and sediment to the low-lying Surma-Kushiyara inter-basin will be reduced by construction of the *Upper Kushiyara Project*. Right bank spills from near the Lubha River will be eliminated by the *Surma Right Bank Project*. This will increase in-channel discharges and water levels along reaches of the Surma and Kushiyara during the monsoon season. The greatest impacts will occur near Kanaighat, where monsoon flood levels will rise by approximately 0.6 m after breaches at the existing embankment are closed (Figure 21B). Further downstream, regional surface water model results showed that monsoon flood levels will rise by on the order of 0.2 m from Sylhet to Sunamganj, and will be virtually unchanged downstream of the Old Surma River junction (near Nilpur). Model simulations indicated water levels will rise by generally 0.5 m or less on the Kushiyara upstream of Sherpur during the monsoon season. Rates of channel migration and bank erosion will be increased along the upper Surma and upper Kushiyara and some channel degradation may be expected.

Spills will also be reduced into the Central Basin after completion of the *Surma-Kushiyara-Baulai Basin Project* and the *Kushiyara-Bijna Interbasin Project*. Sedimentation rates in this main *haor* area will decline due to the reduced inflows. Re-excavation of the interior drainage network (such as Old Surma River and Darain River) will result in some local erosion/deposition.

Construction of partial and full flood control embankments will increase in-channel discharges slightly along the Baulai and lower Kushiyara-Kalni Rivers during the monsoon season. The increased confinement will tend to raise monsoon flood levels (particularly on the Kalni River

where submersible embankments will approach the level of an average monsoon flood). This confinement will be offset by other dredging initiatives. Confinement will also increase the channels' sediment transport capacity which will flush more of the incoming sediment load through the Kalni into the upper Meghna and more sediment from the upper Baulai into the lower Baulai-Ghorautra system.

10.2.2

River improvement initiatives along the Kalni-Kushiyara and Baulai will reduce the variability of depths and will produce a more uniform, incised single channel pattern. Spoil from dredging may raise ground levels on the floodplain or in side channels and beels. Associated river training works will produce local scour and erosion at shoals and in constricted reaches so that considerable local channel re-organization can be anticipated. Pre-monsoon and post-monsoon water levels will be lowered in the dredged reaches and upstream. As shown in Figure 21A, water levels at Markuli will be reduced by as much as 1.5 m during the winter and pre-monsoon periods. Monsoon peak water levels will be reduced by 0.1 m to 0.2 m, while the channel discharge will be increased by as much as one-third. Dredging on the Baulai River was found to have less impact, with pre-monsoon water levels lowered by 0.2 m and post-monsoon water levels lowered by 0.5 m. It should be noted that water levels and discharges at Bhairab Bazar on the Meghna were not impacted by these initiatives.

Dredging of the Kalni and Baulai appears to mitigate the effect of higher discharges in the post-monsoon season due to Tipaimukh Dam. Actual impacts would have differed if other upstream dam/irrigation scenarios had been adopted in the simulations. The model results clearly illustrate that upstream flow regulation of the Barak River in India will have a major impact on the region. Therefore, scheduling of some initiatives along the Surma and Kushiyara Rivers will have to fully consider future developments in the Barak River basin.

The *Manu River Improvement Project* will divert a portion of flood flows into Hakaluki Haor to reduce discharges at Moulvibazar. This will alter the regime of both the Manu River and the area around Hakaluki Haor. Sediment deposition may occur on the Manu River below the diversion since the river's sediment transport capacity will be reduced. The diversion flows will also produce sediment deposition in Hakaluki Haor. This deposition will occur by development of a delta into the haor and by channel switching across the low-lying land. Rapid sedimentation is expected when the diversion is operating.

Major impacts to water levels, discharges, and channel regime are also anticipated due to the construction of embankments and the flow diversion associated with the *Upper Kangsha River Basin Development*. Full flood control embankments will reduce spills along the Kangsha River and will produce higher in-channel discharges. Model simulations indicated peak water levels could be raised by more than 1 m at Sarchapur bridge and that impacts will extend as far downstream as Jaria Janjail (Figure 21B). Water levels and flows were also forecast to increase on the Kangsha between Jaria Janjail and Mohanganj due to closure of the Atrakhali spill channel. This will flush more sediment into the lower Kangsha River and will contribute to infilling of the dredged reach along the Baulai River.

A second component of *Upper Kangsha River Basin Development Project* involves diverting some flows from the Chillikhali and Malijhee Rivers through an excavated channel into the upper Mogra River. This diversion will increase the discharge on the Mogra River and may increase flood stages at Netrokona. Actual water level changes at Netrokona were found to be very sensitive to the assumed project layout so additional analysis will be required to firmly establish

these impacts. The increased discharges could lead to some enlargement of the Mogra River by channel erosion and degradation. The increased flows will also flush fine sediment into the Dhanu-Baulai River system.

10.2.2 Biophysical Impacts (FCD and non-FCD) by Environmental Component

Displacement impacts

FCDI projects
Project physical works (embankments, structures, and larger channels) would displace cultivation and settlement (homesteads) on a total of 3,000 and 400 ha respectively in the region. This would be 0.2% and 0.9% of total cultivated and settlement areas within project areas. Lost agricultural production from these cultivated and homestead areas is included in the Agriculture section below. The population displaced from settlement areas is discussed in Section 10.3.2, Socioeconomic Impacts.

Other projects
Displacement of FWO land usage on very small areas could occur in the construction of wetlands or other facilities for wastewater treatment, and in the *Bhairab Bazar Erosion Protection Project* (see box).

There would be no displacement impacts from any of the other non-FCD projects.

Displacement impacts (non-FCD)

Industrial Pollution Abatement at Smaller Industrial Facilities
Duckweed Wastewater Treatment
Pulp and Paper Mill Effluent Treatment
Bhairab Erosion Protection Project

Settlement and road impacts

FCDI projects
A total of 6400 ha of settlement area (homesteads) would be protected from flood damage (nominal 1:10 return period). This would be 9.7% of the total regional homestead area of 65,000 ha, and 52% of the 12,000 ha of FWO flood-affected homestead area within project areas. Proportionate numbers of people (rural population) would be protected; this is covered in Section 10.6.2, Socioeconomic Impacts.

Spoil from manual excavation and dredging could be used to create new and raise existing homesteads on 740 ha.

Flood damage would be reduced in four of the eight major urban centres (Narsingdi, Narayanganj, Habiganj, Moulvibazar) and fourteen of the 74 *thana* centres. Patterns of future development, and effectiveness of future

Rural settlement impacts (non-FCD)

Regional Water Quality Characterization
Duckweed Waste Treatment
Ground Water Monitoring
Jamuna Floodplain Floodproofing
Pond Aquaculture
Pulp and Paper Mill Effluent Treatment
Locally-Based Management of Key Wetland Sites
Threatened Ecological Community Recovery
Threatened Species Recovery
Village Water Supply and Sanitation
Village Afforestation
Improvement of Homestead Platforms

flood-zoning efforts, will greatly influence the functional future impact (population and urban infrastructure protected) of the urban flood protection provided. Urban population protected is discussed in Section 10.6.2, Socioeconomic Impacts.

Flood damage to roads would be reduced. Assuming that future and existing road networks would be the same, in the absence of site information for future additional roads, there would be 3600 km of roads within projects' gross areas; of which 1,600 (45%) would be FWO flood-affected; of which 580 km (16%) would benefit from flood protection.

Urban settlement impacts (non-FCD)

Urban Potable Water
Urban Sanitation
Regional Water Quality Characterization
Industrial Pollution at Smaller Industrial Facilities
Duckweed Wastewater Treatment
Bhairab Bazar Erosion Protection
Ground Water Monitoring
Jamuna Floodplain Floodproofing

Other projects - rural settlements
Rural settlements' biophysical environment would be positively impacted by a number of projects (see box).

There would be no negative impacts on rural settlements from non-FCDI projects.

Other projects - urban settlements
Urban settlements' biophysical environment would be benefitted by a number of projects (see box).

The *Urban Potable Water Project* has the potential for adverse biophysical impact, since it would greatly increase the volume of urban domestic wastewater. Urban wastewater treatment is addressed by the initiative *Duckweed-Based Wastewater Treatment*. There would be no negative impacts on urban settlements from any of the other non-FCD projects.

Other projects - roads etc.
With the exception of erosion protection in *Bhairab Town Erosion Protection Project*, road impacts would be nil.

Agricultural impacts

FCDI projects
Annual regional paddy and other grain production would increase by 570,000 tonnes, or 10% of the present production of 5.6 million tonnes. Rice-cropped area would increase by 38,000 ha, or 2.0% of the present area of 1.9 million ha. Flood (again, 1:10 year) damage to crops would be reduced on 320,000 ha.

The incremental rice area and annual rice production given here reflects 12,000 tonnes of lost annual production on 5,200 ha of farmland that would be converted to other land uses:

- Up to 700 ha converted to homestead use by spoil deposition to create new homestead platforms;
- 1,500 ha converted to channel area as a result of re-excavation; and
- 3,000 ha converted to embankments and other project infrastructure.

This is a maximal estimate of the adverse impact on land use for rice production, in that it is assumed that the area to be converted to channels is 100% under rice cultivation and already owned by BWDB (i.e. no overlap with land to be acquired; embankments and other project infrastructure would occupy 100% of acquired cultivable land). In fact, not all land along channels is cultivated, not all cultivated land is under rice, and some acquired land would be used for channel re-excavation.

Annual regional production of other food crops would increase by 123,000 tonnes, or about 12% of the present production of 1.0 million tonnes; this includes all non-grain crops except sugar cane, excluded on account of its anomalously high mass yield per hectare and low nutritional and economic value per unit mass. Other-food-crops cropped area would increase by 68,000 ha, or about 20% of the present area of 340,000 ha.

Crop diversity as represented by the ratio of other-food-crop to rice production by mass, would increase slightly from 0.183 to 0.186.

FCD-led increases in irrigation expansion would be modest. Ground water irrigated area would increase by 3,300 ha, 1.5% of the current area of 223,000 ha, and usage by 43 Mm^3. Minor surface water irrigated area would increase by 900 ha, 0.2% of the current area of 351,000 ha, and usage by 11 Mm^3. The area irrigated by mechanized means would increase by 2,700 ha, 0.7% of the current area of 383,000 ha. These impacts are composed of substantial decreases in irrigation (all types) in the *Baulai River Improvement Project* and the *Kalni-Kushiyara River Improvement Projects*, reflecting a net shift from winter to summer crops, balanced by modest increases in irrigation in most of the other projects (IEE Figure 13).[1]

Annual diesel fuel consumption for irrigation would increase accordingly by 0.5 million litres, 0.7% of current requirements of 76 million litres.

Annual agrochemical use – of interest for reasons of ecologic/water quality, human health, economic, etc. – would increase. Annual pesticide use would increase by 47 tonnes, or 9% of current usage of 530 tonnes. Annual fertilizer use would increase by 46,000 tonnes, 20% of current usage of 226,000 tonnes.

Soil quality would need to be managed more carefully in areas provided with full flood control/controlled flooding facilities, and in areas converted to high yielding varieties.

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[1] As this report goes to press, the *Kalni-Kushiyara River Improvement* pre-feasibility study is being finalized, and the loss of irrigated area is now in doubt. The river improvement project draft pre-feasibility studies, unlike the other FCD draft studies, did not include quantification of agricultural impacts.

Fodder supplies would shift, with some increasing and others decreasing. There would be increases in biomass byproducts (straw, husks, and so on) proportionate to increases in primary agricultural production described previously. Also, provision for fodder as a second or third, additional, crop on 26,000 ha has been included in *Baulai River Improvement Project* and *Kalni-Kushiyara River Improvement Project*. Winter grazing area (defined as F0, F1, and F2 winter fallow plus perennially fallow highlands) would decrease by 54,000 ha or 7.0% of the current area of 779,000 ha.

Homestead agricultural (spices, fruit trees, vegetables, livestock, etc.) production would increase on 6,700 ha or 10% of current regional homestead area of 65,000 ha, due to new and raised homesteads from spoil (700 ha), reduced flood damage on flood-protected homesteads (6,400 ha), minus homestead area taken for project works (400 ha).

Other projects
Agriculture would benefit from several projects (see box).

The projects *Applied Research for Improved Farming Systems*, *Fisheries Biological Management*, *Village Afforestation* and the biodiversity initiatives each imply diversification of land use away from field crops, in particular rice cultivation, to uses such as agro-forestry, and swamp forest reed land, and flood plain grassland for fish habitat, village erosion protection, and production of biomass products (fuel, building materials, fodder, green manure, and so on). The areas under these non-agricultural usages would expand into areas now occupied in part by agriculture, in particular (mainly highly flood-damage prone) rice cultivation. Impacts as a percentage of regional rice cropped area and rice production would be small. The impact on agriculture is therefore negative, but the overall biophysical and socioeconomic impact is positive.

Water quality impacts

FCDI projects
Water quality (as experienced by domestic consumers, fisheries, and wetlands) changes cannot be quantified, but would be affected in a number of ways. Drainage improvement would tend to improve water quality, by increasing flushing and flushed volume and duration, and decreasing stagnant water volume and duration. Flood control would improve water quality at some times and places, by eliminating flooding of domestic-supply tube wells and pit latrines for example, and worsen it at others, by decreasing flushing and increasing stagnant water volume and duration. The FCD-led increases in pesticide use (see above) would contribute to water contamination, especially in low pockets surrounded by HYV cultivation. The FCD-led increases in fertilizer use would increase nutrients available to the openwater fishery, but could also aggravate eutrophication problems.

Agriculture impacts (non-FCD)

Ground Water Monitoring
Jamuna Floodplain Floodproofing
Applied Research for Improved Farming Systems

Other projects
Water quality would be improved by a number of projects (see box).

As has been mentioned, the *Urban Potable Water Project* would increase urban domestic waste water volume. There would be no negative

impacts on water quality from any other non-FCD projects.

Water quality impacts (non-FCD)

Urban Potable Water
Urban Sanitation
Regional Water Quality Characterization
Industrial Pollution Abatement at Smaller Industrial Facilities
Duckweed Wastewater Treatment
Ground Water Monitoring
Pulp and Paper Mill Effluent Treatment
Village Water Supply and Sanitation
Threatened Ecological Community Recovery

Openwater fisheries impacts

FCD projects
Open water fisheries habitat and production would be altered:

- Floodplain (defined as F1, F2, F3, and F4 areas, based on monsoon flooding) would decrease by 49,000 ha, or 2.3% of the total current regional floodplain area of 1.2 million ha.

- *Beel* area would increase by 70 ha, or 0.1% of the total current regional *beel* area of 60,000 ha, reflecting the impacts of *beel* bunding and water retention behind regulators, less *beel* area lost to other land uses.

- River and channel area will increase by 1,400 ha, or 4.0% of the current regional area of 35,000 ha, reflecting excavation of 74 million cubic meters of channel sediment.

- The number of river duars will increase by 42 or 14% of the FWO total of 310, reflecting mitigation of duars that would be lost in the FWO scenario due to siltation in the Baulai and Kushiyara Rivers. Impacts on production would be positive, but have not been quantified.

- Major and minor channels will be closed permanently at 48 locations, eliminating fish migration along these routes.

- The *Surma-Kushiyara-Baulai Project* has the greatest quantifiable negative impact on fish production (-3,900 tonnes annually). This is due to the project's large size (320,000 ha gross area), and the pessimistic assumption that the overall migration impact will be -20% ($M = 0.8$). The project includes dredging for habitat rehabilitation in the Kaliajuri mother fishery and key wetland site, and flood control works designed to preserve the ecological character of the fishery by leaving the lowest and most important migration routes open.

- The *Manu River Improvement Project* has the next greatest negative impact on fish production (-2,900 tonnes annually). Assumed impacts on Hakaluki Haor, a key wetland and mother fisheries site, account for most of this: it has been assumed pessimistically that Hakaluki Haor would be completely destroyed as a mother fisheries site by sediment deposited there during diversion events. Some mitigation appears to be possible, in the form of structural confinement of sediment deposition to selected areas.

- Dredging implementation-phase impacts on fish populations are not known and need to be investigated during feasibility studies. Dredging would be performed in the dry season (wet season velocities are too high) when turbidity under normal conditions is low and stresses on fish populations are already at their highest. A key issue will be possible disruption, particularly of benthic biological communities, due to sedimentation and high-velocity turbid plume flows; and the spatial and temporal scale of the fisheries impact. Some methods are in use to mitigate aquatic impacts of dredging, for example, use of booms and curtains to protect valued areas.

- For manual excavation, fisheries impacts occur during the site preparation phase when channels are drained out usually resulting in total catch of fish populations in the affected reach. The regional biophysical and economic impacts of this activity are not readily distinguishable from normal fishing activities, however.

The overall quantified impact on openwater fisheries annual production would be a decrease of 10,600 tonnes or 11.0% of current regional annual production of 96,000 tonnes, with over half due to losses due to flood protection measures included in the *Surma-Kushiyara-Baulai Project* and the assumed destruction of Hakaluki Haor by the *Manu Diversion Project*. The overall quantified impact includes FCD-induced changes in migration access and water quality for most of the projects.

No impact on the three fish species thought to be threatened is anticipated, but further study of these species would be needed to confirm this.

Other projects

Openwater fisheries would benefit from a number of projects (see box). Benefits from these projects would help to mitigate the adverse fisheries impacts of the FCD projects; in terms of overall openwater fish production, the net impact (FCD+other) would be significantly positive.

The same concerns that were mentioned above with respect to FCD dredging would apply to *Dredging for Navigation*. There would be no negative impacts on openwater fisheries from any other non-FCD projects.

Openwater fish impacts (non-FCD)

Regional Water Quality Characterization
Industrial Pollution Abatement at Smaller Facilities
Applied Research for Improved Farming Systems
Fisheries Engineering Measures
Fisheries Management Programme
Pulp and Paper Mill Effluent Treatment
Biodiversity Initiatives (4)
Village Afforestation

Aquaculture impacts

FCD projects

Flood-free pond area would increase by 1,600 ha or 8.3% of the regional total of 18,700 ha. The potential increment in annual aquaculture production would be 1,600 tonnes, 8.8% of the current regional production of 18,000 tonnes.

Aquaculture impacts (non-FCD)

Duckweed Wastewater Treatment
Pond Aquaculture
Applied Research for Improved Farming Systems

Other projects
Aquaculture would benefit from several projects (see box). There would be no negative impacts on aquaculture from non-FCD projects.

Navigation impacts (non-FCD)

Dredging for Navigation
Support to Country Boats
Pilot Project to Institutionalize Public Consultation
Rural Infrastructure Planning

Navigation impacts

FCD projects
Navigation would be benefitted by river and channel excavation, and disbenefitted by the 48 closures of major and minor channels at embankments and across spill channels.

Other projects
Navigation would benefit from several projects (see box).

There would be no negative impacts on navigation from non-FCD projects.

Biodiversity impacts

FCD projects
The impact on biodiversity would be mainly adverse:

- Winter wetland area (defined as F3 land lying fallow in winter, plus perennially fallow lowlands, plus *beels* and channels) would decrease by 7,000 ha or 5.7% of the regional total of 124,000 ha.

- Summer wetland area (defined as F1, F2, and F3 land lying fallow in summer, plus perennially fallow lowlands, plus *beels* and channels) would decrease in area by 50,000 ha or 11% of the regional total of 440,000 ha.

- Key wetland sites: *Manu River Improvement Project* would adversely affect Hakaluki Haor. *Jadukata-Rakti Project* and *Sarigoyain-Piyain Project* could benefit the key wetland sites and mother fisheries at Tangua Haor and Companyganj by reducing sediment infilling.

- Swamp forest and reed swamp would not be affected. About half (250 ha) of the region's remaining floodplain grassland (550 ha) could be adversely affected by *Surma Right Bank Project*.

- No threats to particular threatened and commercially threatened plant and animal species are apparent with the information currently available, except for the obvious threat to floodplain grassland-dependent species. Further study would be required to understand species impacts of the elimination of one of the two remaining areas of this community. Further study of the other threatened and commercially threatened species would be needed to confirm lack of impact.

Openwater fishery biodiversity impacts were discussed above.

Other projects
Biodiversity would benefit from a number of projects (see box). Benefits from these projects would help to mitigate adverse impacts of the FCD projects on biodiversity, including migratory waterfowl populations (see below). There would be no negative impacts on biodiversity from non-FCD projects.

Biodiversity impacts (non-FCD)

Regional Water Quality Characterization
Industrial Pollution at Smaller Industrial Facilities
Duckweed Wastewater Treatment
Applied Research for Improved Farming Systems
Pulp and Paper Mill Effluent Treatment
Biodiversity initiatives (4)
Village Afforestation
NEMREC
Biodiversity Strategic Planning for MOEF

Impacts on areas outside flood protection within the region; areas outside the region; and migratory populations

FCD projects
Three areas in the region - the Mogra basin, Hakaluki Haor, and the lower Sarigoyain River basin - will remain both outside of flood control embankments and may be vulnerable to displaced flooding from Plan FCD projects, which could cause increased flood damage to crops, homesteads, and roads in these unprotected areas.

There would be no hydrologic or sediment impact on areas downstream of the region, given conditions at the region's outfall. A possible exception could be transient effects due to turbidity from dredging.

Migrating waterfowl populations will be adversely affected by the overall reduction of winter wetland areas and the adverse impacts on Hakaluki Haor. This could be somewhat compensated by positive impacts on Tangua Haor and Companyganj area.

Pesticide pollution of regional surface water outflows would increase slightly.

Other projects
Areas outside the Northeast Region would benefit from improved water quality of regional surface water outflows due to a number of projects (see water quality box). Migratory fish populations would be benefitted by a number of projects (see openwater fish box).

Other biophysical impacts
Dredging could have other adverse impacts, in addition to the fisheries impacts mentioned above. It involves movement of vast quantities of spoil, initially in the form of a water/sediment slurry, which must be properly managed (proper settling basins, deposition in acceptable locations, and so on), or negative impacts can be considerable: spoil deposited in areas where it is not wanted or destructive, turbid flows into the original dredged or other water body with unwanted effects, and so on. Another concern may be a need to check sediments for toxic chemicals, in channels downstream of industrial facilities.

13 SOCIOECONOMIC IMPACTS

13.1 Regional Economic Impacts

Gross Regional Product

The FWO and FW economic forecasts are not based on straight-line trend extrapolation, but on the best judgement of future conditions, and in the case of the FW forecast, on the best judgement of the magnitude and timing of additional project investments. The goal is an indicative description of regional economic impacts.

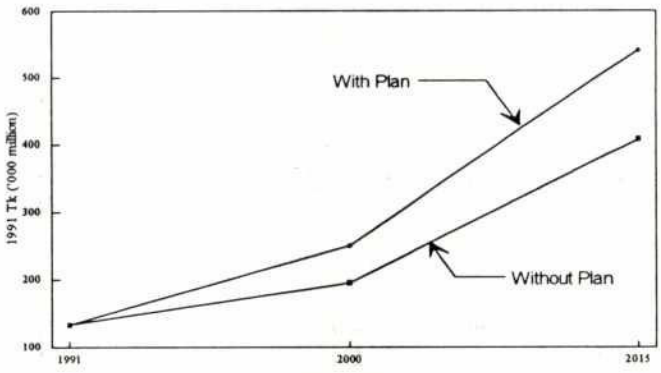
By 2015, the regional economy as measured by GRP would expand to almost Tk 550 billion and four times its 1991 size (Graph 10.1). Almost 33% of this increase would be attributable to implementation of the strategy. All sectors would expand more rapidly than in the FWO forecast (Graph 10.2).

The FWO forecast for the region estimates that the GRP per capita will, by 2015, fall below the national average. This trend is reversed as a result of strategy implementation and forecasts a per capita GRP that is 10% higher than the national average.

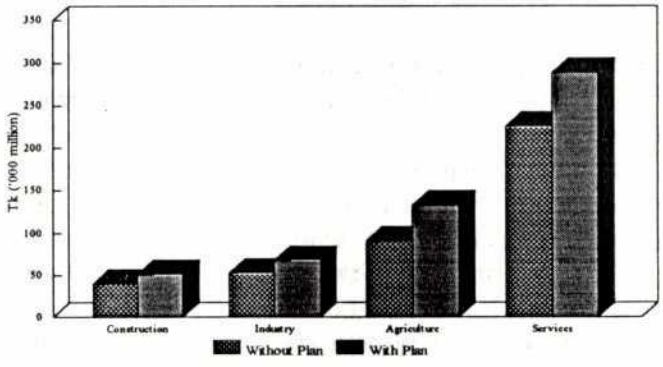
Level of investment

Annual capital investment in the region will more than double by 2015, but, with a decreasing proportion going into repair and replacement, the total capital base is forecast to increase more than three times the 1991 level (Graph 10.3).

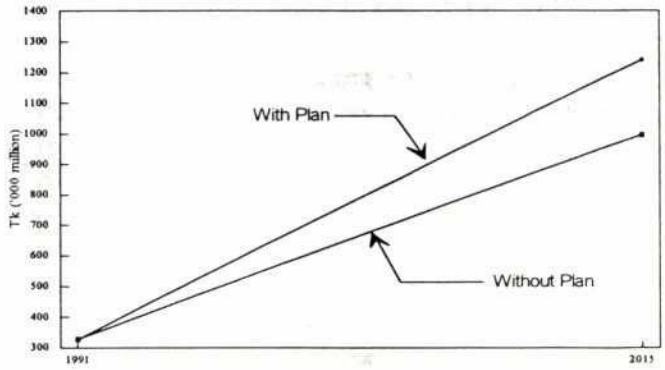
Graph 10.1: Gross Regional Product



Graph 10.2: GRP by Sector (2015)



Graph 10.3: Total Capital Base



Total incremental investment to implement the strategy would be Tk 248 billion through the Plan period or Tk 13 billion per year on average. It is assumed that 53% would be provided by the private sector and 47% by public funds including foreign development assistance funds.

Sectoral distribution of economic impacts

Looking at the economy in terms of sectoral percentage shares, strategy implementation would tend to slow the transformation of the economy away from agriculture, marginally slowing the erosion of agriculture's share (+3%), and the sharewise gains of industry (-1%), construction (-1%), and services (-1%) (Table 26).

Table 26: Sector Shares of GRP

Sector	%		
	1991	FWO	FW
Agriculture	33	22	25
Industry	8	13	12
Construction	6	10	9
Services	52	55	54

Income, wages, and employment

Strategy implementation would result in annual incremental wages of Tk 95.6 billion, a 37% increase over the FWO forecast. Average household income would increase by Tk 18,300 per year over the FWO value.

Net (agriculture gains minus openwater fisheries losses) direct employment creation in FCDI projects would be 0.08 million jobs, which is 0.9% of the FWO 9.2 million rural labour force.

Overall, strategy implementation is forecast to create 4.7 million job equivalents. The number of new jobs created would be less than this, as labour demands an increasing proportion of the incremental benefit in the form of higher wages. The split between job creation and wage increases is difficult to estimate. The strategy-induced incremental net return per rural household (landowning and landless) would be relatively low, at slightly under Tk 1,000, with a disproportionate amount accruing to middle and larger landowners. These low returns to agriculture, compared to the potential maximum average wage increase (that is, setting new job creation to zero) of Tk 7,600 per job, suggest that wage increases will be moderated in favor of non-agricultural job creation; this would favor increased rural-to-urban migration, and increased rural non-agricultural employment.

Economic and agricultural diversification

Economic diversification due to strategy implementation would amount to over Tk 60 billion per year in 2015. Over half of this diversification gain would be in the agriculture sector.

Substantial agricultural production increases would be expected due to strategy implementation; much of the increase in value in agriculture will derive from increased diversification rather than higher production as such. With growing urbanization and rising real wage incomes, demand for higher valued non-cereal crops and livestock will grow.

The FWO forecast anticipated a continued and sustained period of regional rice self-sufficiency varying toward modest surpluses. Under an assumption that this scenario reflects the national situation, it would be anticipated that domestic rice prices will more closely reflect international prices. International prices will be kept low by relatively thin rice export markets combined with large cereal production capacity, and price increases are unlikely to be maintained above inflation throughout the Plan period; real prices can be expected to decline.

10.3.2 Other Socioeconomic Impacts

Displacement impacts
Some rural residents will be very directly impacted through impacts on homestead lands. FCD works will displace 107,000 people from rural homesteads; the *Kalni-Kushiyara River Improvement Project* accounts for almost half of this. In this and other projects, compensation of the impact on the regional stock of homestead land would be achieved by constructing new homestead areas from excavation spoil.

Homestead flood protection
The 6400 ha of homestead which would be protected from flooding are occupied by 1.4 million residents, who would experience less flood damage to possessions, including the homestead plot itself and to homestead agricultural production.

Urbanization and migration impacts
Strategy implementation would tend to accelerate urbanization, some of which would occur as rural areas shift over to urban economic activities, and some as rural-to-urban migration. Both urban and rural economic and environmental conditions would improve over the FWO forecast, but improvement in urban conditions would proceed more rapidly. One result would be that per-household rural income would improve, with incremental rural gains being shared among a smaller number of people. In particular, it is expected that the *Narsingdi-Narayanganj Project* and the *Narsingdi District Project* would boost urban population in this area by 1 million. Some of this represents more rapid urbanisation of rural landless people already within the area (especially as villages along the Dhaka-Sylhet and Dhaka-Chittagong corridors urbanise), and the rest represents in-migration from other areas. Integration of this area with the Dhaka mega-urban field will be accelerated as well.

Socioeconomic equity and impacts on landless people
The strategy will reduce the total number of rural landless people in the region compared to the FWO situation, mainly by boosting the urban population of the Narsingdi-Narayanganj area through faster urbanisation of local landless people and increased in-migration to urban areas of rural landless people from other areas.

The benefits of strategy implementation will accrue to different sections of the society in varying proportions. FCD initiatives will mainly benefit landowners, which should slow down the overall rate at which small farmers become marginalized and eventually landless. The strategic thrusts for improved urban environment and improved liveability of rural settlements will benefit all strata of the population with optimum equity.

In FCD projects, the net incremental increase in employment in project agriculture less employment lost in fisheries, is composed of 66,000 jobs which would accrue to landowners and 16,000 jobs which would accrue to hired labourers (that is, landless people). Additional jobs in downstream post-harvest activities would also be created.

The overall figure for hired labourers masks the fact that as many as 41,000 jobs in the openwater fishery (about 12% of jobs in the sector) could be lost. Additional downstream jobs in post-catch processing would also be lost. This represents a significant negative impact on fishing families, particularly poorer families dependent upon subsistence fishing, as a group.

Gender equity

The strategic thrust to improve liveability of rural settlements would improve the conditions in which most women spend most of their lives and perform most of their work. This would also support expansion of household-based employment. The initiatives on potable water, both urban and rural, will benefit women, who collect and use most domestic water, more than proportionately.

Several of the strategic thrusts would support crop diversification, which could be positive for women, in the sense that adoption of non-traditional crops might provide an opportunity for eased cultural constraints on women's involvement in field activities in agriculture.

Otherwise, the other strategic thrusts benefit women mainly as members of households; to the extent that women share in the total work, income, assets, and so on of their households, to that extent they will benefit from the strategy. The other strategic thrusts neither fortify nor transform the social construction of gender roles as these would exist in urban and rural settings.

Literacy

The strategy will not impact literacy directly, but the improvement in general economic conditions and better living conditions in rural and urban areas will have positive impact on the people's attitudes towards and ability to afford education for their children. The elasticity of income for education is believed to be greater than one at the above-subsistence level: once basic food requirements are met, people spend more on education.

Well-protected settlement areas will prevent disruption of education from flooding of school buildings and roads.

As higher education facilities are concentrated in urban areas, improved protection of the roads and water links between the villages and urban centres would have some impact on higher enrolment in secondary and college level education.. This is particularly true for Sylhet Region which has few colleges compared to other areas; these are mostly concentrated in urban centres where female enrolment is low.

While improved access will help to increase gross enrolment rate, increased household income is expected to reduce the dropout rate significantly.

Water and sanitation

10.4

The implementation of the proposed strategies on improved urban environment and improved liveability of rural settlements will contribute to achieve the national goal for universal coverage of potable water for drinking. With improved accessibility and motivation, the use of tube well water for all purposes can be expanded. This will help to reduce the incidence of water-borne diseases and will have positive impact on health and personal hygiene.

10.4.1

10.4.2

Tubewell maintenance by women will enhance their role and status in the community. In addition, increased accessibility will reduce the labour in drawing and managing domestic water supplies, traditionally women's work.

Proposed initiatives (*Urban Sanitation, Rural Water and Sanitation*), will also contribute to improved sanitation through proper disposal of human waste and waste treatment.

Nutritional status
Enhanced production systems including pond aquaculture in seasonally flooded areas and integrated development of the deeply flooded areas will contribute to increased production of high value nutritious crops, fish, and livestock and will increase their availability in the market.

The FCD projects alone would result, relative to FWO conditions, in food availability per person increasing by 10% for rice, increasing by 12% for other crops, and decreasing by 11% for fish. The impacts of the total strategy would be significantly more favourable than this. Increased aquaculture fish production (increase of 11% with fewer ponds at risk of regular flooding) would partly offset decreasing openwater fish production, but will provide little consumption benefit to poorer groups.

Income is directly correlated with nutritional status. With increased per capita income, the extent of child malnutrition (stunting, wasting, underweight) would decline. The impact on nutritional status will be less in rural than urban areas due to the lower impact of strategy implementation on rural incomes.

Increased household income would be accompanied by increased expenditure for food. This will contribute to ensure minimum caloric intake for the vulnerable population. The average incremental income would be sufficient to overcome absolute poverty (defined as Tk 4,800 per person per year), but many poorer households' income would remain below this level.

Life expectancy
The increase in aggregate household income expected as a result of strategy implementation would directly contribute to overall improvement in living conditions, particularly through improvement in health and nutritional status. It is likely that with increased household income, per capita expenditure on nutritious food, sanitation and health care will increase. All these together will have positive impact on life expectancy, particularly on the reduction of infant and child mortality.

Socioeconomic impacts of biodiversity and wetland changes
People dependent on floodplain grassland and on wetlands will be adversely affected, in proportion to the impacted areas noted above. This impact will be localized and will mainly affect poorer people who are most dependent on these types of resources.

10.4 CUMULATIVE IMPACTS WITH NON-PLAN ACTIVITIES AND PROCESSES

10.4.1 Introduction
This section examines how Plan impacts add to (or subtract from) the impacts of non-Plan activities and processes.

10.4.2 Plan + Increasing Population
What effects could Regional Plan implementation (i.e. water management development over then next 20 years) have on population growth in the Northeast Region?

Many of the Regional Plan strategies and initiatives address income, public health, and nutrition objectives, and through them could affect birth, death, and thus population growth rates. A straightforward (Malthusian) interpretation suggests that increasing food availability and improved

public health would raise the population growth rate. A more nuanced interpretation of recent experience in developed and developing countries suggests that population growth rates are highly dependent upon parents' perceptions of ideal or desired family size; perceived insecurity in old age; and acceptance of and access to effective family planning. These factors are in turn strongly influenced by income, child mortality, women's status, and access to family planning services (World Bank, 1992). All but the last (which very clearly lies entirely outside the ambit of water management planning) would be impacted positively by strategy implementation.

10.4.3 Plan + Growth of Urban Populations and Infrastructure

In addition to the urbanization and migration impacts noted previously in Section 10.3.2, flood control will accelerate infrastructure development and in-migration into flood-prone urban and peri-urban areas. Over time, this may increase total flood damage, integrated over floods of all recurrence intervals: damage from more frequent, lower magnitude floods will be somewhat less, but damage from less frequent, high magnitude floods which overwhelm water control infrastructure will be much greater because of the increased population and investment. In addition to this, however, flood control will reduce hidden costs associated with exposure to frequent flood damage, such as the cost of low productivity due to low investment; that is, there is a trade off between incremental flood damage and incremental productivity gains.

10.4.4 Plan + Climate Change

Over the 20 year period of the Regional Plan, air temperature and sea level will remain effectively constant (that is the presumed rates of increase of both are too slow to be discerned over this short time interval).

The tendency observed over recent decades of increasing rainfall and increasing rainfall variability, whether or not this is the expression of anthropogenic changes to the atmosphere, serves well as a prototype for possible future rainfall trends in the region. Impacts of a cumulative nature (Plan + increasing rainfall) relate mainly to:

- Increasing river discharges and water levels (embankments + increased rainfall), leading to morphologic changes (wider channels, aggradation/degradation waves propagating through the system, and increased channel instability and type switching).

- Mitigation of increasing rainfall impacts - drainage improvement could reduce system drainage overloading, habitat conservation and restoration could ensure that development options (swamp forest) suitable for the new conditions are preserved, and so on.

If, on the other hand, rainfall decreases to or below previous levels:

- Existing and Plan FCD investments will produce less benefits relative to the without-project situation, and

- Some existing and Plan partial flood control projects might function as full flood control projects and thus significantly more adverse effects on fisheries, navigation, and possibly other environmental components.

10.4.5 Plan + Tipaimukh Implementation

The impacts of the Tipaimukh Dam/Cachar Plain Irrigation project are described in the FWO scenario (Chapter 7). Thus, in principle, cumulative impacts of Plan + Tipaimukh

implementation are already reflected in the Plan impacts. In practice, however, the project pre-feasibility studies of the four projects affected by the dam used historical (no dam) data, and thus their impacts were quantified in terms of [FW (no dam) - FWO (no dam)]. This introduces unknown errors in impacts and in project design and costs.

10.4.6 Plan + Changing Patterns of Energy Production and Consumption

Bangladesh has access to a rich variety of energy sources, including biomass fuels from a wide variety of natural sources; animal draught power; human muscle power; fossil fuels, including both domestically-produced natural gas and derivatives and imported fuels; and solar energy (grain drying and other uses).

Fossil fuel usage is of particular interest, because such fuels are imported (except for domestically-produced natural gas and its derivatives), non-renewable, and contribute to environmental pollution. Increasing dependence on them increases external dependence, economic unsustainability, and public health and ecological problems. Fossil fuel consumption is expected to remain very low in Bangladesh compared even to other developing countries, and staggeringly so in comparison to the older and newly industrialized countries. Because the contribution of Bangladesh to global fossil fuel consumption is so insignificant, concern for local energy/fossil fuel use issues logically takes precedence over concern for global issues (such as CO_2 emissions). Local energy issues include: access to and management responsibility for sustainable energy supplies by the poor; local self-reliance; national vulnerability to fossil fuel price and supply swings; foreign export costs; improved management of the national draught and dairy herd; and emphasis on appropriate-technology sustainable energy supplies and energy conservation.

Numerous Plan interventions would promote agricultural intensification (in particular irrigation pumping), accelerate urban and industrial development, and alter wetland productivity both negatively (most FCD) and positively (habitat conservation and restoration). These changes imply alterations in the type and quantity of energy sources exploited. Agricultural intensification will greatly increase by-product (mainly rice straw) mass. It will also slightly increase fossil fuel usage, both directly for mechanized irrigation, and indirectly through fossil fuel-derived inputs such as fertilizers and pesticides. Urban and industrial development will greatly increase demands on electric generating capacity and thus fossil fuel usage. Wetland productivity changes will alter supplies of natural biomass fuels; some interventions will cause increases, and others will cause decreases. At the same time, other developmental trends independent of water management development will also alter energy production and consumption patterns, in particular increasing fossil fuel usage.

10.4.7 Plan + Increased Water Contamination

The primary water quality issue is bacteriological contamination, related to inadequate sanitation and unsafe water supply, accompanied by deficient hygiene practices. This issue would be addressed through continuations of ongoing DPHE/UNICEF programmes, which are included in the Plan project portfolio.

Industrial pollution will be an area of increasing concern, if industrial development accelerates during the Plan period as targeted by Government. Industrial development could be accelerated through Plan investments in urban flood control. Industrial pollution is addressed directly through the initiatives *Pulp and Paper Mill Effluent Treatment* and *Industrial Pollution Abatement at Smaller Industrial Facilities*.

10.5 SUSTAINABILITY ANALYSIS

10.5.1 Introduction

This section addresses the following questions:

1. How will Plan interventions help to meet near-term needs of the present without compromising the ability of future generations to meet their own needs, in particular the essential needs of the poor, given technological and social systems' capabilities to satisfy needs from the environment? (p. 43, *Our Common Future*, 1987).

2. How will Plan interventions affect rates of resource use? These should not exceed regeneration rates or the rates of development of sustainable substitutes. (p. 3-16, *Manual for Impact Assessment*, Volume 1; FAP 16, March 1992).

3. How will Plan interventions affect pollution rates? These should not exceed rates of assimilation and breakdown.

4. Will Plan interventions have, contribute to, or prevent irreversible impacts, especially those affecting ecosystem viability, species survival, and life-sustaining processes, placing the ability of future generations to meet their own needs at risk?

10.5.2 Question 1: Overall Sustainability

Will Plan interventions:

- Help to *meet the near-term needs* of the present,
- Without compromising the ability of *future generations* to meet their own needs,
- In particular the *essential needs of the poor*,
- Given technological and social *systems' capabilities* to satisfy needs from the environment?

Meet near-term needs: As reflected in Plan objectives (*Regional Plan*, Section 8.2).

Future generations: Some of the structural interventions have the potential for compromising options of future generations. For example, embankments and the Manu Diversion could have irreversible impacts on river morphology, settlement, and urban development patterns, reduction of key wetland habitats, and loss of regional biodiversity. For each proposed intervention, key subsidiary themes need to be explored, relating to:

(1) What the precluded options might be,

(2) What their value to future generations might be,

(3) Which individuals of these generations could be affected, and

(4) Whether alternative means exist to preserve these options.

Essential needs of the poor: These include secure access to safe air and water, adequate food, clothing, and shelter, essential health, education, and family planning services, based on access to appropriate economic resources and opportunities, in the context of respect for human rights.

Most if not all the FCD projects have some potential for negative effects on (compromise the essential needs of) individuals belonging to poorer socioeconomic groups. These potential effects include exercising right of eminent domain on homesteads belonging to poor people to allow embankment construction and channel excavation; reducing total employment opportunities for hired labourers, or reducing employment opportunities in fishing or for poorer women; and creating or exacerbating conflicts between interest groups (in which the less powerful, which usually means the poorer, group would be expected to lose out). Potential mitigation or compensation measures have been identified in some instances, but not in others. Feasibility studies of these projects will need to investigate these issues further if sustainability with regard to this criterion is to be achieved.

System capabilities: Proposed Plan interventions took technological and social system capabilities into account as follows. Existing technological and social systems of resource exploitation and management were extensively studied, in the areas of water management, agriculture, river manipulations, fisheries, navigation, wetland resources, water quality, and village social systems. These systems were then analyzed in terms of strengths, weaknesses (needs for change), opportunities for change, and threats (undesirable changes which could occur unless action is taken). Potential interventions were formulated based on this information. As the proposed projects are studied and developed further, issues related to social and technological system capability will need continued attention.

10.5.3 Question 2: Sustainability of Resource Use

How will Plan interventions impact rates of resource use, and will the Plan contribute to rates which exceed regeneration rates or the rates of development of sustainable substitutes?

Affected resources include:

- Agricultural resources. Shifts from local to high-yielding varieties and intensification of cropping increase risks of soil depletion, of higher plant pest and disease infestation levels. Sustainable management of these impacts may be possible based on improved soil and pest management based on locally-generated inputs (e.g. improved management of manure, green manures, integrated pest management). Some such measures are already an integral part of ongoing Ministry of Agriculture research and development programs.

- Openwater fisheries. The openwater fisheries of the region are under increasing stress from many factors. In seasonal terms, dry season survival of broodstock is a critical factor for the survival of the fishery, and management of quality, quantity, and exploitation pressure on dry season habitat will be key. FCD contributes to the stresses on the fishery and causes reduced production, mainly through impacts on wet season habitat.

- Wild plants and animals. Especially high concentrations of biodiversity remain at the key wetland sites and in threatened community areas. *Manu Diversion Project* would adversely impact Hakaluki Haor, and *Surma Right Bank* could adversely affect Bara Haor.

It may be possible to compensate for these impacts under the biodiversity initiatives through interventions to enhance biodiversity at other sites. 10.6.2

- Quarry materials. Depletion of quarry materials does not appear to be a problem.
- Energy resources. Discussed above in Section 10.4.6.

10.5.4 Question 3: Sustainability of System Capacity to Assimilate and Break Down Pollution

Plan implementation will increase pesticide use by 9% and fertilizer use by 20%. Despite this, use rates in the Region are and will remain very low even by developing country standards. Thus, the key issues in this area will relate to regulation of pesticide imports to prevent dumping of materials barred by industrialized countries for environmental reasons, and better public education to improve handling (for example, not to reuse pesticide containers for water or food) and to ensure compounds are applied at minimum effective levels.

The surface water quality management initiatives would improve management of industrial and domestic effluents.

10.5.5 Question 4: Irreversible Impacts

Ongoing natural morphological processes in the region are irreversible - river channel development, overland sedimentation, erosion - and, in many cases, have adverse biophysical and socioeconomic impacts. Some Plan initiatives seek to alter the course of these events and may themselves be irreversible. 10.6.3

Embankments and closures, in this environment, seem to be all too reversible in their vulnerability to erosion, breaches, public cuts, and channel shifting. In principle, however, these types of structures should be viewed as irreversible alterations to the landscape. Likewise some of their effects, in particular displacement and biodiversity impacts, should be viewed as irreversible.

These interventions can threaten ecosystem viability, species survival, and life-sustaining processes, and place the ability of future generations to meet their own needs at risk, unless projects are very carefully designed and operated to avoid these outcomes.

10.6 ENVIRONMENTAL MANAGEMENT PLAN (EMP) CONSIDERATIONS

10.6.1 Introduction

Environmental management refers to the mitigation and compensation of the adverse impacts of an intervention; the monitoring and reporting of expected impacts (both beneficial and adverse) of an intervention; environmental enhancement; and contingency plans for abnormal events including disasters. Implementation of these measures may in addition require institutional strengthening, training, technical assistance, and public participation activities.

Broad management options and major constraints can be appropriately considered at the pre-feasibility level (ISPAN, 1992).

10.6.2 Main programmatic issue: EMP institutionalization

The most important EMP issue at the programmatic (regional) level relates to institutional development. Satisfactory environmental management of projects will require adequate institutional arrangements and institutional competence. For the programme presented here, there is a need for communication and coordination between institutions in the areas of water resources agriculture, fisheries, environment (meaning here biodiversity and water quality management/pollution control), public health, transportation, navigation, and urban planning. Further, institutional arrangements must also function to transfer information, responsibility, and resources vertically, between the grassroots and national agencies (increased pubic consultation/participation). Proper reporting and accountability arrangements need to be developed as well.

Institutional development in support of EMP in fact parallels and complements institutional development for the more narrow objective of improved sectoral development planning, implementation, operation, and maintenance. As such, improved EMP capability should be incorporated as an objective into all relevant institutional development initiatives. The institutional strengthening interventions proposed in the NERP portfolio reflect this perspective. Additional national institutional changes, outside NERP's mandate as a regional planning project, will also be needed, and should be addressed by the appropriate entities, such as FPCO.

10.6.3 Mitigation of Pre-Construction and Construction Phase Impacts

Significant pre-construction and construction activities and impacts are associated with the FCD and river improvement projects.

Land acquisition and site preparation

Land acquisition and site preparation activities and thus impacts occur during the pre-construction phase. For the Regional Plan, the magnitude of these impacts (number of people, hectares of land affected) are small in regional terms, but the impacts can be severe for the particular *de facto* land and resource users who are affected, including renters, share-croppers, grazers and gleaners, and squatters, with or without legal status.

Impacts can be minimized mainly through careful planning at feasibility and detailed design stages to minimize land use conversion, and to choose infrastructure sites of least value in current use (Shahabuddin, 1994). Residual impacts will require compensation (see below).

Temporary adverse impacts during construction of water control structures

During the construction of water control structures, it appears that temporary adverse impacts on drainage, fish movement, navigation, and road transport are possible. To our knowledge, systematic mitigation measures have never been applied to this type of impact in Bangladesh; they are simply accepted by the receiving communities. Project feasibility studies should investigate these considerations, and if these impacts are significant, detailed mitigation measures proposed.

Dredging and re-excavation spoil disposal

Dredge spoil disposal will be a major issue for the regional drainage improvement projects. If the spoil were simply dumped back in the river, then some of the benefits of the work could be lost. Furthermore, inadequate disposal methods could produce undesirable impacts to fisheries habitat and agricultural land. Formulation of a dredge disposal plans as part of each of the projects having a dredging component will require gathering considerable amount of site-specific primary information which is currently unavailable.

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10.6.4 Mitigation of Operation & Maintenance Phase Impacts

Regional hydrology and morphology mitigation measures
River improvement is mitigative of flood control and loop cut impacts on river morphology and water levels.

Fisheries mitigation measures
Fish passes, water retention, bottom-open embankment design, and water control operational measures, including the inclusion of fishermen on project committees, are each mitigative of flood control impacts on fisheries. The *Fisheries Engineering Project* (other than fish passes) and *Fisheries Biological Management* may also provide mitigation, but their main thrust is compensation and enhancement (see Section 10.6.5 below).

Navigation mitigation measures
Boat passes should be provided as part of individual projects' infrastructure where warranted.

Physical maintenance of infrastructure
Maintenance requirements will increase, due to the larger amount of infrastructure in the region and increasing channelization accompanied by higher water levels and velocities on some rivers. Improved maintenance will require greater involvement of local people and local ownership of projects. A local project committee is proposed for each of the Plan FCD projects as a means to achieve these ends. Development of adequate responses will be a challenge. 10.6.6

10.6.5 Compensation and Enhancement

Compensation of Displacement Impacts
An analysis of land acquisition and resettlement experience and legal arrangements is presented in the FAP 15 final report (1992). The study notes a number of deficiencies in current arrangements and provides a comprehensive set of recommendations for an improved compensation framework. This appears to be the first step in a series of actions that will be necessary to achieve adequate compensation of displacement impacts.

Compensation of Impacts on Regional Stock of Homestead Land
In terms of the total amount of homestead land available with in the region, loss of homestead land to infrastructure construction would be compensated by constructing new village platforms above the level of the monsoon flood from dredge and re-excavation spoil in the river improvement and some of the FCD initiatives. This type of village construction is experimental and will require development from a pilot scale.

Fisheries Impact Compensation and Enhancement
Improved fisheries management, including habitat restoration. Possibly dredging projects can be designed to be fish friendly since through them, habitat can be increased.

Navigation Impact Compensation and Enhancement
Overall, the Plan places greater emphasis on drainage improvement than was evident in past water resources developments. The projects *Dredging for Navigation* and *Support to Country Boats* would act synergistically with the major river improvement (drainage improvement) projects to enhance navigation.

Wetland and Biodiversity Impact Compensation and Enhancement
The biodiversity initiatives address improved wetland management at key sites and threatened community and species recovery. The initiative *Village Afforestation* addresses afforestation and habitat restoration under village management.

Water Quality Impact Compensation and Enhancement
The surface water quality initiatives include actions to reduce regional water contamination from domestic and industrial sources.

Disaster Management
The initiative *Improved Flood Warning* addresses management of catastrophic flood risks in the Tripura and Meghalaya piedmont areas. This is a pre-existing (FWO) hazards which does not affect and is not affected by any other Plan projects.

Disaster planning and other risk management measures for Tipaimukh Dam failure should be dealt with under the auspices of the Joint Rivers Commission.

10.6.6 Environmental Effects Monitoring and Impact Reporting

Monitoring can be effected at a variety of temporal and spatial scales. To monitor the effects of Plan implementation, it would be desirable to:

- Upgrade existing national monitoring systems (BBS, BFRSS, DOE). Recommendations on this are beyond the scope of NERP, however.

- Incorporate appropriate monitoring measures into each Plan FCD project, as an integral part of the project operation and management activities of the local project committees, with external technical assistance as needed. Detailed designs should be developed as a part of feasibility studies.

- Incorporate appropriate monitoring into each non-FCD project. Detailed designs should be developed as a part of feasibility studies.

- Design and institute specialized new monitoring systems and activities in specific areas where these are needed. One such system which has been identified by NERP is the need for a central log of all floodplain infrastructure development (embankments, closures, roads, bridges, culverts, etc.), by all agencies and local communities. This is necessary if future observed river morphology changes are to be understood, and in some cases, diagnosed before they occur.

The levels at which reporting would be done parallel the monitoring levels: national, Plan FCD and non-FCD project, and by specialized monitoring system. The existing and likely near-term future institutional framework all but ensures that such monitoring and reporting will be on a somewhat *ad hoc* basis, that is, with reference to particular executing agency guidelines and donor conditionalities.

10.6.7 Implementation of Environmental Management Plan

Public Participation
Under the *Pilot Project to Institutionalize Public Consultation*, and as an integral part of individual FCD initiatives studies and implementation, ongoing public participation activities would be carried out, building upon Plan public consultation activities (described in IEE Chapter 5) and on the FPCO guidelines for public participation.

Institutional Strengthening, Training, and Technical Assistance Needs
BWDB can and should be expected to acquire the institutional and technical capabilities required to incorporate EMP measures which are integral to the activities which it performs or for which it has responsibility. These and other areas would be addressed under the project *BWDB Strengthening*. EMP related strengthening of other national institutions such as DOE is necessary but beyond the scope of this study, though the institutional initiatives addressing biodiversity and surface water quality strategic planning would partially address EMP capabilities in these areas.

EMP Implementation Schedule
Detailed schedules for implementation of the wide range of EMP measures discussed above will be dictated by the phasing of Plan implementation (given that there is mitigation, compensation, and enhancement between and among Plan projects) and by individual projects' detailed schedules, developed during feasibility.

EMP Costs
Some costs associated with Plan implementation clearly should be counted as EMP costs. Other Plan components have both a primary developmental function and an environmental management function (e.g. major river improvement). Keeping this in mind, EMP costs could include any or all of the following (overall total US$361.3 million, 34% of total Plan costs):

- EMP study and implementation costs included in Plan FCD initiatives' budgets: US$42.7 million.
- Total costs of Plan non-FCD projects which mitigate, compensate, enhance, or monitor environmental components subject to potentially adverse impacts from Plan FCD projects: US$239.2 million.
- River improvement project costs (exclusive of EMP costs quoted above): US$75.9 million
- Total costs of institutional strengthening projects not already included: US$3.4 million

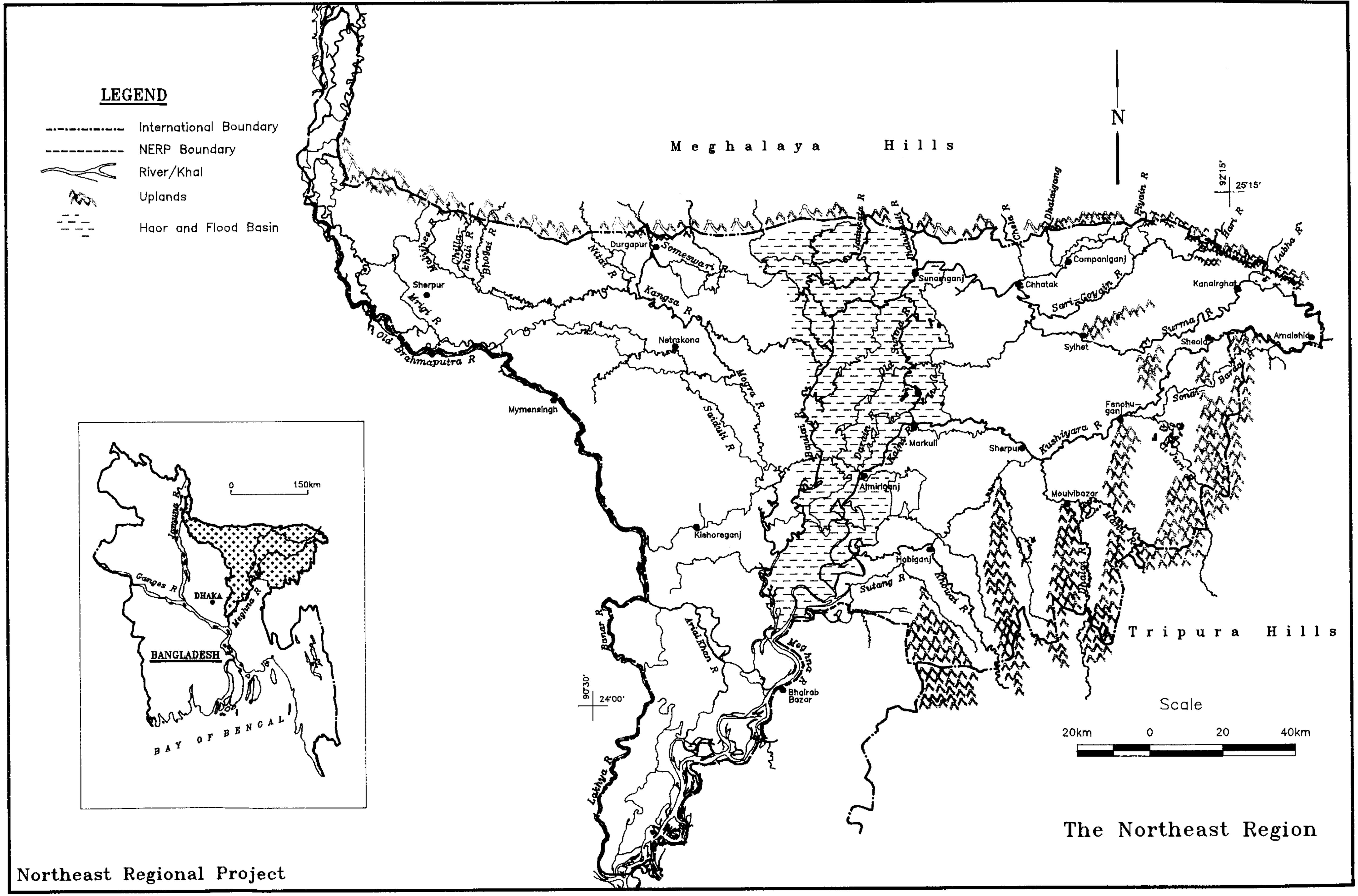
10.6.8 Linking Impact Assessment to Project Assessment
The results of environmental impact assessment need to be transferred or linked to the overall project assessment process. The goal is to ensure that environmental concerns are given due weight in deciding whether projects warrant investment.

The tool used by NERP, and more broadly by the FAP, is the multi-criteria analysis. This is to include quantitative and qualitative indicators of all important environmental and economic impacts and criteria. Explicit MCAs were included in the final chapters of most of the project pre-feasibility studies.

ANNEX A

FIGURES

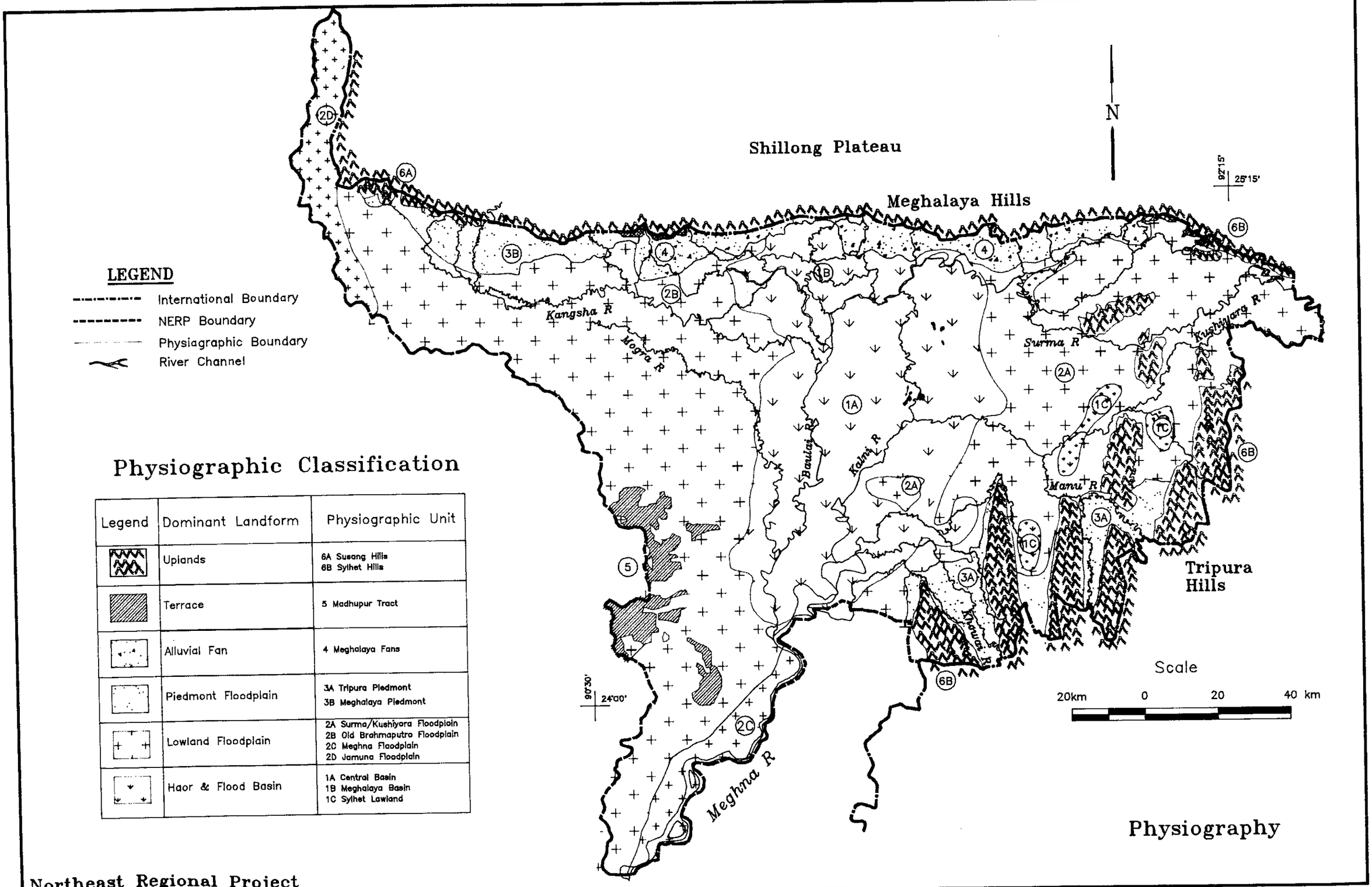
Figure 1



The Northeast Region

Northeast Regional Project

Figure 2

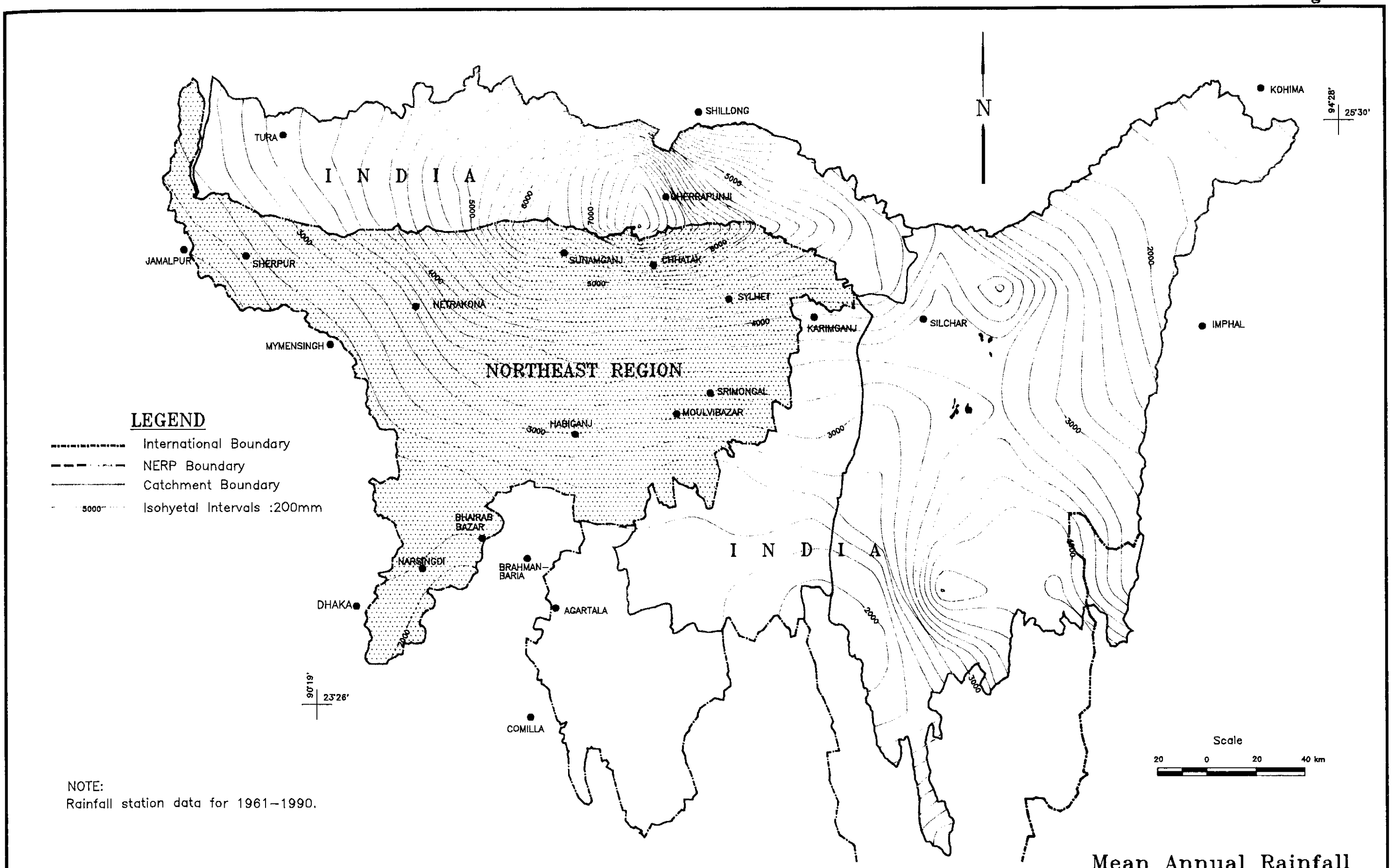


Physiographic Classification

Legend	Dominant Landform	Physiographic Unit
	Uplands	6A Susang Hills 6B Sylhet Hills
	Terrace	5 Madhupur Tract
	Alluvial Fan	4 Meghalaya Fans
	Piedmont Floodplain	3A Tripura Piedmont 3B Meghalaya Piedmont
	Lowland Floodplain	2A Surma/Kushiyara Floodplain 2B Old Brahmaputra Floodplain 2C Meghna Floodplain 2D Jamuna Floodplain
	Haor & Flood Basin	1A Central Basin 1B Meghalaya Basin 1C Sylhet Lowland

Northeast Regional Project

Figure 3



Northeast Regional Project

Figure 4

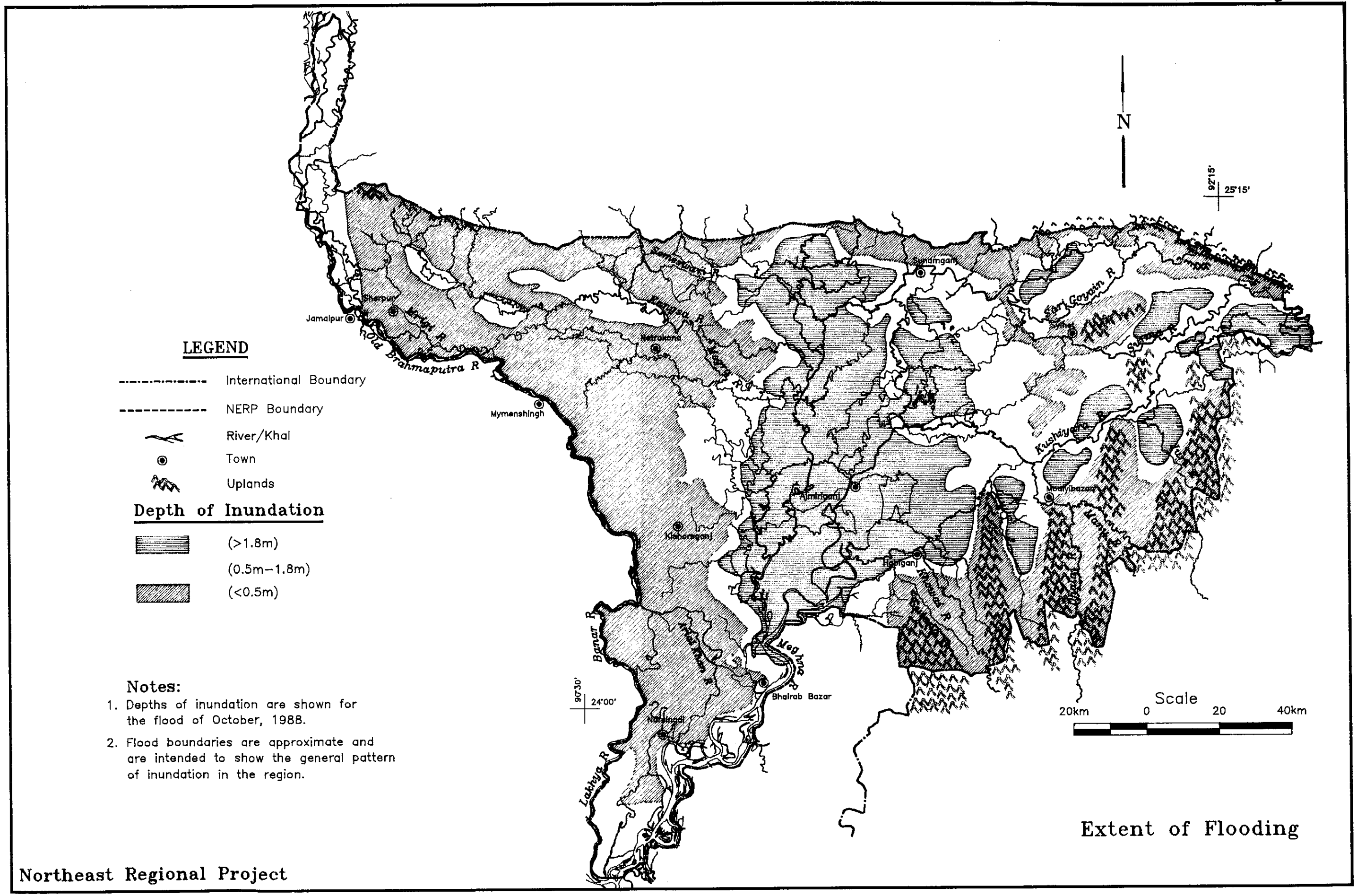

N
92°15'
25°15'
LEGEND
International Boundary
NERP Boundary
River/Khal
Town
Uplands
Depth of Inundation
(>1.8m)
(0.5m–1.8m)
(<0.5m)
Notes:
1. Depths of inundation are shown for the flood of October, 1988.
2. Flood boundaries are approximate and are intended to show the general pattern of inundation in the region.
Jamalpur
Sherpur
Mymensingh
Netrokona
Sunamganj
Sylhet
Kishoreganj
Habiganj
Moulvibazar
Bhairab Bazar
Narsingdi
Old Brahmaputra R
Kangsa R
Surma R
Kushiyara R
Sari Goyain R
Meghna R
Lakhya R
90°30'
24°00'
Scale
20km 0 20 40km
Extent of Flooding
Northeast Regional Project

Figure 5

N

Kauniar char
Sherpur
Jamalpur
Haluaghat
Phulpur
Zaria
Purbadhala
Netrakona
Barhatta
Mymensingh
Katiapara
Sunamganj
Dhirai
Jalntiapur
Chhatak
Kanairghat
Jaintiapur
Sylhet
Sheola
Zakiganj
Amalshid
Fenchuganj
Sherpur
Juri
Ajmiriganj
Moulvibazar
Kulaura
Kishoreganj
Habiganj
Lakhi
Astagram
Bhairab Bazar
Ashuganj
Narsingdi

LEGEND

International Boundary	—·—·—	
NERP Boundary	— — —	
Transmission	Existing	Under Construction
230 KV	———	— — —
132 KV	—·—·—	— — —
33 KV	—·—·—	
33 KV Line energised at 11 KV	———	
Power Plant	▲	▲
Grid Sub-station	■	■
Natural Gas Field	◖	

Scale

20km 0 20 40km

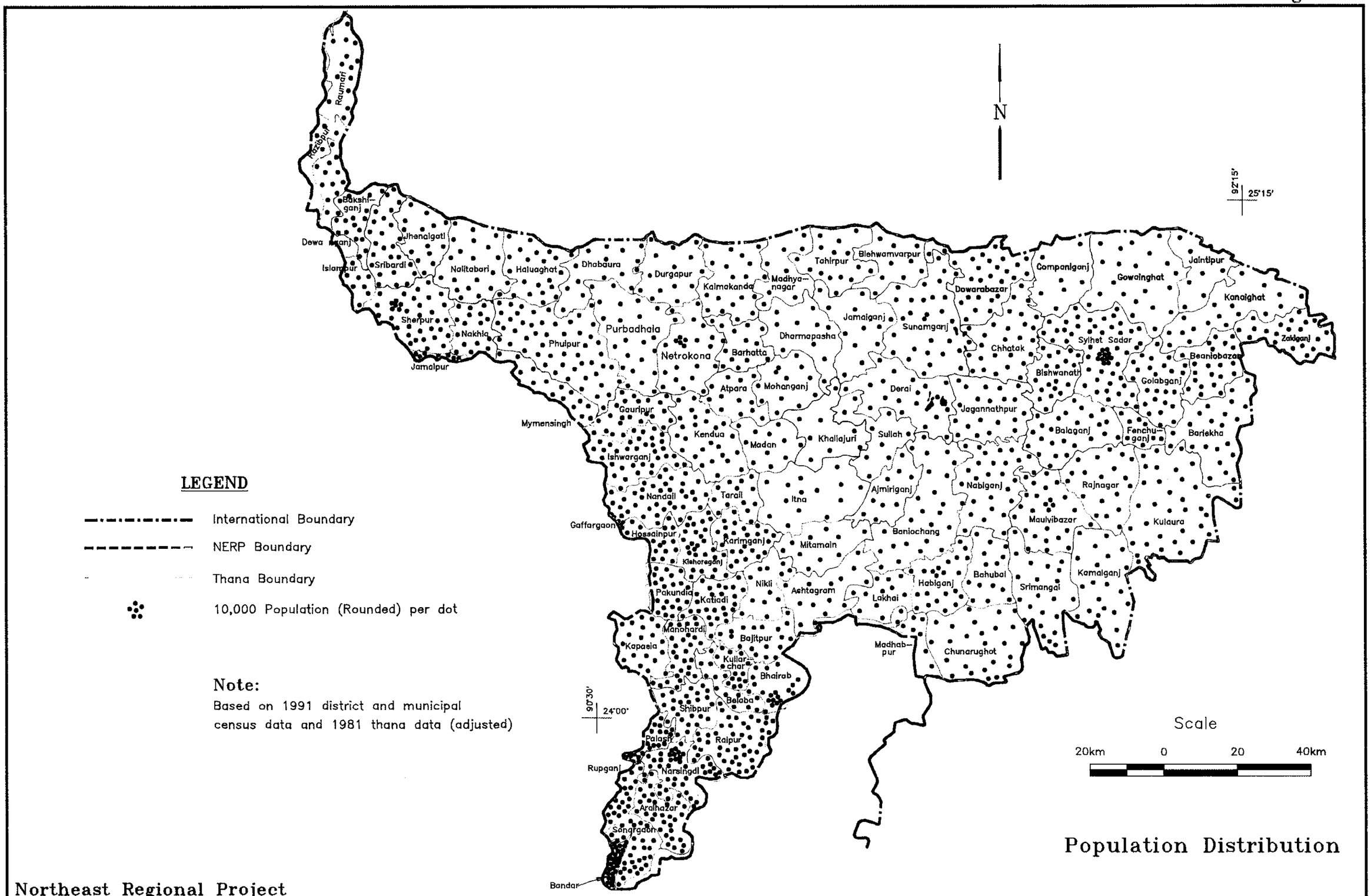
Note:

1. Extent of electrical grid reproduced from "Rural Electrification Project Phase I & II".
2. Extent of PDB grid in central portion of region may not be complete.
3. 230,132 & 33 KV grid from Directorate of Systems Planning BPDB.

Northeast Regional Project

Gas Fields and Electrical Distribution

Figure 6



LEGEND

- International Boundary
- NERP Boundary
- Thana Boundary
- 10,000 Population (Rounded) per dot

Note:
Based on 1991 district and municipal census data and 1981 thana data (adjusted)

Population Distribution

Northeast Regional Project

Figure 7

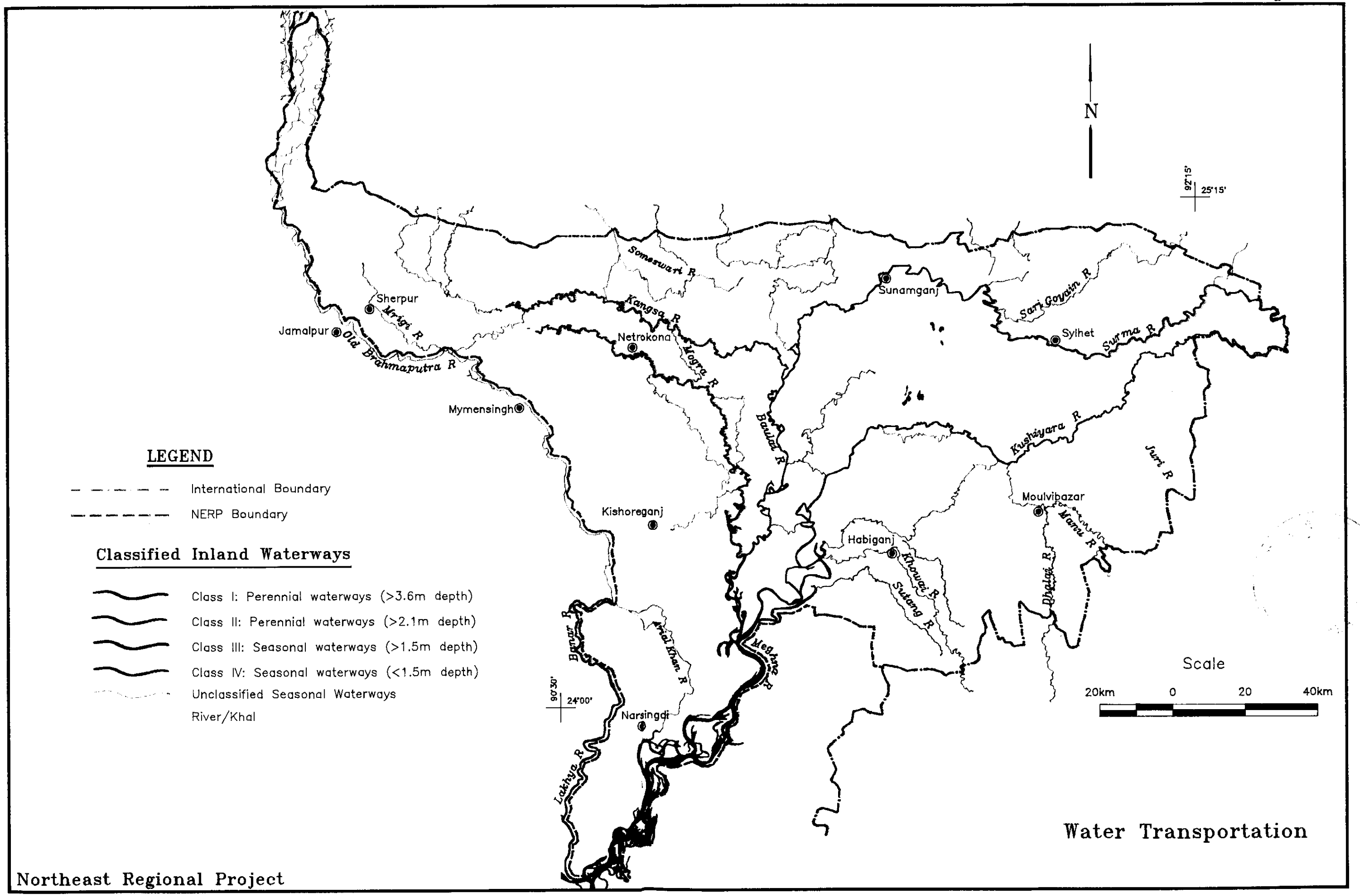

N
92°15'
25°15'
Someswari R
Sherpur
Kangsa R
Sunamganj
Sari Goyain R
Jamalpur
Mrigi R
Old Brahmaputra R
Netrokona
Magra R
Sylhet
Surma R
Mymensingh
Bauia R
Kushiyara R
Juri R
Kishoreganj
Moulvibazar
Habiganj
Khowai R
Sutang R
Dhalai R
Mana R
Bangar R
Atai Khan R
Meghna
90°30'
24°00'
Narsingdi
Lakhya R
LEGEND
International Boundary
NERP Boundary
Classified Inland Waterways
Class I: Perennial waterways (>3.6m depth)
Class II: Perennial waterways (>2.1m depth)
Class III: Seasonal waterways (>1.5m depth)
Class IV: Seasonal waterways (<1.5m depth)
Unclassified Seasonal Waterways
River/Khal
Scale
20km 0 20 40km
Water Transportation
Northeast Regional Project

Figure 8

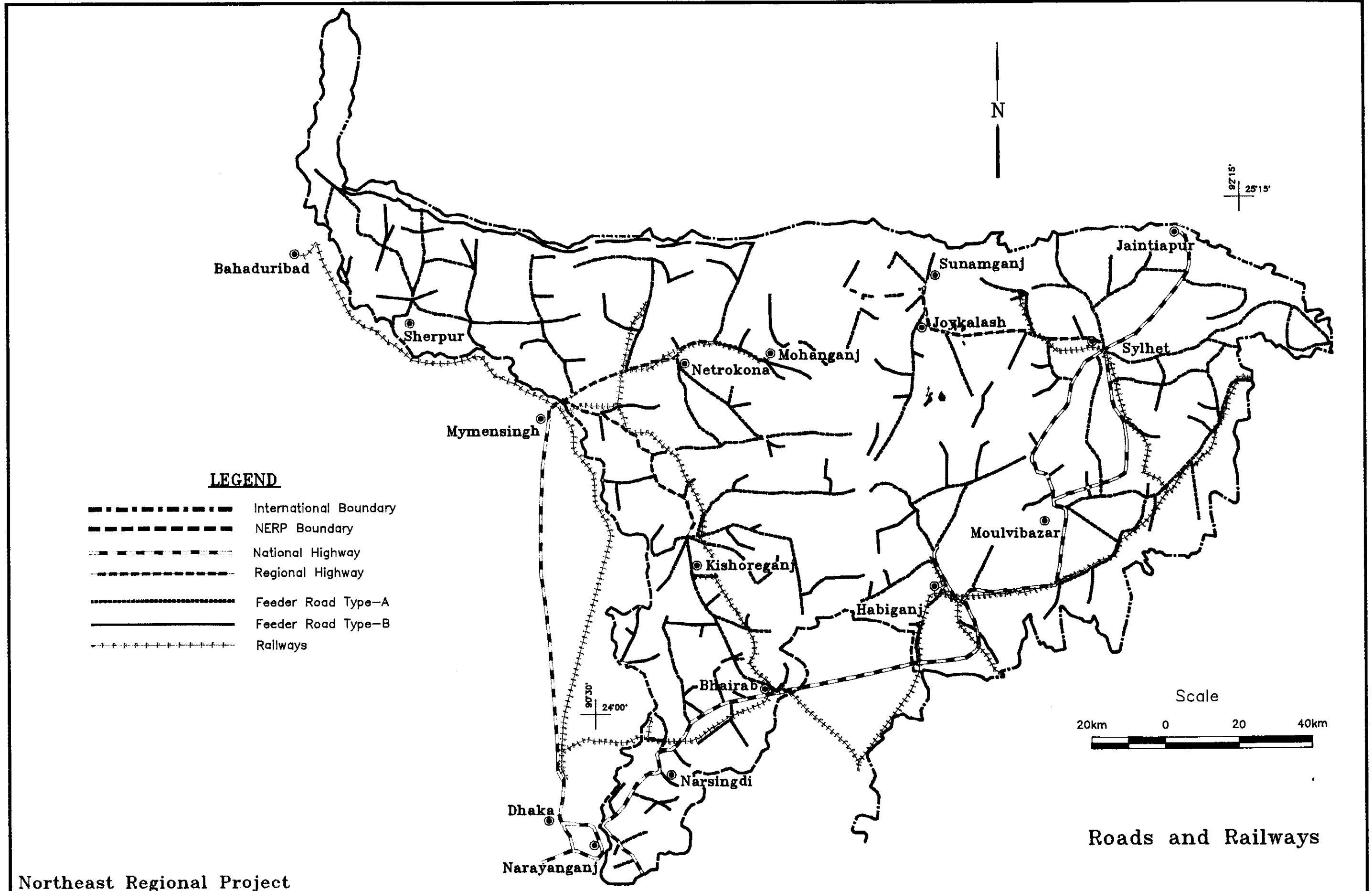

N
92°15'
25°15'
Bahaduribad
Sherpur
Mymensingh
Netrokona
Mohanganj
Sunamganj
Joykalash
Jaintiapur
Sylhet
Moulvibazar
Kishoreganj
Habiganj
Bhairab
90°30'
24°00'
Narsingdi
Dhaka
Narayanganj
LEGEND
International Boundary
NERP Boundary
National Highway
Regional Highway
Feeder Road Type–A
Feeder Road Type–B
Railways
Scale
20km 0 20 40km
Roads and Railways
Northeast Regional Project

Figure 9

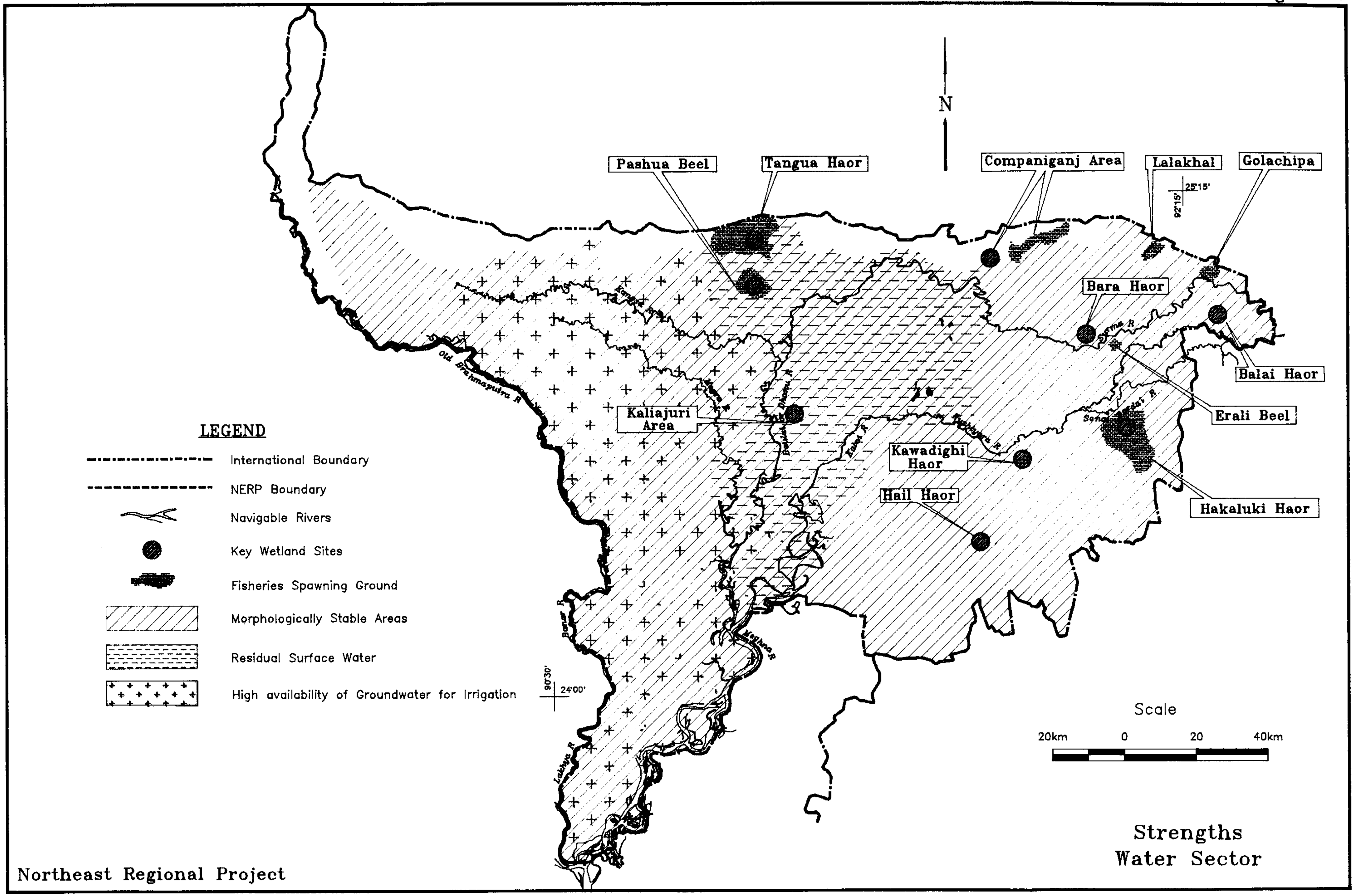

N
Pashua Beel
Tangua Haor
Companiganj Area
Lalakhal
Golachipa
Bara Haor
Balai Haor
Erali Beel
Kaliajuri Area
Kawadighi Haor
Hail Haor
Hakaluki Haor
Old Brahmaputra R
Meghna R
Lakhya R
Banar R
Surma R
Kusiyara R
Kangsa R
Baulai R
Dhanu R
Kalni R
25°15'
92°15'
90°30'
24°00'
LEGEND
International Boundary
NERP Boundary
Navigable Rivers
Key Wetland Sites
Fisheries Spawning Ground
Morphologically Stable Areas
Residual Surface Water
High availability of Groundwater for Irrigation
Scale
20km
0
20
40km
Strengths
Water Sector
Northeast Regional Project

Figure 10

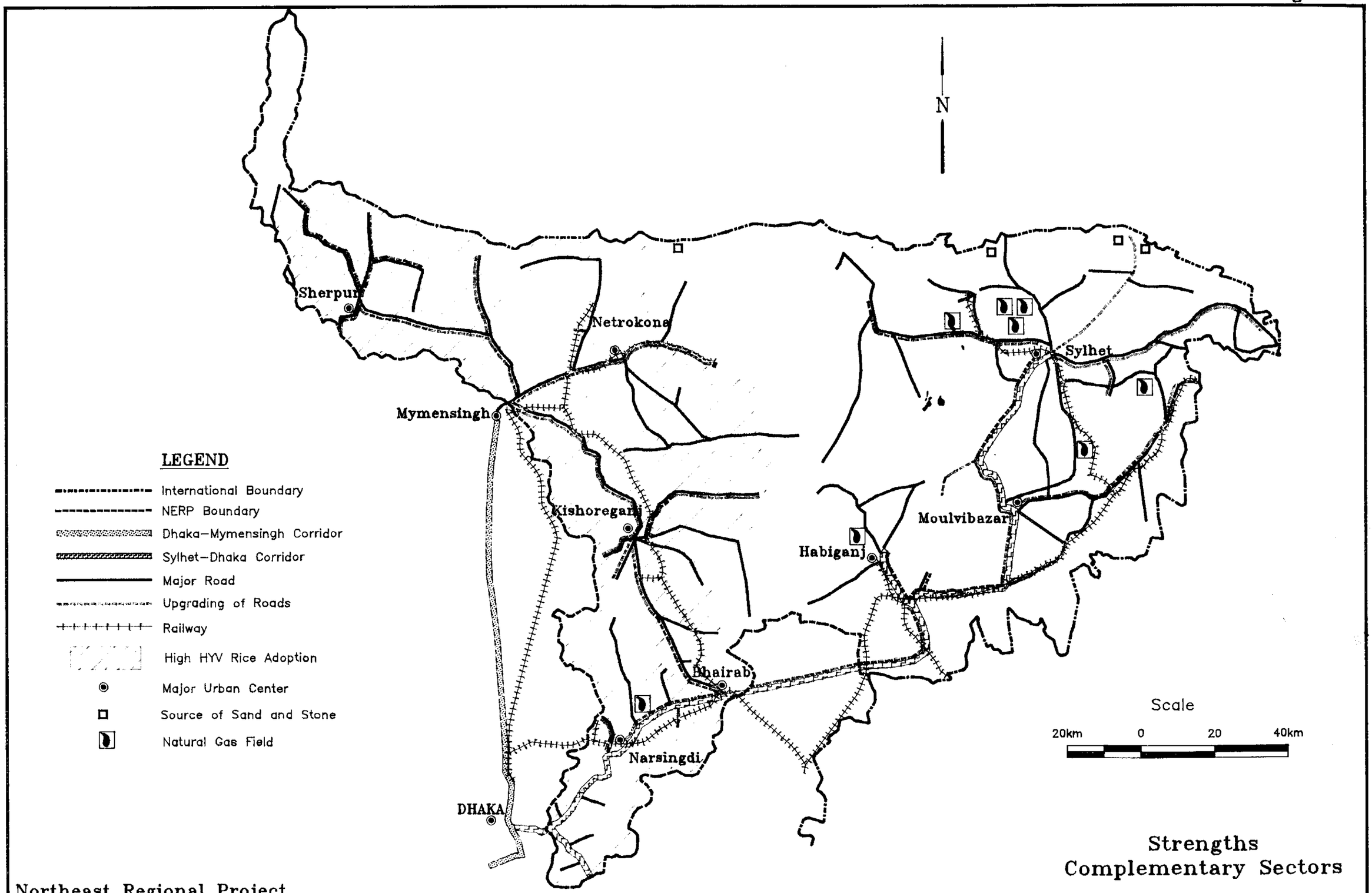

N
Sherpur
Netrokone
Mymensingh
Sylhet
Kishoreganj
Habiganj
Moulvibazar
Bhairab
Narsingdi
DHAKA
LEGEND
International Boundary
NERP Boundary
Dhaka–Mymensingh Corridor
Sylhet–Dhaka Corridor
Major Road
Upgrading of Roads
Railway
High HYV Rice Adoption
Major Urban Center
Source of Sand and Stone
Natural Gas Field
Scale
20km 0 20 40km
Strengths
Complementary Sectors
Northeast Regional Project

Figure 11

N

Jamuna R

Kangsa R

Mrigi R

Old Brahmaputra R

Surma R

Kushiyara

Manu R

Dhaurdi R

Barak R

Meghna

LEGEND

- International Boundary
- NERP Boundary
- River
- Annually Flooded
- Annually Flooded with Drainage Affected by the Lower Meghna River
- Morphologically Unstable Area and Annually Flooded
- Major River Aggradation

Scale

20km 0 20 40km

Weaknesses Water Sector

Northeast Regional Project

Figure 12

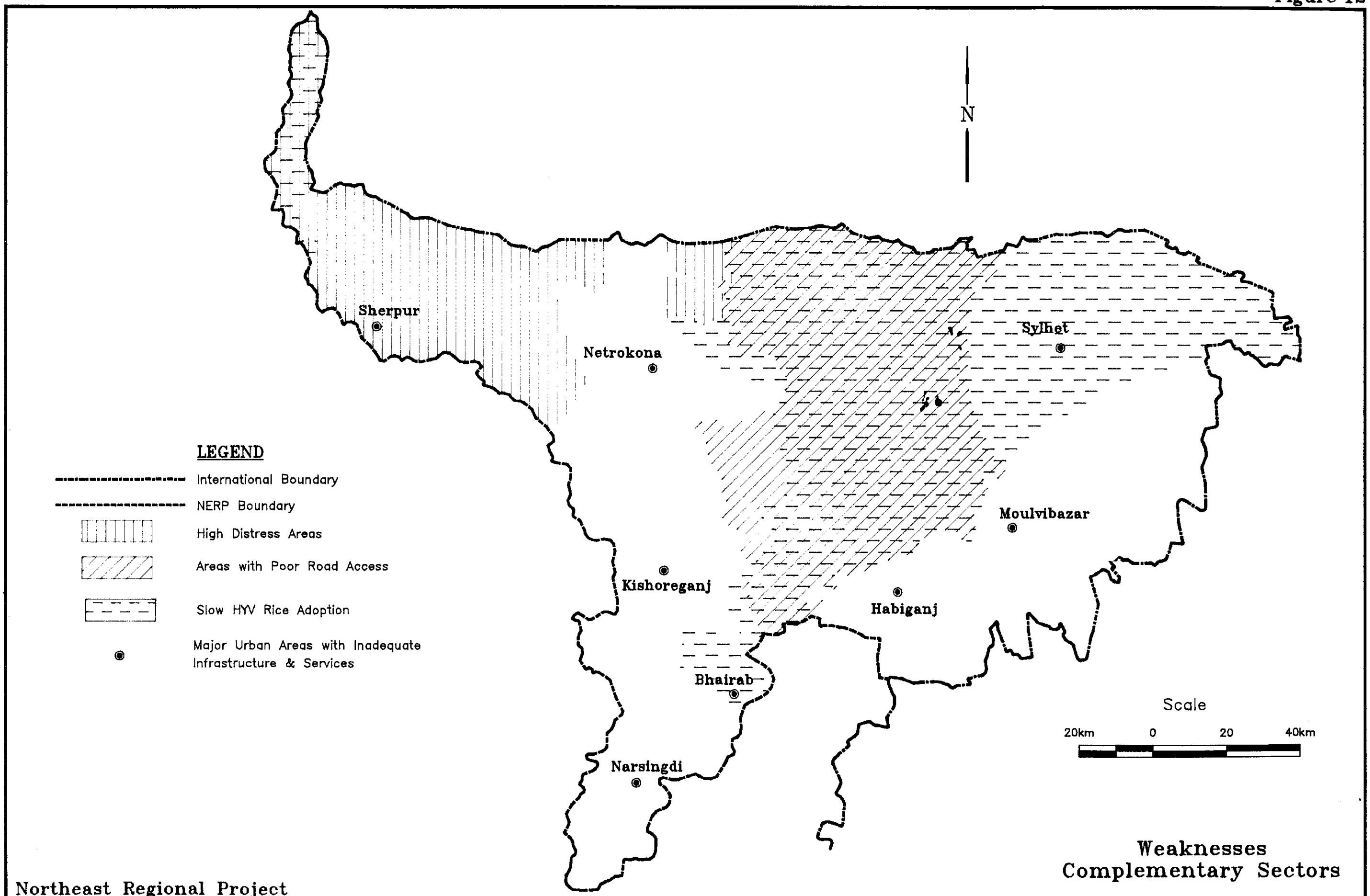

N
Sherpur
Netrokona
Sylhet
Moulvibazar
Kishoreganj
Habiganj
Bhairab
Narsingdi
LEGEND
International Boundary
NERP Boundary
High Distress Areas
Areas with Poor Road Access
Slow HYV Rice Adoption
Major Urban Areas with Inadequate Infrastructure & Services
Scale
20km 0 20 40km
Weaknesses
Complementary Sectors
Northeast Regional Project

Figure 13

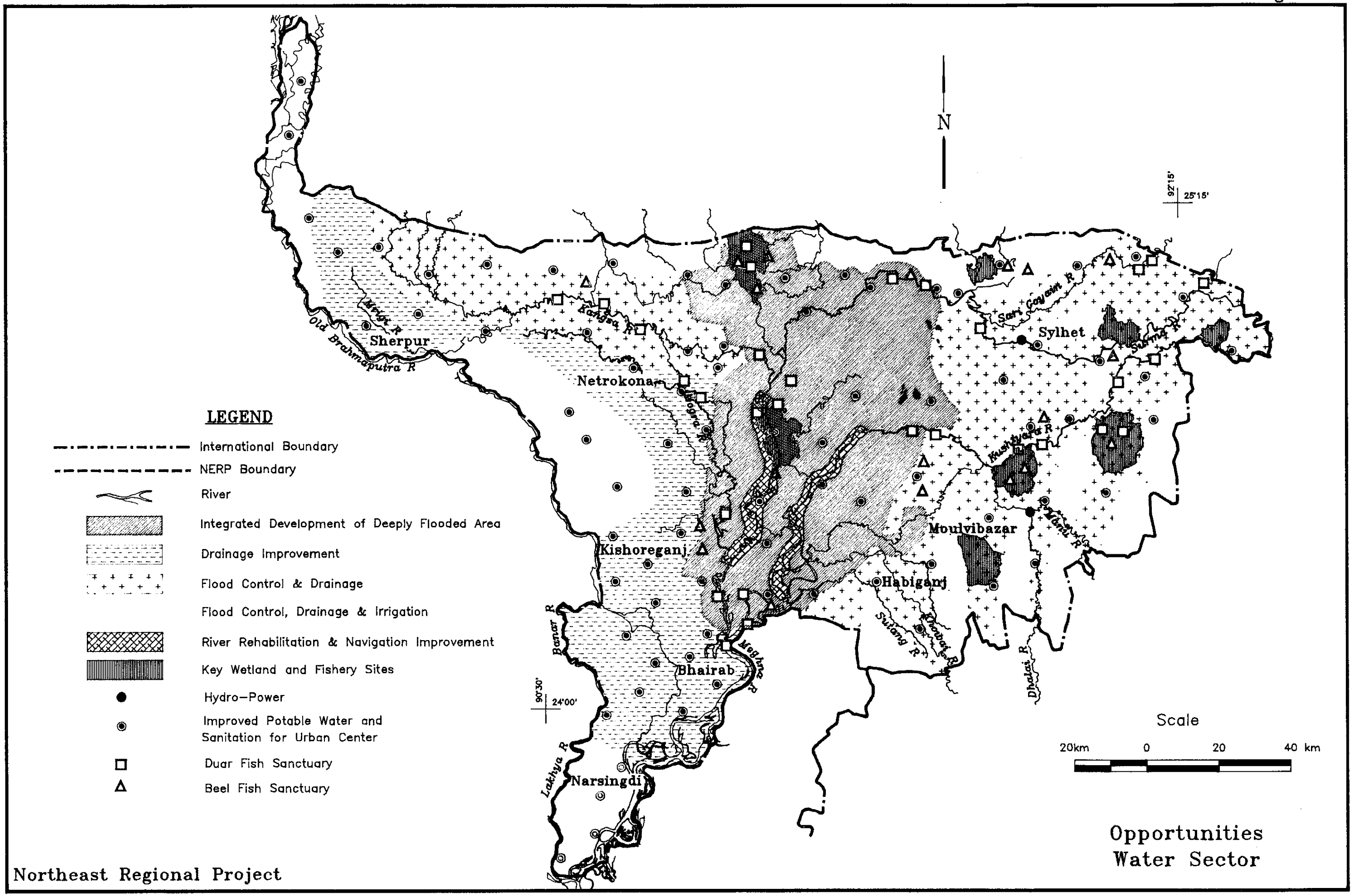

N
92°15'
25°15'
Sherpur
Old Brahmaputra R
Netrokona
Sylhet
Sari Goyain R
Kushiyara R
Moulvibazar
Kishoreganj
Habiganj
Bhairab
Narsingdi
90°30'
24°00'
Scale
20km 0 20 40 km
LEGEND
International Boundary
NERP Boundary
River
Integrated Development of Deeply Flooded Area
Drainage Improvement
Flood Control & Drainage
Flood Control, Drainage & Irrigation
River Rehabilitation & Navigation Improvement
Key Wetland and Fishery Sites
Hydro–Power
Improved Potable Water and Sanitation for Urban Center
Duar Fish Sanctuary
Beel Fish Sanctuary
Northeast Regional Project
Opportunities
Water Sector

Figure 14

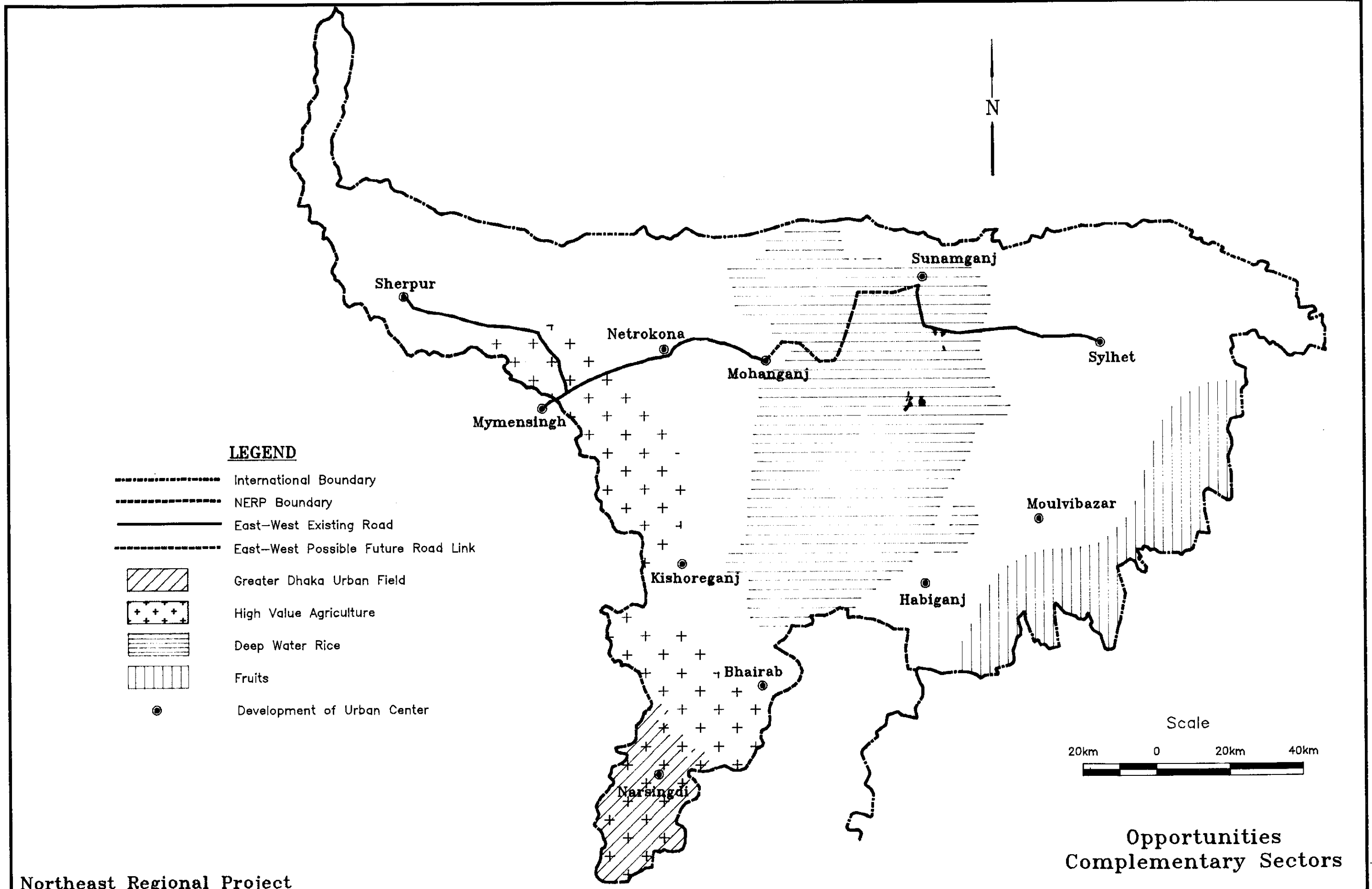

N
Sherpur
Netrokona
Mymensingh
Sunamganj
Sylhet
Mohanganj
Moulvibazar
Kishoreganj
Habiganj
Bhairab
Narsingdi
LEGEND
International Boundary
NERP Boundary
East–West Existing Road
East–West Possible Future Road Link
Greater Dhaka Urban Field
High Value Agriculture
Deep Water Rice
Fruits
Development of Urban Center
Scale
20km 0 20km 40km
Opportunities
Complementary Sectors
Northeast Regional Project

Figure 15

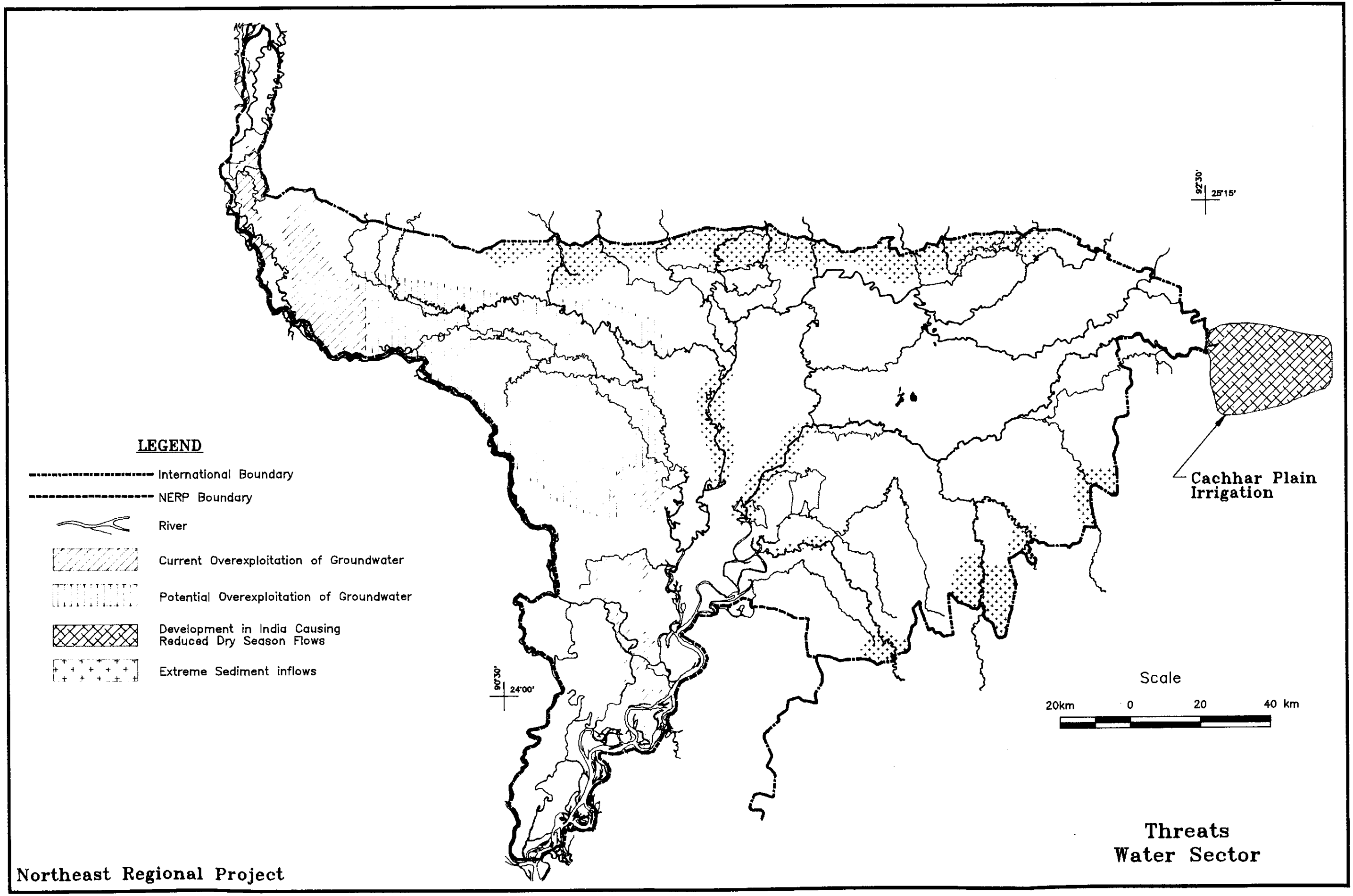

92°30'
25°15'
Cachhar Plain Irrigation
90°30'
24°00'
LEGEND
International Boundary
NERP Boundary
River
Current Overexploitation of Groundwater
Potential Overexploitation of Groundwater
Development in India Causing Reduced Dry Season Flows
Extreme Sediment inflows
Scale
20km 0 20 40 km
Threats
Water Sector
Northeast Regional Project

Figure 16

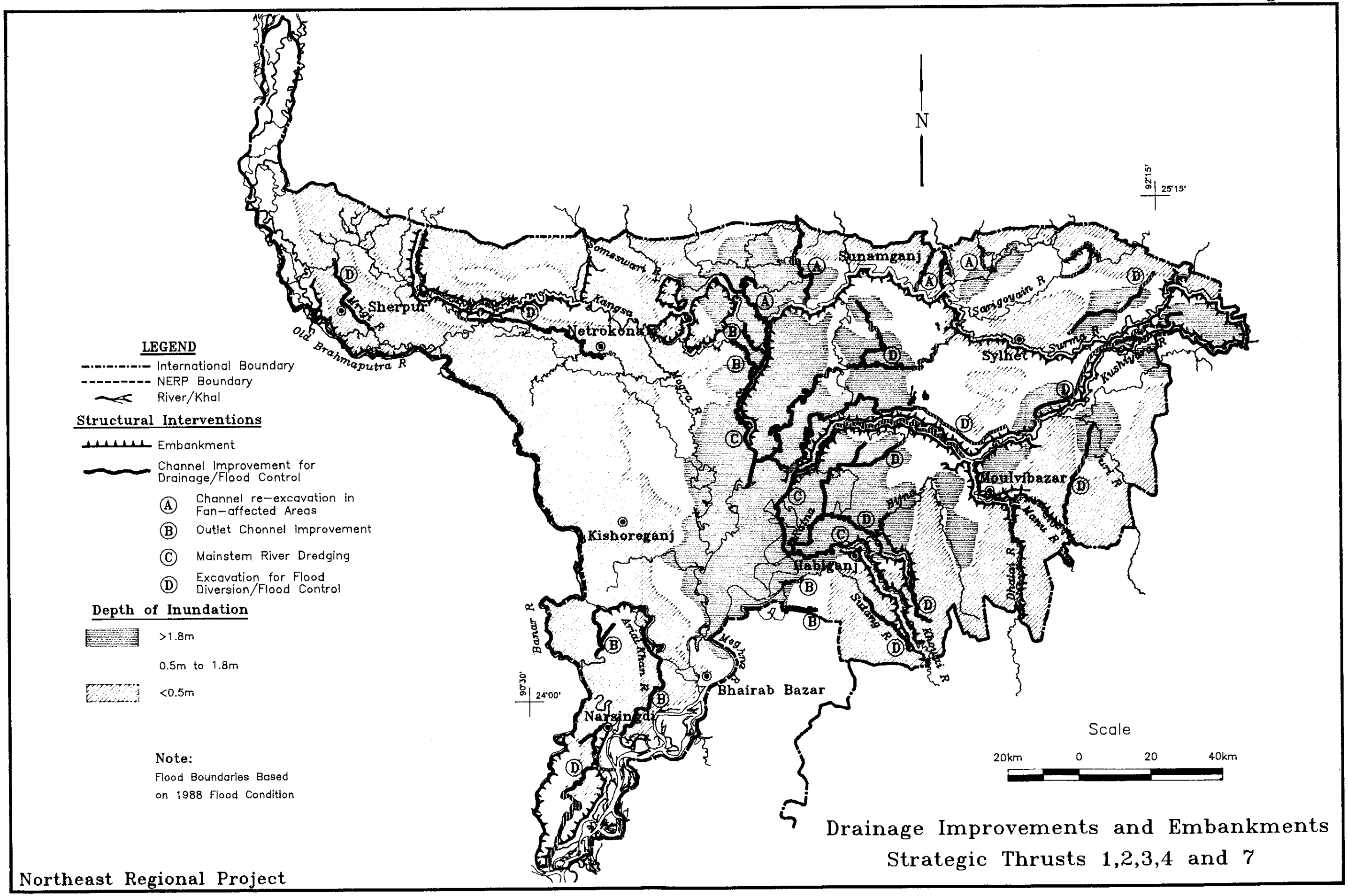

N
92°15'
25°15'
LEGEND
International Boundary
NERP Boundary
River/Khal
Structural Interventions
Embankment
Channel Improvement for Drainage/Flood Control
(A) Channel re-excavation in Fan-affected Areas
(B) Outlet Chonnel Improvement
(C) Mainstem River Dredging
(D) Excavation for Flood Diversion/Flood Control
Depth of Inundation
>1.8m
0.5m to 1.8m
<0.5m
Note:
Flood Boundaries Based on 1988 Flood Condition
Sherpur
Netrokona
Sunamganj
Sylhet
Moulvibazar
Kishoreganj
Habiganj
Bhairab Bazar
Narsingdi
Old Brahmaputra R
Kangsa
Someswari R
Surma R
Kushiyara R
Sarigoyain R
Meghna R
Dhalai R
Kalni R
Banar R
Arial Khan R
Scale
20km 0 20 40km
90°30'
24°00'
Drainage Improvements and Embankments
Strategic Thrusts 1,2,3,4 and 7
Northeast Regional Project

Figure 17

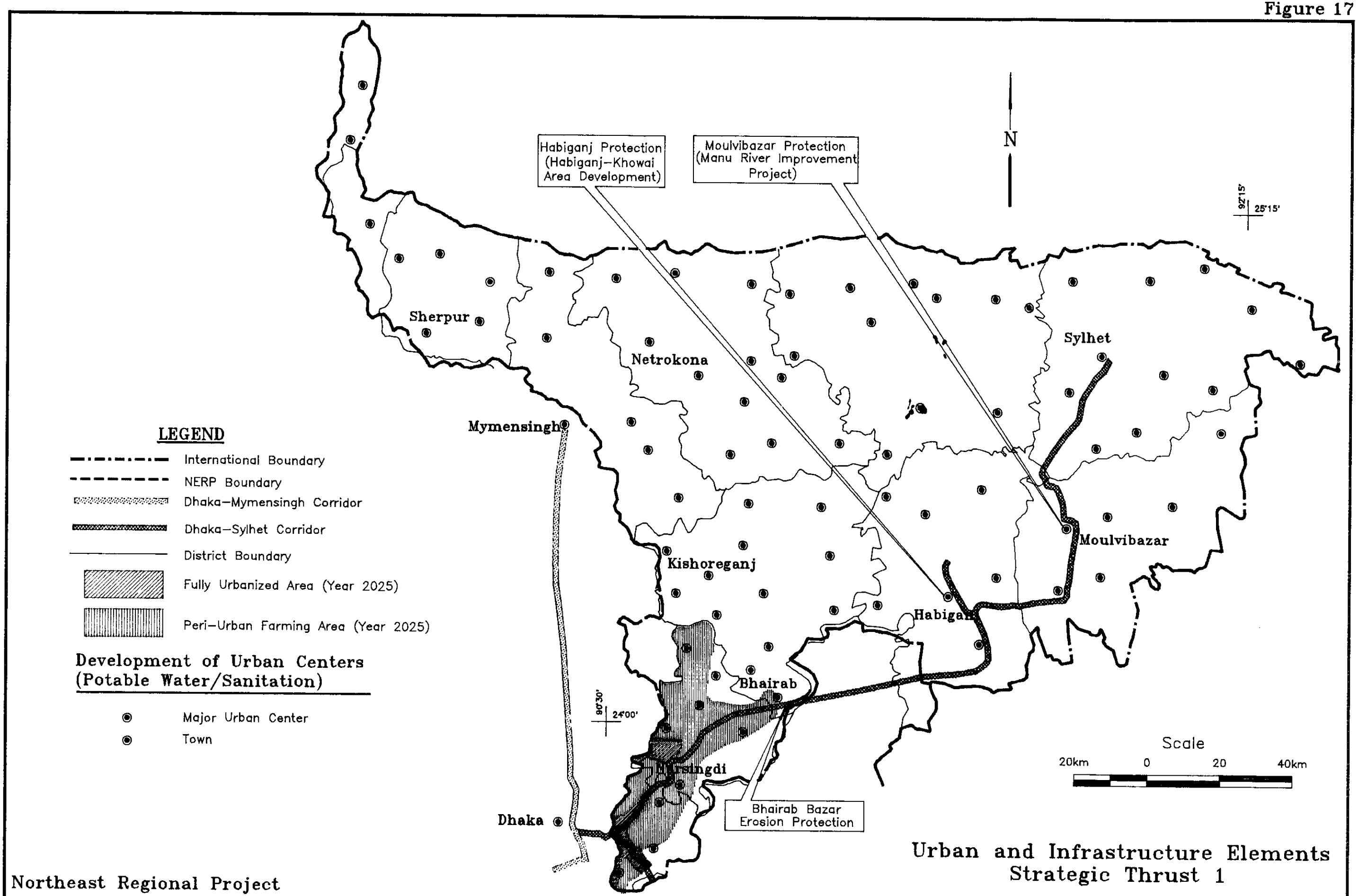

Habiganj Protection (Habiganj–Khowai Area Development)
Moulvibazar Protection (Manu River Improvement Project)
N
92°15'
25°15'
Sherpur
Netrokona
Sylhet
Mymensingh
Kishoreganj
Moulvibazar
Habiganj
Bhairab
90°30'
24°00'
Narsingdi
Dhaka
Bhairab Bazar Erosion Protection
Scale
20km 0 20 40km
LEGEND
International Boundary
NERP Boundary
Dhaka–Mymensingh Corridor
Dhaka–Sylhet Corridor
District Boundary
Fully Urbanized Area (Year 2025)
Peri–Urban Farming Area (Year 2025)
Development of Urban Centers (Potable Water/Sanitation)
Major Urban Center
Town
Urban and Infrastructure Elements
Strategic Thrust 1
Northeast Regional Project

Figure 18

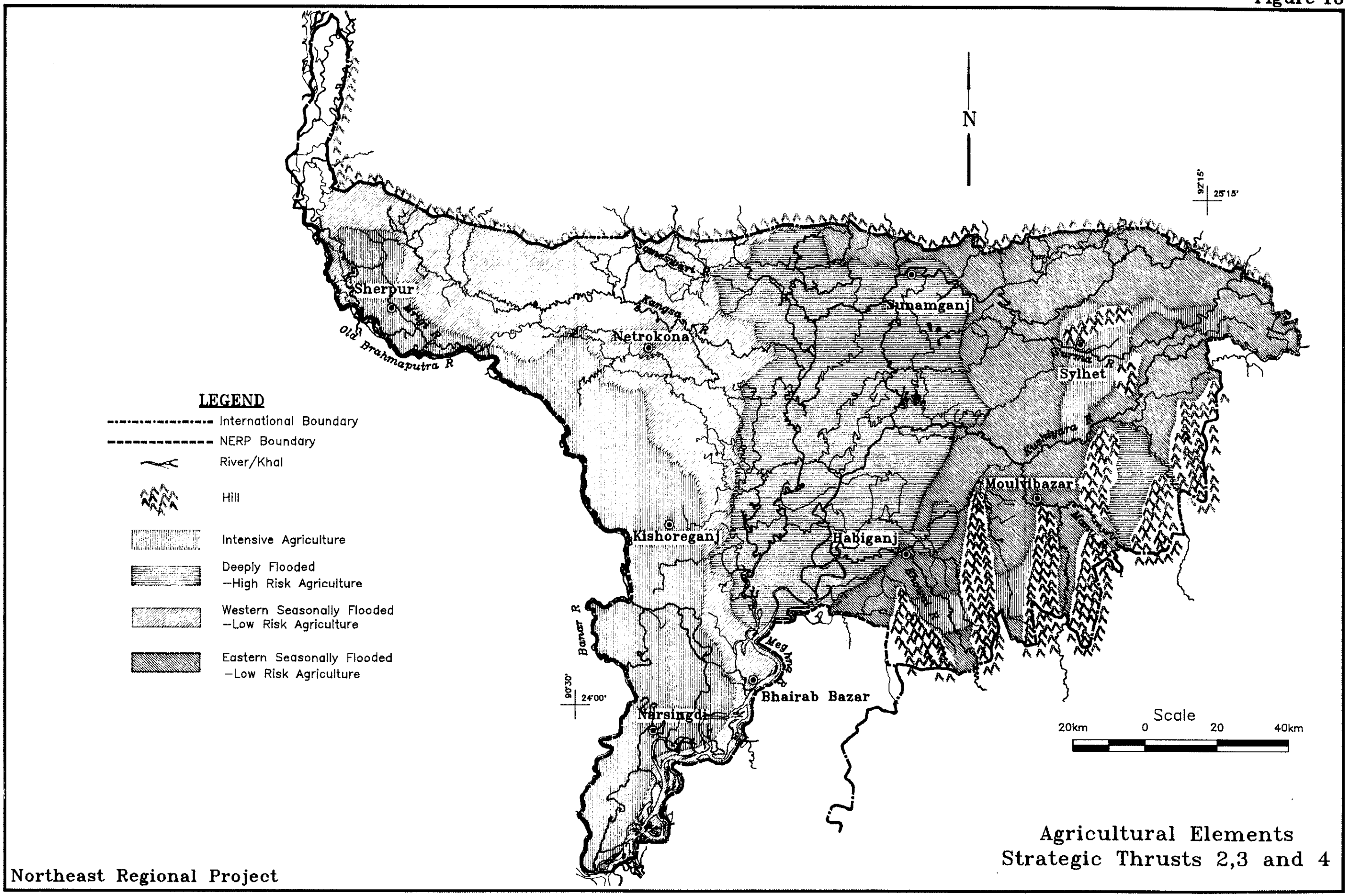

N
92°15'
25°15'
Sherpur
Old Brahmaputra R
Kangsa R
Netrokona
Sunamganj
Surma R
Sylhet
Kushiyara R
Moulvibazar
Kishoreganj
Habiganj
Baner R
Meghna
90°30'
24°00'
Bhairab Bazar
Narsingdi
Scale
20km 0 20 40km
LEGEND
International Boundary
NERP Boundary
River/Khal
Hill
Intensive Agriculture
Deeply Flooded
—High Risk Agriculture
Western Seasonally Flooded
—Low Risk Agriculture
Eastern Seasonally Flooded
—Low Risk Agriculture
Agricultural Elements
Strategic Thrusts 2,3 and 4
Northeast Regional Project

Figure 19

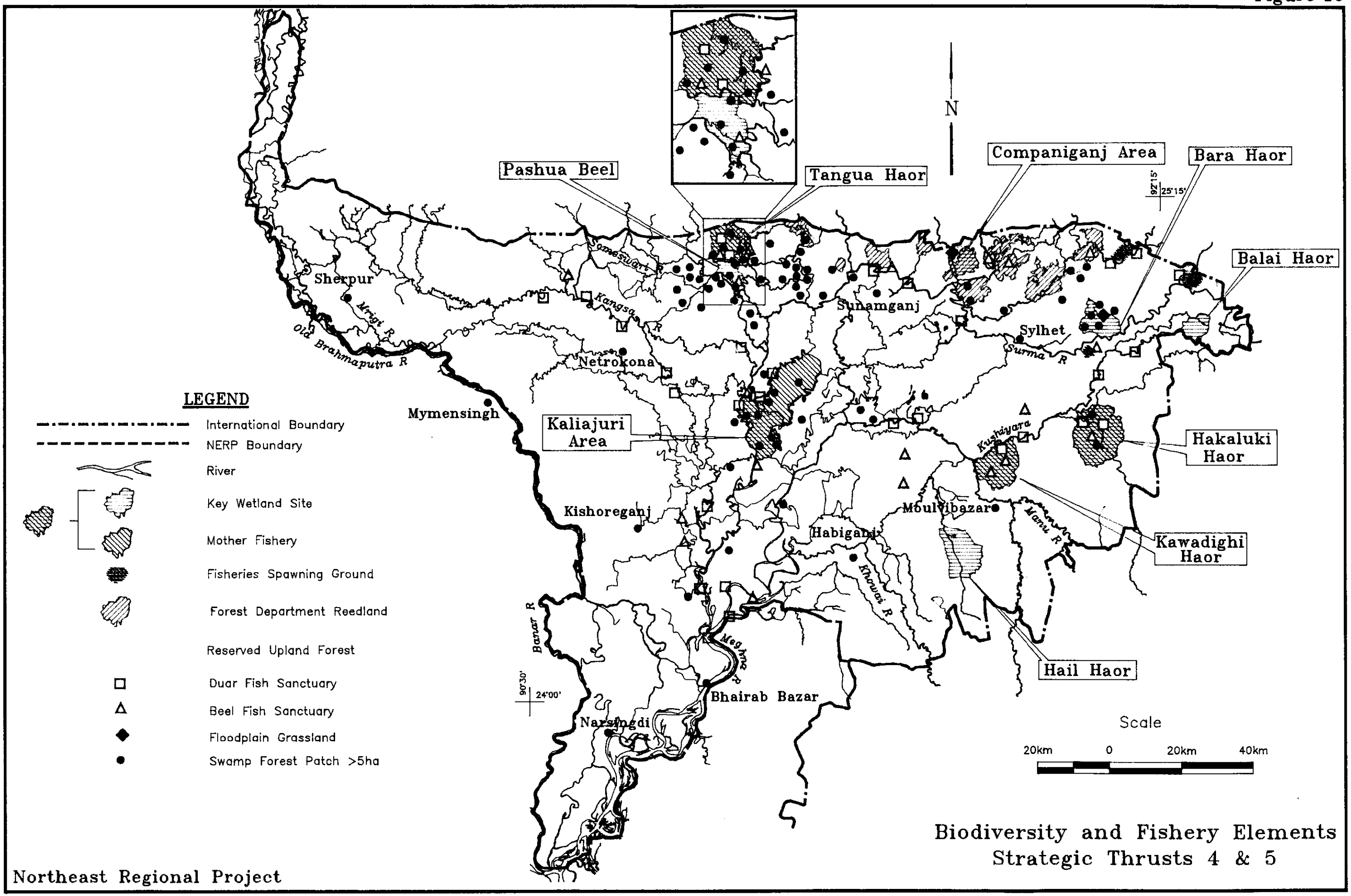

N
Companiganj Area
Bara Haor
Balai Haor
Pashua Beel
Tangua Haor
92°15'
25°15'
Sherpur
Jamuneswari R
Mrigi R
Old Brahmaputra R
Kangsa R
Netrokona
Sunamganj
Sylhet
Surma R
Mymensingh
Kaliajuri Area
Kushiyara
Hakaluki Haor
Kishoreganj
Moulvibazar
Habiganj
Manu R
Kawadighi Haor
Khowai R
Hail Haor
Banar R
Meghna R
90°30'
24°00'
Bhairab Bazar
Narsingdi
Scale
20km 0 20km 40km
LEGEND
International Boundary
NERP Boundary
River
Key Wetland Site
Mother Fishery
Fisheries Spawning Ground
Forest Department Reedland
Reserved Upland Forest
Duar Fish Sanctuary
Beel Fish Sanctuary
Floodplain Grassland
Swamp Forest Patch >5ha
Biodiversity and Fishery Elements
Strategic Thrusts 4 & 5
Northeast Regional Project

Figure 20

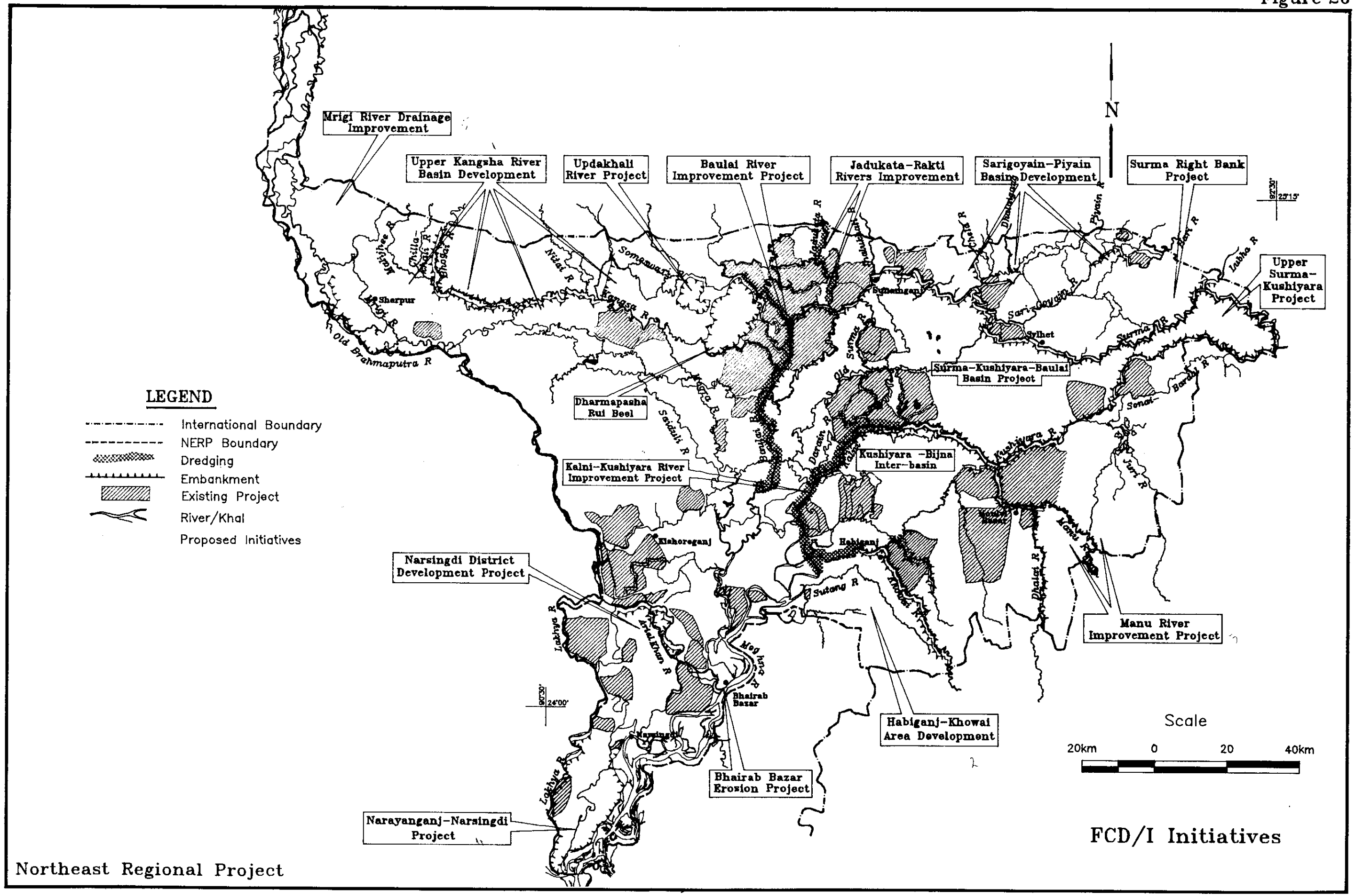
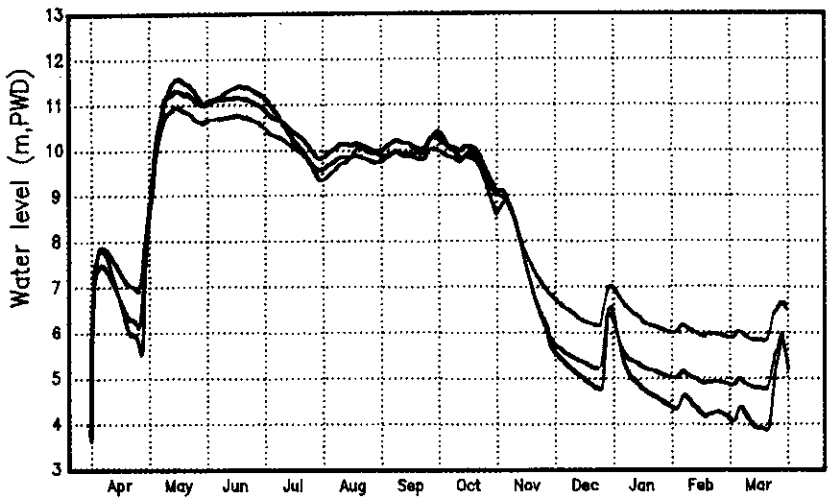
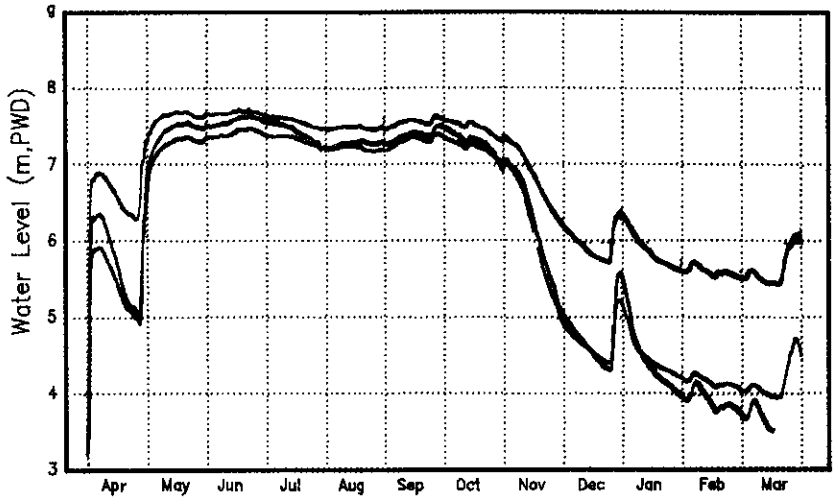

Mrigi River Drainage Improvement
Upper Kangsha River Basin Development
Updakhali River Project
Baulai River Improvement Project
Jadukata-Rakti Rivers Improvement
Sarigoyain-Piyain Basin Development
Surma Right Bank Project
Upper Surma-Kushiyara Project
Surma-Kushiyara-Baulai Basin Project
Kushiyara -Bijna Inter-basin
Kalni-Kushiyara River Improvement Project
Dharmapasha Rui Beel
Narsingdi District Development Project
Habiganj-Khowai Area Development
Manu River Improvement Project
Bhairab Bazar Erosion Project
Narayanganj-Narsingdi Project
N
LEGEND
International Boundary
NERP Boundary
Dredging
Embankment
Existing Project
River/Khal
Proposed Initiatives
Sherpur
Kishoreganj
Habiganj
Sylhet
Bhairab Bazar
Old Brahmaputra R
Old Surma R
Sutang R
Scale
20km 0 20 40km
FCD/I Initiatives
Northeast Regional Project

Figure 21(A)

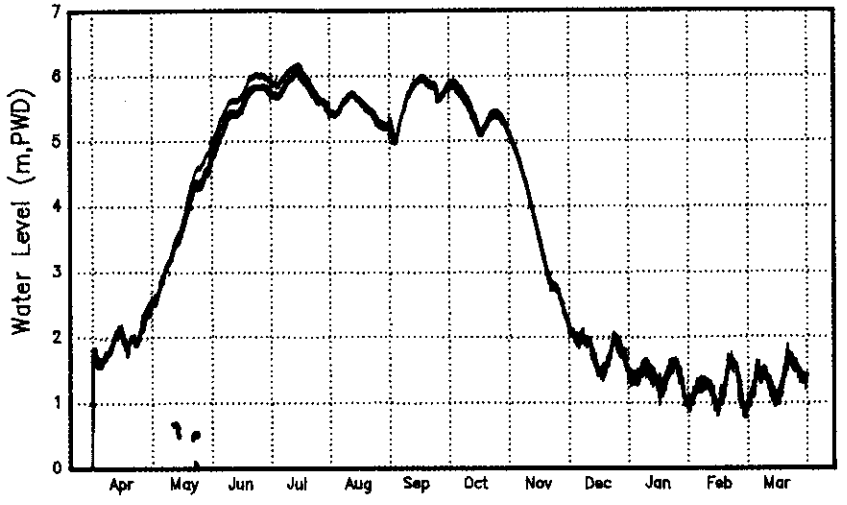
WATER LEVELS AT FENCHUGANJ



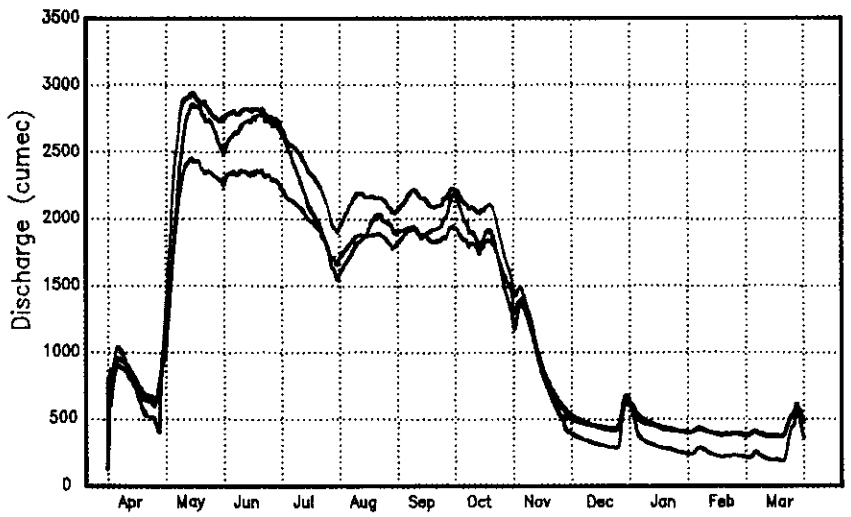
WATER LEVELS AT MARKULI



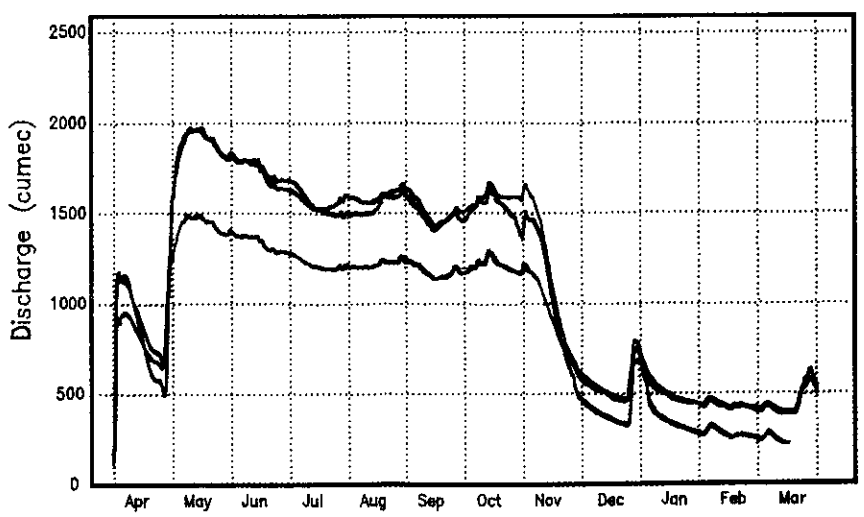
WATER LEVELS AT BAHIRAB BAZAR



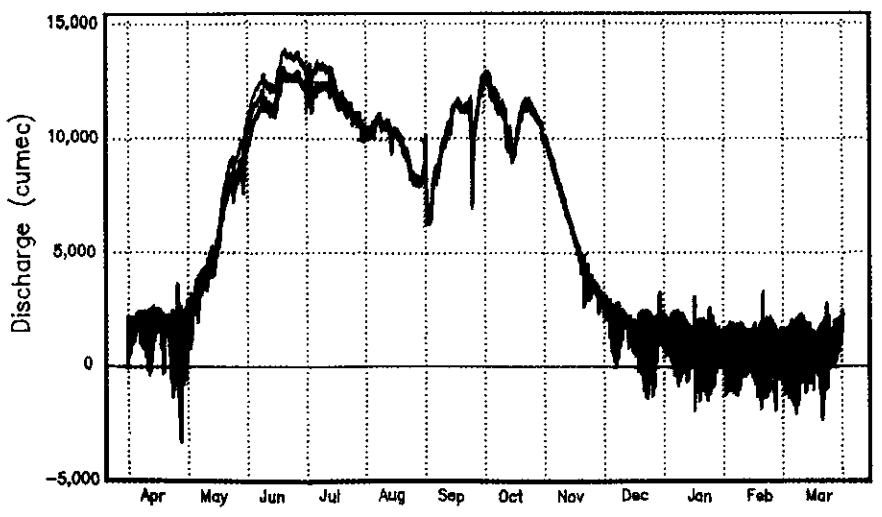
DISCHARGES AT FENCHUGANJ



DISCHARGES AT MARKULI



DISCHARGES AT BHAIRAB BAZAR



LEGEND

EXISTING CONDITIONS

FUTURE WITH NO INTERVENTION

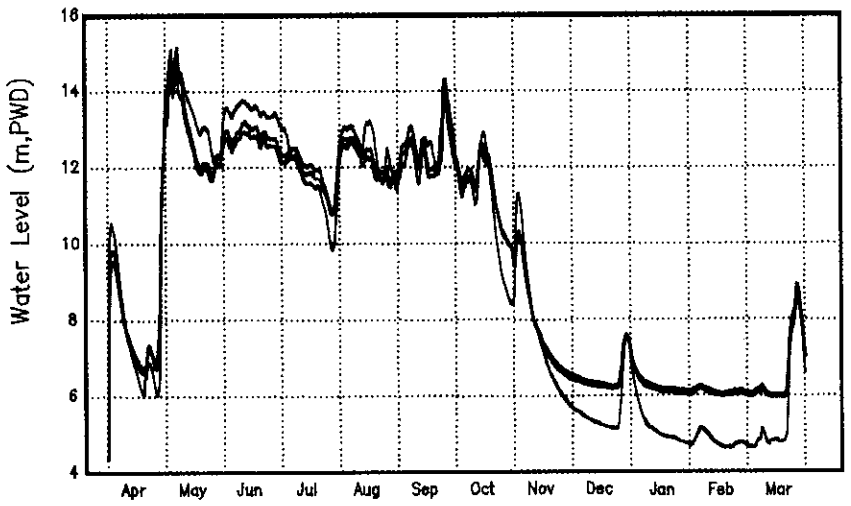
FUTURE WITH REGIONAL DEVELOPMENT PLAN

Existing and Future Water Levels and Discharges

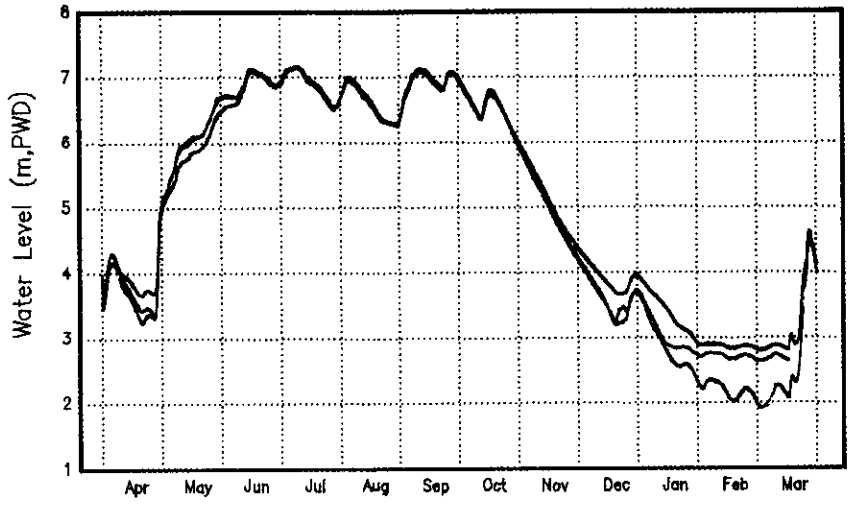
Northeast Regional Project

Figure 21(B)

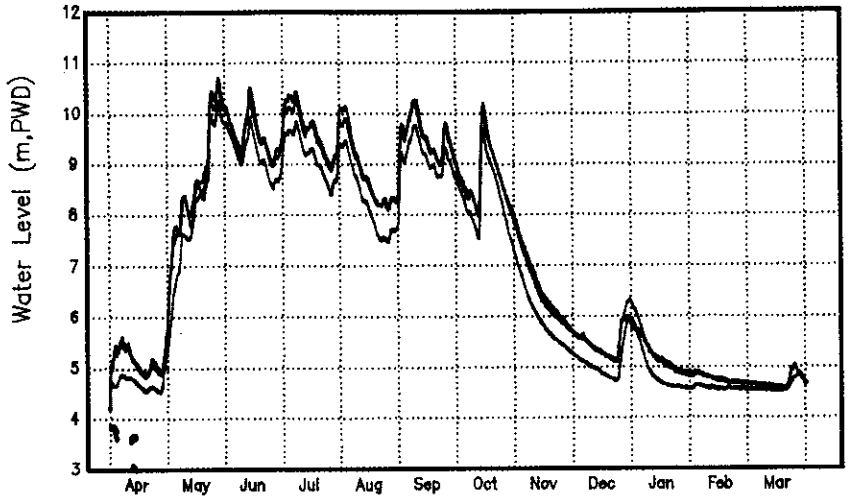
WATER LEVELS AT KANAIGHAT



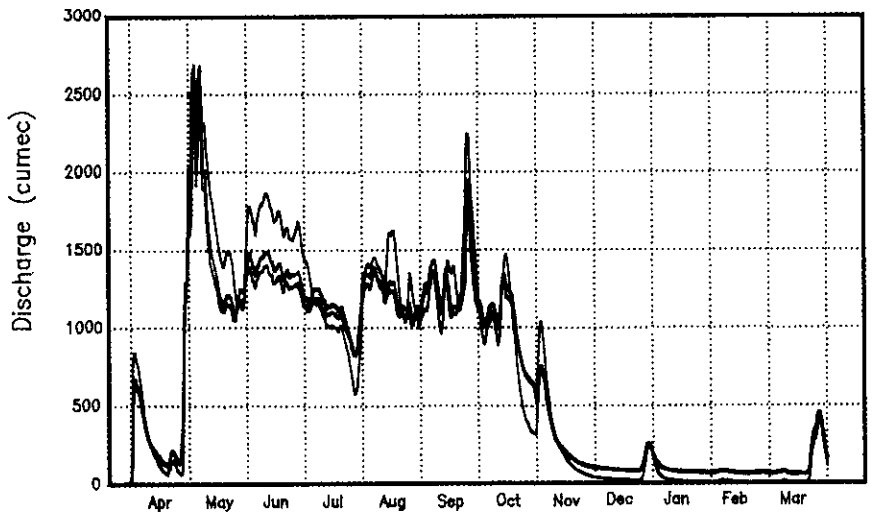
WATER LEVELS AT SUKDEVPUR



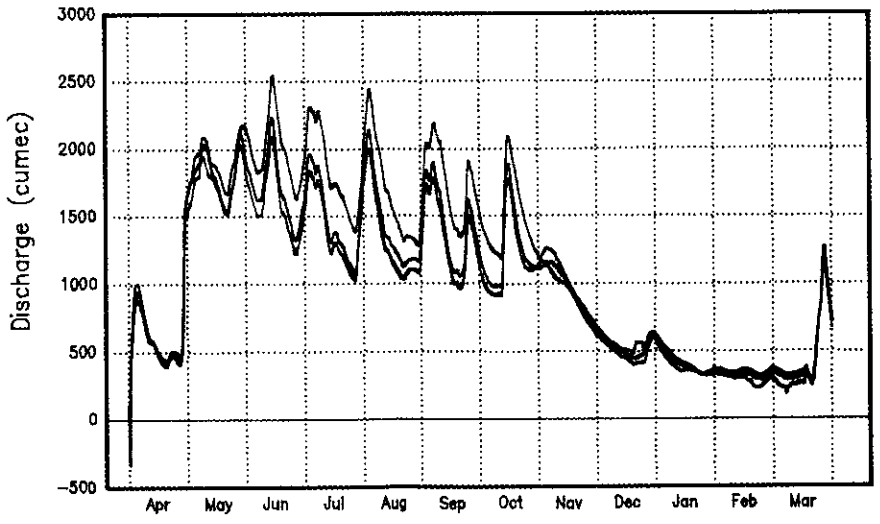
WATER LEVELS AT JARIA JANJAIL



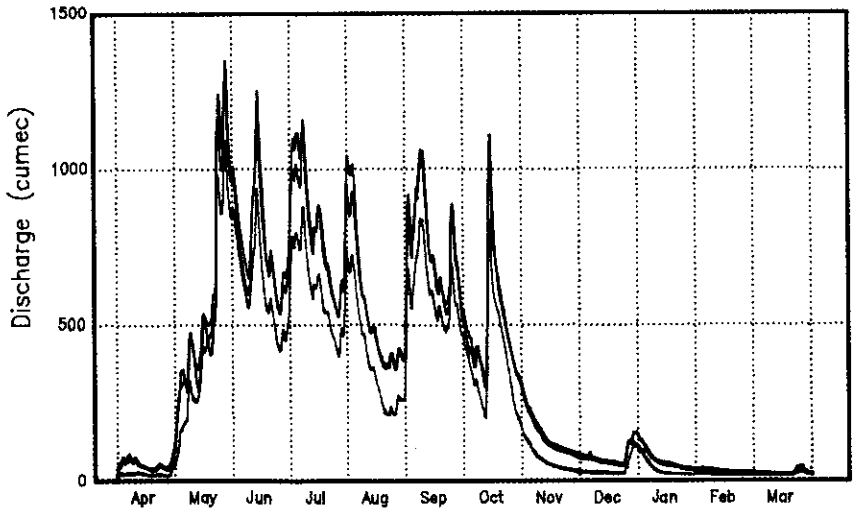
DISCHARGES AT KANAIGHAT



DISCHARGES AT SUKDEVPUR



DISCHARGES AT JARIA JANJAIL



LEGEND

EXISTING CONDITIONS

FUTURE WITH NO INTERVENTION

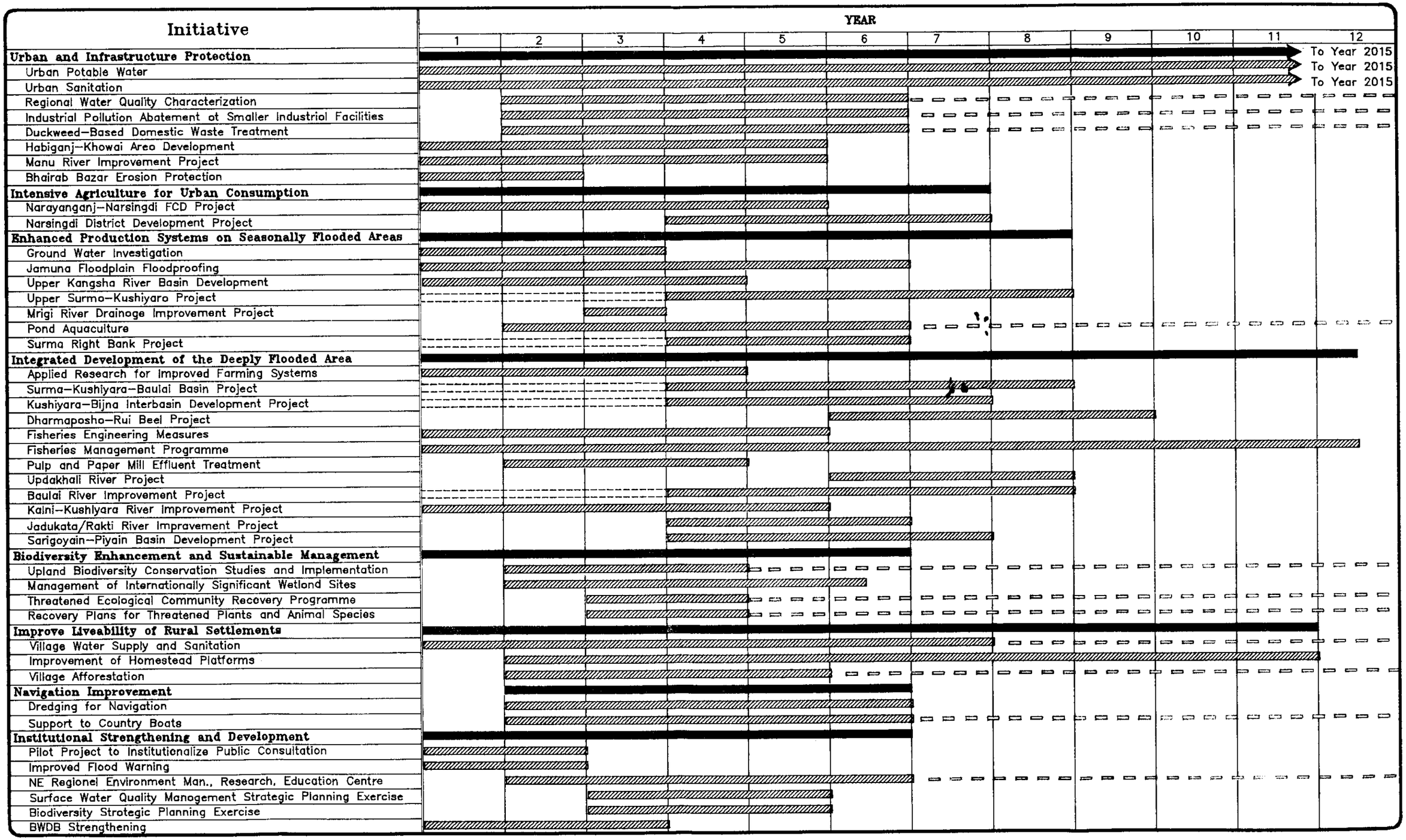
FUTURE WITH REGIONAL DEVELOPMENT PLAN

Existing and Future
Water Levels and Discharges

Northeast Regional Project

NORTHEAST REGIONAL PLAN SCHEDULE

Figure 22



Note: Work schedules include feasibility study, design, and implementation

LEGEND: Strategic Thrust; Initiative; Strating date subject to resolution of Tipaimukh dam implementation; Ongoing need for action, possibly by public participation/private sector and not requiring outside funding

NORTHEAST REGIONAL PLAN–CAPITAL DISBURSEMENT SCHEDULE

Figure 23

Initiative	Capital Cost (US $ Millian)	YEAR 1	2	3	4	5	6	7	8	9	10	11	12
Urban and Infrastructure Protection													To Year 2015
Urban Potable Water	232.00	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	To Year 2015
Urban Sanitation	150.00	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	To Year 2015
Regianal Water Quality Characterization	0.70		0.14	0.14	0.14	0.14	0.14						
Industrial Pollution Abatement at Smaller Industrial Facilities	0.30		.006	0.06	0.06	0.06	0.06						
Duckweed–Based Domestic Waste Treatment	1.00		0.20	0.20	0.20	0.20	0.20						
Habiganj–Khowai Area Development	15.23	1.22	4.72	5.03	3.35	0.91							
Manu River Improvement Project	22.24	2.00	2.45	5.78	7.78	4.23							
Bhairab Bazar Erosian Protection	15.80	7.11	8.69										
Intensive Agriculture for Urban Consumption													
Narayanganj–Narsingdi FCD Project	15.16	0.61	1.67	4.55	4.24	4.24							
Narsingdi District Development Project	3.72				0.48	0.89	1.56	0.78					
Enhanced Production Systems on Seasonally Flooded Areas													
Ground Water Investigation	0.90	0.27	0.27	0.36									
Jamuna Flaodplain Floodproofing	5.00	0.75	0.85	0.85	0.85	0.85	0.85						
Upper Kangsha River Basin Development	21.44	6.43	5.36	5.36	4.29								
Upper Surma–Kushiyara Project	22.21				1.11	5.55	6.66	5.77	3.11				
Mrigi River Drainage Improvement Project	1.36			1.36									
Pond Aquaculture	2.50		0.68	0.50	0.50	0.50	0.33						
Surma Right Bank Project	1.74				0.17	0.80	0.77						
Integrated Development of the Deeply Flooded Area													
Applied Research for Improved Farming Systems	0.80	0.24	0.18	0.18	0.19								
Surma–Kushiyara–Baulai Basin Project	36.79				1.84	9.20	11.77	10.30	3.68				
Kushiyara–Bijna Interbasin Development Project	9.61				0.48	2.69	3.65	2.79					
Dharmapasha–Rui Beel Project	3.40						0.31	0.99	1.22	0.85			
Fisheries Engineering Measures	8.09	1.78	0.40	0.24	2.43	3.24							
Fisheries Management Programme	32.00	2.88	2.55	1.60	3.85	4.48	4.48	4.16	1.60	1.60	1.60	1.60	1.60
Pulp and Paper Mill Effluent Treatment	2.00		0.60	0.80	0.60								
Updakhali River Project	2.06						0.43	0.64	1.01				
Baulai River Improvement Project	39.00				5.85	5.85	11.70	11.70	3.90				
Kalni–Kushiyara River Improvement Project	39.56	1.19	0.79	11.47	15.43	10.68							
Jadukata/Rakti River Improvement Project	7.25				0.94	2.61	3.70						
Sarigoyain–Piyain Basin Development Project	6.4				0.51	1.92	3.20	0.77					
Biodiversity Enhancement and Sustainable Management													
Upland Biodiversity Conservation Studies and Implementation	0.50		0.15	0.20	0.15								
Management of Internationally Significant Wetland Sites	3.00		0.60	0.60	0.60	0.60	0.60						
Threatened Ecological Community Recovery Programme	2.00			1.00	1.00								
Recovery Plans for Threatened Plants and Animal Species	0.40			0.20	0.20								
Improve Liveability of Rural Settlements													
Village Water Supply and Sanitation	64.50	10.32	9.03	9.03	9.03	9.03	9.03	9.03					
Improvement of Homestead Platforms	158.10		15.81	15.81	15.81	15.81	15.81	15.81	15.81	15.81	15.81	15.81	
Village Afforestation	4.00		1.00	1.00	1.00	1.00	1.00						
Navigation Improvement													
Dredging for Navigation	14.90		2.98	2.98	2.98	2.98	2.98						
Suppart to Country Baats	10.00		2.00	2.00	2.00	2.00	2.00						
Institutional Strengthening and Development													
Pilot Project to Institutionalize Public Consultation	0.50	0.25	0.25										
Impraved Flood Warning	2.66	1.33	1.33										
NE Regionel Environment Man., Research, Education Centre	0.70		0.14	0.14	0.14	0.14	0.14						
Surface Water Quality Management Strategic Planning Exercise	0.30			0.08	0.15	0.08							
Biodiversity Strategic Planning Exercise	0.30			0.08	0.15	0.08							
BWDB Strengthening	0.25	0.10	0.80	0.08									
Total	**960.37**	**55.58**	**82.09**	**90.77**	**107.61**	**109.86**	**99.47**	**81.84**	**49.43**	**37.36**	**36.51**	**38.51**	**20.70**

Note: Disbursement schedules include fesibility study, design, and implementation costs

NORTHEAST REGIONAL PLAN–QUANTIFIABLE INDICATORS AND IMPACTS, FCD PROJECTS

Figure 24

STRATEGIC THRUST	PRIORITY				PROJECT	PROJECT TYPE/OBJECTIVES									MEASURES		PLANNING SUBREGION						REPORT/STATUS				AGENCY				COST US$M
	N	SI	SID	SED		Improve regional drainage	Flood control		Improve local drainage	Improve biological resource management	Water quality, supply, sanitation	Erosion protection, flood proofing& warning	Improve navigation	Improve institutions	Structural	Non-structural	Peri-Urban	Tripura Piedmont	Western Seasonally Flooded	Eastern Seasonally Flooded	Meghalaya Alluvial Fans	Central Basin/ Deeply Flooded	PFS	NEMREP	FEVDEP	Other NERP & Non-NERP	BWDB	MOEF	UDNPIHCEEF	Other	
							Full	Partial																							
1. Urban and Infrastructure Protection and Improvement	X				Urban Potable Water						X				X	X	X	X	X	X						DPHE			X		232
	X				Urban Sanitation						X				X	X	X	X	X	X						DPHE UNICEF			X	NGOs	150
	X				Regional Water Quality Characterization						X					X	X	X	X	X	X	X		X				X	X	Muni Corps	0.7
	X				Pollution Abatement, Smaller Industrial Facilities						X					X	X	X	X	X				X				X		NGOs	0.3
	X				Duckweed-Based Wastewater Treatment						X					X	X	X	X	X				X				X	X	Muni Corps	11.0
		X			Habiganj-Khowai Area Development		X	X	X						X	X		X					X				X				15.2
		X			Manu River Improvement Project		X								X			X					X				X				22.2
		X			Bhairab Bazar Erosion Protection							X			X				X					X			FAP 9B	X				15.8
2. Intensive Agriculture for Urban Consumption		X			Narayanganj-Narsingdi Project		X		X						X		X						X				X				15.2
			X		Narsingdi District Development		X		X						X		X						X				X				3.7
3. Enhanced Production Systems on Seasonally Flooded Areas	X				Ground Water Investigation					X					X	X	X	X	X	X	X	X				Ground Water Specialist Study	X	X			0.9
	X				Jamuna Floodplain Floodproofing							X			X	X			X							FAP	X			NGOs	5.0
		X			Upper Kangsha River Basin Development		X		X						X				X				X				X				21.4
				X	Upper Surma-Kushiyara Project		X	X	X						X					X			X				X				22.2
			X		Mrigi River Drainage Improvement				X						X				X				X				X				1.4
	X				Pond Aquaculture					X				X	X	X	X	X	X		X		X							DOF NGOs	2.5
				X	Surma Right Bank Project		X	X	X						X					X			X				X				1.7

NORTHEAST REGIONAL PLAN–QUANTIFIABLE INDICATORS AND IMPACTS, FCD PROJECTS

Figure 24 (continued)

STRATEGIC THRUST	PRIORITY				PROJECT	PROJECT TYPE/OBJECTIVES									MEASURES		PLANNING SUBREGION						REPORT/STATUS				AGENCY				COST US$M
	N	SI	SID	SED		Improve regional drainage	Flood control		Improve local drainage	Improve biological resource management	Water quality, supply, sanitation	Erosion protection, flood proofing & warning	Improve navigation	Improve institutions	Structural	Non-structural	Peri-Urban	Tripura Piedmont	Western Seasonally Flooded	Eastern Seasonally Flooded	Meghalaya Alluvial Fans	Central Basin/ Deeply Flooded	PFS	NEMREP	FEVDEP	Other NERP & Non-NERP	BWDB	MOEF	UNDP/ICEF	Other	
							Full	Partial																							
4. Integrated Development of the Deeply Flooded Area	X				Applied Research for Improved Farming					X				X		X						X	X				X			BRRI	0.8
				X	Surma-Kushiyara-Baulai	X		X	X						X					X		X	X				X				36.8
				X	Kushiyara-Bijna Interbasin Development		X	X	X						X							X	X				X				9.6
			X		Dharmapasha-Rui Beel Project			X	X						X							X	X				X				3.4
		X			Fisheries Engineering Measures					X					X							X	X				X			DOF	8.1
	X				Fisheries Management Programme					X				X	X	X						X	X							DOF	32.0
	X				Pulp and Paper Mill Effluent Treatment									X	X	X						X		X				X		BCIC	2.0
			X		Updakhali River Project			X							X							X	X				X				2.1
		X			Baulai River Improvement Project	X							X		X							X	X				X			BIWTA	39.6
		X			Kalni-Kushiyara River Improvement	X							X		X							X	X				X			BIWTA	39.6
			X		Jadukata-Rakti River Improvement	X							X		X						X		X				X			BIWTA	7.3
			X		Sarigoyain-Piyain Basin Development		X	X	X						X						X		X				X				6.4
5. Biodiversity Enhancement and Sustainable Management	X				Upland Biodiversity Conservation					X						X		X			X			X				X			0.5
	X				Locally-Based Management of Key Wetland Sites					X				X		X		X		X	X	X		X				X		NACOM	3.0
	X				Threatened Ecological Communities Recovery					X						X		X		X	X	X		X				X		NACOM	2.0
	X				Threatened Species Recovery					X						X		X		X	X	X		X				X		NACOM INGOs	0.4

NORTHEAST REGIONAL PLAN–QUANTIFIABLE INDICATORS AND IMPACTS, FCD PROJECTS

Figure 24 (continued)

STRATEGIC THRUST	PRIORITY				PROJECT	PROJECT TYPE/OBJECTIVES									MEASURES		PLANNING SUBREGION						REPORT/STATUS				AGENCY				COST US$M
	N	SI	SID	SED		Improve regional drainage	Flood control: Full	Flood control: Partial	Improve local drainage	Improve biological resource management	Water quality, supply, sanitation	Erosion protection, flood proofing & warning	Improve navigation	Improve institutions	Structural	Non-structural	Peri-Urban	Tripura Piedmont	Western Seasonally Flooded	Eastern Seasonally Flooded	Meghalaya Alluvial Fans	Central Basin/ Deeply Flooded	PFS	NEMREP	FEVDEP	Other NERP & Non-NERP	BWDB	MOEF	UNDP/HCEEF	Other	
6. Improved Liveability of Rural Settlements	X				Village Water Supply						X				X	X			X	X		X			X	DPHE			X	NGOs	64.5
		X			Improvement of Homestead Platforms							X		X	X	X			X	X		X			X					NGOs	169.7
	X				Village Afforestation					X		X		X	X	X			X	X		X			X					NGOs	4.0
7. Navigation Improvement			X		Dredging for Navigation								X		X	X										Water Transport Study				BIWTA	14.9
			X		Support to Country Boats								X		X	X										Water Transport Study				BIWTA	80.0
8. Institutional Strengthening and Development	X				Institutionalize Public Consultation									X		X											X			NERP	0.5
		X			Improved Flood Warning							X			X	X		X			X		X				X				4.7
	X				Northeast Region Environment Management, Research, and Education Centre					X				X		X									X			X			NGOs	0.7
	X				Surface Water Quality Management Strategic Planning Exercise						X			X		X									X			X			NGOs BCIC BCS Muni Corps	0.3
	X				Biodiversity Strategic Planning Exercise					X				X		X									X			X			NGOs	0.3
	X				BWDB Strengthening									X		X										Training Plan	X					0.3

TOTAL: 1,054.7