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)

DRAFT I

REGIONAL PLAN CONSIDERATIONS

August 1992

Shawinigan Lavalin (1991) Inc.
Northwest Hydraulic Consultants

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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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
BWDB	Bangladesh Water Development Board
CBM	Community Based Management
CIDA	Canadian International Development Agency
cm	centimetre
GDP	Gross Domestic Product
GNP	Gross National Product
GWH	gigawatt hours
km	kilometre
m	metre
MPO	Master Plan Organization
MW	megawatt
NERP	Northeast Regional Water Management Project
BPDB	Bangladesh Power Development Board
USAID	US Agency for International Development
WARPO	Water Resources Planning Organization (formerly the Master Planning Organization)

TABLE OF CONTENTS

1. INTRODUCTION

The Flood Action Plan for Bangladesh is the first stage in the development of a long-term plan for flood control, drainage and river management. It is comprised of a phased programme of flood control activities, supported by special studies, surveys and pilot projects. A full list of the various components of the Flood Action Plan is included as Annex A to this report.

The Northeast Regional Water Management Project 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."

This document, the output of the Consolidate Parameters work element of the Project work plan, summarizes information gathered by the Northeast Regional Project team to date, into a broad perspective of the region. This will provide the foundation upon which the regional water management plan -- a development strategy and a prioritized portfolio of policies, programs, and projects -- can be constructed.

The planning process being followed is to address, on and iterative basis, the subjects of: objectives, objectives criteria, intervention principles, policies, programmes, and projects. Because the process is iterative, the starting point or the order in which the subjects are addressed is not important, and usually represents a matter of personal preference. The process is iterative because development planning requires knowledge of projects, and project planning requires knowledge of the development plan. "Inadequate plans are first formulated using inadequate methods of project appraisal. These in turn should permit improvements in project analysis and appraisals, and so on. By such iteration and reiteration, one gradually tries to come near to optimum planning."[1/]

The major focus of the development plan will be a sustainable development. The concept of sustainable development provides a framework for integrating economic, social, environmental, cultural and political aspects in the planning process. It requires explicit recognition of the various development objectives, and their relationships with each other. The analysis therefore requires a multi-criteria approach in evaluating strategies and projects, without the benefit of standard units of measurement or comparison. The analysis does not identify a "best" strategy

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1/ I. Little, *Project Analysis in Relation to Planning in a Mixed Economy*, OECD Development Centre, 1967)

or project; rather, it concentrates on bringing together the various positive and negative impacts of alternative courses of action, as an aid to decision making.

Chapter 2 summarizes relevant national policies which impact on the formulation of a regional water management plan. Chapter 3 provides a multi-disciplinary profile of the region, and Chapter 4 provides a summary analysis of the region as it is currently understood highlighting the major issues and constraints. The next step in the planning process will be to start defining development objectives and evaluating political development initiatives.

2. THE PLANNING CONTEXT

2.1 National Development Strategy

There has been a substantial amount of work carried out over the past several months on the 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 has drawn up a vision for the future development of the country, known as the "New Development Perspective". The Fourth five Year Plan (1990-95) has been re-examined and adjusted accordingly, and several changes in the development approach are being formulated into policies.

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.

[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.

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."

The goals of the New Development Perspective are:

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

Table 2.1: National Development Targets

Item	Now	Target
GDP growth	3.8	5.0 % per year
Agriculture & fisheries growth	2.3	3.6 % per year
Industrial growth	5.7	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 % per year

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:

- 5 percent growth rate in GDP (up from the present 3.8% percent). "It has to be at least 5 percent and even higher in the near future."
- 3.6 percent growth rate in agriculture and fisheries (up from the present 2.3 percent). It "...has to grow at about 3.6 percent 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 9-10 percent (up from 5.7 percent) including appropriate growth in agro-business and linkage of agriculture with industry; "...a resultant growth rate of about 9-10 percent per year in the industries sector is possible."
- increase domestic investment to 20% of GDP (up from 11-12%).
- increase domestic savings to 10-12% of GDP (up from 3-4%)

- "...generation of productive employment particularly to meet the basic needs of the lower 50 percent 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 percent of the population).

- "...greater investments in social sectors." (unspecified, but up from the present 20 percent of development expenditures, 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).

National Development Strategy

Specific strategies towards achieving the national goals and objectives include:

- 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 an adequate budget allocation to the socio-economic 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.

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

- Maximizing inter-sectoral 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...".

Table 2.2: National Strategies

Adequate allocation to socio-economic sectors
Participatory planning
Development of the rural economy
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
Decentralized participatory planning

> "...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, i.e. 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, i.e. as opposed to the "trickle down" assumptions.

- combining government programmes with private investment, particularly in the delivery of social services, eg. 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).

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 2.3.

Government established "Eleven Guiding Principles" to provide a broad framework for the physical works and measures to improve preparedness and management of floods (Table 2.4).

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.

Table 2.3: FAP Objectives

Safeguard lives and livelihoods
Improve agro-ecological 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

1/ Guidelines For Project Assessment, Flood Plan Coordination Organization, Ministry of Irrigation Water Development and Flood Control, Dhaka, May 1992.

Table 2.4: 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. REGIONAL PROFILE

3.1 Regional Setting

Bangladesh is the site of the world's largest delta (143,000 km^2), formed by the Ganges, Brahmaputra, Padma and Meghna Rivers and the world's largest submarine fan which extends more than 2,000 km into the Bay of Bengal (Johnson and Alam, 1991). It is also one of the most densely populated countries in the world with a population density of 728 persons per square kilometre.

The Northeast Region of Bangladesh encompasses 2.4 million hectares of land. The topography is irregular, falling from the piedmont hills near India across gently sloping plains to the Sylhet Depression near the geographic centre of the region (Figure 3.1). Interfluvial depressions called *haors* are dominant features of the region. Within the region, population densities vary from about 460 persons per square kilometre in the district of Sunamganj, to about 2290 in the district of Narayanganj. The population growth rate, while it has been declining in recent years, has averaged an estimated 1.8% per year over the past 10 years.

The eastern part of what is now the Northeast Region was once under the Kingdom of Jaintia whose rulers came from China and were the ancestors of the Khasi people. The kingdom, which had its capital in the northern hill areas, survived for many centuries and not even the Mughals who occupied Sylhet town at the beginning of the 17th century were able to overthrow it.

A Muslim invasion led by Shah Jalal in 1302 destroyed the Gaur kingdom, which had been under Jaintia, and established the first Islamic rule in the Northeast Region. Meanwhile, the Laur kingdom to the west continued to be ruled by Hindu kings. The capital of Laur in the 15th century was Nabagram, situated in Tahirpur upazila of Sunamgonj district. The Laur kingdom was conquered in the 16th century by one Habib Khan from Baniyachong, a descendant of a Hindu zamindar, who had converted to Islam. In the 17th century, the Sylhet region was invaded by Afghan warriors who were finally ousted after heavy fighting with the Mughals. The Mughal rule continued until 1765 when power passed on to the British East India Company and William Thackeray became the first British officer to be posted in the district. In 1874, Sylhet became part of Assam province in spite of protests from the Sylhetis who linguistically and culturally had more in common with Bengal than Assam. Except for some years in the beginning of this century, Sylhet remained part of Assam province until Partition in 1947. A referendum was held at the time to decide whether Sylhet should join Pakistan or not. The Muslim population then represented a little over 60% of the total and the Sylhetis opted for Pakistan with a very small majority.

The western part of the northeast region was formally attached to the Mughal Empire in 1612 and remained so until the British East India Company obtained the effective control of land revenue in 1765. However, in the northern side of the district, local Chiefs called the Baro Bhuiyas who belong to the Koch, Mech, Garo, Kachari and Bhot tribes, maintained a large degree of independence from the rival Sultanates which competed for Bengal. Throughout this period local Hindu and Muslim zamindars are said to have held considerable power.

During the 20th century, there was considerable migration of landless peasants from Jamalpur to Assam and from the high lands of Mymensingh, Netrakona and Kishorgonj to the low land of the Sylhet Basin. This expanse of deeply flooded land was very sparsely populated, mainly by Hindu's who were agriculturists and fishermen.

3.2 Geology and Geomorphology

Most of Bangladesh has developed by a process of ongoing deltaic sedimentation into a slowly subsiding tectonic basin (the Bengal Basin). Thus, two important geological processes have shaped the landforms in the Northeast Region -- tectonics and fluvial sedimentation.

Bangladesh has evolved since Cretaceous times when the northward moving Indian Plate and the stationary Eurasian Plate collided (Fig. 3.2). During Oligocene times (38 -26 million years ago) a portion of northeastern India fractured and sank below sea level. This portion was eventually covered with the sediments which form the Bengal Basin.

The Sylhet Basin, which underlies most of the Region, is a sub-basin of the Bengal Basin and consists of alluvial and deltaic sediments (13 - 20 km thick) underlain by much older gneiss and granitic rocks. The basin is bounded by the Shillong Plateau on the north, by the Indian-Burman ranges on the east and southeast and by the Indian Shield to the west. Rapid subsidence has occurred in the basin since Miocene times (22 million years ago) as a result of westward encroachment of the Indo-Burman ranges to the east and overthrusting of the Shillong Plateau to the north (Johnson and Alam, 1991). These tectonic processes continue today and are expressed in terms of three important features:

- Ongoing subsidence throughout much of the Sylhet basin. The region is considered to be experiencing some of the greatest subsidence rates in Bangladesh (in the order of 2 m/century);

- Active faulting, tilting and uplifting of Quaternary, Pleistocene and Holocene sediments in the region;

- Occurrences of devastating earthquakes, particularly in 1762, 1885, 1897 and 1918. Besides causing structural damage and loss of life, these events also contributed to long-term river instability as a result of bank collapse and increased sediment supply from mass wasting.

Most of the landforms in the Northeast Region are derived from alluvial sediments deposited in the Holocene time, roughly the last 10,000 years. Older Pleistocene deposits such as the Madhupur Tract outcrop as isolated, elevated blocks which stand above the level of the more recent floodplain deposits.

The Northeast Region is covered by an intricate maze of ancient paleo-channels which attests to the past history of channel shifting throughout the region. The most prominent ancient channels are associated with former courses of the Brahmaputra River. It appears that the most eastern extent of the Brahmaputra reached to about the vicinity of Shanir Haor, where it turned

southward towards its delta. Other channel scars indicate the river has gradually swung to the west over time.

The last major shift of the Brahmaputra occurred between 1780-1830 when the river turned south down the Jhenai and Konai Rivers and developed its present braided Jamuna channel on the west side of the Madhupur Tract. The Old Brahmaputra River, which forms the western border of the northeast region is the relic of this event.

The evolution of the Kushiyara River over the last 200 years from a minor distributary of the Sonai Bardal channel to its present course as the main distributary of the Barak River is another important historic channel change. Ongoing channel erosion and widening along portions of the Kushiyara continue to this day as a result of this event. By comparison, the upper reach of the Surma River has remained virtually static over the last two centuries.

Over the last 20 - 40 years two notable channel changes have occurred in the Northeast Region:

- Abandonment of the Surma River channel below Chattak and westward diversion of the Surma into the Baulai/Kalni River system; and,

- Infilling of the Bibyana River below Sherpur and subsequent diversion of the Kushiyara into the Suriya River;

In addition, there has been considerable instability of distributary channels on the lower reaches of the alluvial fans along the Meghalaya Plateau. The incidence of major avulsions on the fans seem to be surprisingly rare given the apparent large sediment loads that are being carried by these streams. Furthermore, the avulsions (such as the shift on the Dhalai River near Companiganj) seem to develop over a period of several years rather than during a single flood event. This provides an opportunity to diagnose future channel changes and if necessary, construct river training works to possibly prevent the change from occurring.

Preliminary studies using sediment observations on the Kushiyara River indicate that annual sediment inflows were substantially higher during the period between 1978 - 1990 than in the previous period between 1964 - 1977. However, the main factor contributing to the apparent increase in sediment loads was due to increased runoff during the last 12 years, not changes to the basin's sediment supply.

Furthermore, there is no evidence of systematic increases in water levels from channel aggradation along the Surma, Kushiyara, Khowai or Manu Rivers. In fact, comparison of stage-discharge rating curves indicates that the water levels have been lowering slightly over the last 25 years at most hydrometric stations. Therefore, the commonly held assumption that sedimentation is raising water levels throughout the region is probably incorrect.

Sediment aggradation is occurring along the alluvial fans bordering the Meghalaya Plateau and in haors and flood basins on the distal margins of these fans. Sediment aggradation also appears to be occurring along the lower reaches of some main stem channels such as the Barak

(lower Kushiyara) and Kalni River. This aggradation is probably governed by the decrease in slope that occurs along these rivers and by the backwater from the Meghna River.

3.3 Hydrology

The Northeast Region comprises an area of 24 thousand km^2 almost all of which is devoted to agriculture. It consists of two portions, the larger comprising 20,261 km^2, or 83.5% of the Region, lying within the Meghna River basin. The smaller portion comprising 4,004 km^2, or 16.5% of the Region, lies on the left bank of the Old Brahmaputra/Lakhya River.

Although the two portions of the Region experience essentially the same climate and are similar geologically, they differ significantly in the number and nature of their cross-boundary inflows. The Meghna portion receives many flashy inflows from the adjacent Indian states of Tripura, which lies south of the Region, and Meghalaya to the north. It also receives the substantial outflow of the Barak River basin which lies to the east and occupies parts of the Indian states of Assam, Mizoram and Manipur. In contrast, the Old Brahmaputra/Lakhya portion receives only flood waters spilling into the Old Brahmaputra from the Jamuna Brahmaputra River.

Characteristically, the Northeast Region is flood-affected during the wet season, and drought-affected in the dry season. Wet season flooding involves inundation of about two-thirds of the Region which is mostly located in the central part of the Meghna portion where the depth of inundation ranges up to about 6 metres in the lowest-lying areas. Drainage of this flood water after the wet season ends typically takes up to 3 months and seriously delays planting of the dry season rice crop. The dry season drought is sufficiently severe that irrigation is generally required. Irrigation water is obtained in some areas from wells, but mostly it is pumped directly from rivers or from pools of retained drainage water.

Climate

The Northeast Region has a typical monsoon climate characterised by the twice-yearly reversal of air movement over the Region. For about four months in winter (December through March) air flows to the region from the northeast, while for about four months in summer (June through September) it flows to the region from the southwest. These air flows, or winds, are called "*monsoons*", that of winter being the "*northeast monsoon*" while that of summer is the "*southwest monsoon*". A reversal of the *monsoons* takes about two months, the first occurring in spring (April-May) when the change of wind direction is from northeast to southwest via northwest, and the second occurring in autumn (October-November) when the change is from southwest to northeast via southeast. These periods of changing wind direction may be called "the spring reversal" and "the autumn reversal".

The *southwest monsoon* brings moist air into the region from the Bay of Bengal and rainfall in this season is so abundant that it is often referred as "the *monsoon*", meaning the rainy season. Typically, the rainfall in this season increases northwards across the region and reaches a maximum on the southward - facing slopes of the Shillong Plateau in Meghalaya; Cherrapunji, on these slopes, is well-known as the wettest place on Earth, its mean annual rainfall being over

12 metres. Across the Northeast Region the rainfall ranges from around 2 metres in the south to around 6 metres at the border with Meghalaya. In contrast, the northeast monsoon brings dry air into the region from China and rainfall in this season is essentially zero. The spring reversal is characterized by increasing sporadic rainfall, and the autumn reversal by decreasing sporadic rainfall, except when major weather disturbances are present and give heavier rainfall than is usual.

Not surprisingly, agricultural activity is closely linked to the monsoon periods, Rabi crops (mainly *boro* rice) being cultivated with irrigation during the northeast monsoon, while Kharif crops (almost exclusively rice) are grown during the southwest monsoon when rainfall is abundant.

During the northeast and southwest monsoon periods weather conditions, although quite different in the two periods, are rarely severe. Thus, during the northeast monsoon most days are sunny and dry with temperatures ranging from their seasonal minimum in December-January to their seasonal maximum in April/May, while during the southwest monsoon the days are mostly cloudy and rainy with intermediate and stable temperatures. In contrast, during the spring and autumn reversals severe weather conditions can arise and are mainly responsible for the occurrence of disasters. These severe weather conditions are basically of two types: line squalls, known locally as "nor-westers" or "*kalbaishakhi*", and cyclones, known locally as "typhoons" or "*tufan*".

Nor-westers are particularly prevalent during the spring reversal although they may also occur during the northeast monsoon as on 28 January 1992. Nor-westers are caused by outbreaks of cold air from Central Asia, and occur at the interface between the advancing cold air and the warm air already present in the region. The temperature difference across the interface is large enough to generate large-scale turbulence which, in turn, generates thunderstorms along the interface. High winds, even tornadoes, thunder and lightning, and rain and hail, mark the passage of a nor-wester which typically lasts for an hour or two. Several tornadoes were experienced in the spring of 1992 in the vicinities of Mymensingh and Brahmanbaria where they caused localized but severe damage. The usual high winds and hail frequently damage standing crops and homesteads over wider areas. More widespread, however, is the damage to crops, both standing and harvested, caused by the flash floods generated by the intense rainfall associated with nor-westers. Such flooding is particularly prevalent during the spring reversal when the most important crop, *boro* rice, is either still standing in the fields or under harvest. To protect the *boro* crops from this flooding, embankments have been constructed around many agricultural lands (*haors*) in the Northeast Region; these are intended to keep the flash floods off the land at least until 15 May, by which time the crops have mostly been harvested.

Typhoons can occur during both the spring and autumn reversals of the monsoon, and with more or less equal severity in both seasons. Their occurrences over Bangladesh in spring is particularly noteworthy as in most other monsoon climates it is restricted to the autumn reversal. The typhoon which struck Bangladesh on 29 April 1991 was a particularly severe example of a spring typhoon. It is noteworthy, however, that the effects of this typhoon on the Northeast Region were not nearly as severe as in the southern parts of the country. This was due to the fact that the moisture supply which fuels a typhoon is cut off as soon as it moves over land. The

Northeast Region, being some 300 km inland is thus spared the full force of typhoons; it lies beyond the zone of their maximum devastation.

Surface Waters

The principal rivers of the Meghna portion of the Northeast Region are the Surma and Kushiyara rivers which drain the eastern part of the Region westwards, the Kangsha which drains the western part eastwards, and the Kalni and Baulai which drain the central part southwards, collect the flows of the fore-mentioned rivers, and discharge into the Meghna estuary a short distance upstream of Bhairab Bazar. Many other channels, both natural and man-made, interconnect these rivers making the drainage pattern of the Region very complex (Fig. 3.3). Characteristically, some of these channels are occasionally abandoned while new ones develop; some of them carry flow only in the wet season while others can carry flow in either direction depending on water levels prevailing in the main rivers they connect.

The principal river of the Old Brahmaputra portion of the Region is the Old Brahmaputra itself and its main distributary, the Lakhya which carries most of the flow in the downstream reaches. The downstream reach of the Old Brahmaputra, below the Lakhya offtake, has been largely abandoned and carries flow only when the Old Brahmaputra is in flood. Both these downstream distributaries split up into numerous minor distributaries as they approach the Meghna estuary. The only significant tributary of the Old Brahmaputra is the Banar which enters the Lakhya reach from the North Central Region. The main source of flow into the Old Brahmaputra/Lakhya is the Jamuna-Brahmaputra which spills into the Old Brahmaputra just upstream of Bahadurabad.

Old mapping indicates several channels interconnecting the Old Brahmaputra and the Meghna portions of the Region, but the information is that these were closed off by closure dams built by local authorities in the past two decades. While the two portions of the Region appear to be hydraulically independent of each other at present, future developments may involve controlled re-opening of these interconnecting channels.

Virtually all highlands, within which flood control dams could be constructed, lie in the Indian territories adjacent to the Meghna portion of the Region. The river catchments in these highlands fall into three groups (Fig.3.4):

- Tripura river catchments which discharge northwards into the Kushiyara and Kalni rivers, and drain an area of 6845 km^2 within the state.

- Meghalaya river catchments which discharge southwards into the Kangsha and Surma rivers, and drain 13466 km^2 within this state.

- The Barak River basin which drains 25263 km^2 in the states of Assam, Manipur and Mizoram, and which discharges westwards into the Surma and Kushiyara rivers at Amalshid on the Indo-Bangladesh border.

As shown by the water balance study mentioned below these Indian catchment areas produce, on average, 60.5 percent of the total water supply of the Northeast Region, mostly in the form of

flash floods in the wet season, say April to September. The flash floods from Meghalaya are particularly ferocious, and cause many problems for agriculture in April and May.

Between the many river channels of the Region are interfluvial areas called *haors* which consist of dish-shaped depressions within a perimeter consisting of river levees. Typically, the levees reach elevations of 6 to 8 metres above the haor centre. Static water bodies, known as *bils*, are found at the centre of virtually every *haor* in the dry season. These *bils* are in contact with the ground water in the underlying sediments; where the ground water table remains above ground level in the dry season the *bils* are permanent, but where it falls below ground level the *bils* are seasonal. In many cases the *bils* are connected to nearby rivers by stream channels, known as *khals*, but in numerous other cases they are isolated from the river system. In the wet season, river floods overtop the levees, and back up the *khals*, until the entire *haor* is under water. At the peak of the monsoon season only the highest segments of the levees, on which the villages are mainly built, remain above water. As seen from the air in this season the central part of the Meghna portion of the Region is one lake, the perimeter of which runs roughly through Bhairab Bazar, Kishoreganj, Sunamganj, Sylhet, Moulvi Bazar, Habiganj, and back to Bhairab Bazar. An impression of the extent of inundation in the Region can be gained from Fig. 3.5.

The *haors* comprise an important part of the agricultural land of the Region, and their inundation severely constrains the agriculture. In many *haors* crops can be grown only in the dry season, and even these are subject to damage by flash flooding in the pre-monsoon season, i.e during the spring reversal of the monsoon. To protect these crops from flooding many of the *haors* levees have been embanked to provide protection from flooding up to 15 May (submersible embankments) or even year round (full embankments). Unless, however, regulators are installed on all of a *haor's khals* these embankments can impede drainage of the haor lands in the autumn, and hence delay planting of the next crop. After planting in the dry season, residual soil moisture can provide crop water requirements for some time but by February it is necessary to irrigate. In the Northeast Region water for irrigation is mostly obtained by pumping from the *bils* using low lift pumps (LLP's), and the haor regulators are usually closed before land drainage is complete so that sufficient water is regained in the *bils* for irrigation.

Ground Waters

The Northeast Region is underlain by a vast thickness of sedimentary deposits containing a huge volume of ground water. While this ground water is being used for potable water supplies, it is also used for irrigation particularly in the western part of the Region where 4000 deep tubewells have been installed over the past decade for this purpose. It is estimated that the total yield from these wells is in the order of 200 m^3/s in the irrigation season. They extend down to depths of about 100 m, but there are many other shallower wells in the Region.

The relative success of the deep tube wells in the western part of the Region is due, however, to the relatively high transmissivities of the sediments in that area. Eastwards from this area the transmissivities decrease to about half, or even a tenth, of the values found in the west. Furthermore, the sediments thin eastwards and are underlain by the submerged portions of the

20

plunging anticlines which enter the Region from Tripura, and may serve to impede ground water movement. While relatively little is known of the hydrogeological conditions in the central and eastern parts of the Region, and these should be investigated more extensively.

The Water Balance

A water balance study was undertaken using traditional rainfall-runoff studies to check the reliability of the inflows from Tripura and Meghalaya, and to produce more reliable estimates of the flows of the ungauged rivers. The resulting re-estimates of mean flows, when input to the water balance, lead to the conclusion that there is a significant by-passing of the main outflow station on the Meghna River at Bhairab Bazar. Specific findings are as follows:

- The mean flow of the Someswari River is 77% higher than reported by the Durgapur gauging station
- The mean flow of the Piyain River is 21% higher than reported by the Ratnerbhanga gauging station.
- The mean flow of the Juri River is 253% higher than reported by the Juri Railroad Bridge Station, and 11% higher than reported by the Continala gauging station.
- The mean flow of the Khowai River is 7% higher than reported by the Shaistaganj gauging station.

Table 3.1: Water Balance - Meghna Portion of the Region

Summary

	km^3/yr	%
Total Inflow from India	104.9	60.5
Rainfall on Northeast/Meghna	68.4	39.5
Total Water Supply to Northeast/Meghna	173.3	100.0
Total Outflow at Bhairab Bazar	160.7	92.7
Actual Evapotranspiration from Northeast/Meghna	12.6	7.3

Details

Inflow from Tripura	10.2	5.9
Inflow from Meghalaya	62.9	36.3
Inflow from the Barak River Basin	31.8	18.3
Total Inflow from India	**104.9**	**60.5**
Total Outflow from Northeast/Meghna	160.7	92.7
Measured Outflow at Bhairab Bazar	149.0	86.0
Total Flow by-passing Bhairab Bazar	11.7	6.7
Ground Water by-passing Bhairab Bazar	0.7	0.4
Surface Water by-passing Bhairab Bazar	**11.0**	**6.3**
Rainfall on Northeast/Meghna	68.4	39.5
Runoff from Northeast/Meghna	55.8	32.2
Actual Evapotranspiration from Northeast/Meghna	**12.6**	**7.3**

- The mean flow of the Meghna River is 7% higher than reported by the Bhairab Bazar gauging station.

These significant, and in three cases substantial, errors are not due to unreliable gaugings or rating curves, but to flows by-passing the gauging stations. In all five cases it is apparent that the gauging station should be moved upstream of the bifurcation or, if this is not practical, a satellite gauging station should be set up on the by-pass channel. Mean flows for all other gauging stations at the periphery of the Northeast Region were found to be satisfactory and consistent with one another.

The results of the water balance study are summarized in Table 3.1 for the Meghna portion (20,261 km^2) of the Northeast Region. The table includes other useful results, again with percentages of the total water supply.

While much of the water, 39.5%, which affects the Northeast Region originates as rainfall over the region, 60.5% originates from rainfall over the upper portions of the Meghna River basin all of which lie within India. It is imperative, therefore, that water resources management for the Northeast Region takes into account the river flows entering the region from India, and any manipulation of those flows by the Indians.

3.4 Water Resources Development

Attempts to protect the *boro* rice crop from early monsoon flash flooding within the deeply flooded *haors* in the region originated as much as a century ago. The initiative was taken by the then *zamindars* of the respective haors working with *talukdars* (independent land owners) and the zamindar's tenants. For larger scale infrastructure, the *zamindars* organized people to contribute (in payment or in kind) to the construction of embankments or other forms of temporary earthworks to delay the pre-monsoon flooding. For smaller scale work, local cultivators organized themselves to construct earthen dykes across neighbourhood canals through which early flood water entered the agricultural area. It is understood, however, that protection measures were usually provided only for selected segments of the larger haors. Thus, the haors were divided into one or more units depending on land elevation and other criteria (location of levees, beels etc.). The villagers working under the leadership of the *zamindar* or *talukdars* were responsible for protecting the land of their own village.

During this time period, a serious problem was considered to be water stagnating in the haors as a result of inadequate drainage. Drainage was being obstructed because the drainage canals were ingrown with wild grasses, shrubs and jungle. Stories are told that the *zamindars* used their own resources and combined these with those of the local people to re-excavate drainage canals so that post-monsoon drainage was improved.

These locally initiated flood protection activities are thought to have continued until 1950. The *zamindari* system was effectively abolished in the mid fifties and, in the majority of cases, the cultivators became the land owners.

The increasing population brought additional land under cultivation and the land which was cleared and brought under the plough was usually land located in the lower parts of the haor. This land was much more vulnerable to early flooding. The Water and Power Development

Authority was not generally tasked with these early flooding problems. Flood prevention measures continued through the 50's and 60's at the initiative of local people.

When there was a problem and a labour force needed to be organized, the information was circulated by village *choukidars*, through village leaders, by relatives and sometimes through union *parishad* officials. Distant villages within the same haor also maintained information linkages since the status of the floods and the embankments were also of concern to them. These villagers were then also requested to provide construction materials such as bamboo and jute bags.

Farmers did not generally have to pay a cash subscription but were responsible to assist with labour and materials. The villagers usually promised certain animal sacrifices or *pujas* as well on a communal basis for the safe harvest of their crop. Hindus and Muslims both performed such rituals in accordance with their respective practices.

With the independence of Bangladesh, the situation changed. The government mandated the Bangladesh Water Development Board (BWDB) to initiate measures to protect *boro* paddy in the haors from early flooding and BWDB started constructing flood protection infrastructure during the mid-seventies.

Today, people in large areas still rely on local initiatives to protect their crops. It is being observed, however, that the villagers form less cohesive and less responsive communities than in the past. This reduces the effectiveness of their collaborative efforts for reasons which might include:

- The sheer magnitude of the problem which is sometimes unmanageable at the local level;
- An increasing dependency on government agencies; and,
- A lack of confidence or trust among the local villagers.

Current Situation

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 3.2.

A total of 66 major surface water resource projects have either 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 and their potential net benefitted area is estimated to be 395,000 hectares. Nearly all were constructed during the past two decades.

Surface water is used to irrigate an estimated 450,200 hectares within the region. The area irrigated through the private sector (low-lift pumps and traditional methods) accounts for 98% of this total. Ground water is used to irrigate an estimated 211,900 hectares but is mainly concentrated in Sherpur, Mymensingh, Netrokona, Kishoreganj, and Narsingdi districts. Only

5% of the area irrigated by ground water is located in Greater Sylhet District.

In addition, other water requirements are for domestic water supply (estimated in 1991 to be 22.5 Mm^3/month) and industrial supply (estimated in 1990 to be 5.0 Mm^3/month). The Inland Water Transport Authority maintains about 1400 kilometres of classified navigation routes within the region.

Table 3.2: 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

Existing Projects: Performance and Considerations

Flood Control and Drainage Projects[1/]. A moderately high percentage (about 80%) of all projects of this type in the region have some positive impact though the positive impacts do not necessarily include agriculture benefits -- the main purpose for which the projects were originally constructed. Positive non-agricultural impacts include improved fisheries, navigation and transportation.

Negative impacts of these projects are also fairly common and were noted in about half the projects. The most commonly perceived negative impact was related to sedimentation which was causing operating problems in about 25% (16 total) of the major water control projects and were seriously threatening project viability in five cases (NERP, 1991) The location of these problem sites is summarized on Figure 3.6.

Implementation of future flood control and drainage projects must recognize that there is a need:

- for much improved level of direct and effective beneficiary participation in project development, operation and maintenance; and a reversal of the "top-down" approaches;
- to provide for shelter, communications, and industrial areas which are not prone to flood hazard;

[1/] Material presented here is based on a review of the existing projects and is excerpted from the *Draft Thematic Study, Regional Water Resources Development Status*, dated July 1992.

- to preserve fish production and fish species diversity as a counterpoint to a singular focus on increased paddy production;
- to recognize that the agricultural impacts of full flood control measures are uncertain;
- for flood plain storage and the recognition that improving the conveyance capacity of channels (e.g. dredging) may not necessarily improve post-monsoon drainage; and,
- to design flood control and drainage infrastructure which facilitates water management for optimal winter season production from the deeply flooded areas.

Surface Water and Ground Water Irrigation. There is limited potential to expand the area irrigated by surface water during the winter months. Throughout the eastern side of the region, available surface water is largely being exploited at present; within the Sylhet depression, all available land is irrigated and cropped with *boro* rice; and, on the western side, surface water is mainly exploited but there is potential for additional ground water development.

Estimates of ground water recharge vary between 3900 (WARPO) and greater than 5000 (ADB) million cubic metres. Based on the former estimate, an additional 338,000 hectares could be brought under irrigation using ground water (shallow tube wells and deep tube wells). The largest future ground water development potential in the region is with deep tube wells (274,000 hectares).

Future Prospects

Flood Control Versus Flood Protection. Virtually all high land within the Meghna River basin, and within which flood control dams could be built, lies within Indian territory. This means that any possibilities to control floods int he Northeast Region by storing their water behind dams can only be taken up by the Indians. If the Indians do take up any of the several possibilities for flood control dams on their territory there may be significant flood control benefits for the Northeast Region. Such possibilities are known to include dams on the Barak at Tipaimukh, on the Sonai and Dhaleswari tributaries of the Barak, on the Manu is Tripura, and possibly on the Someswari in Meghalaya. The problem with most of these dam projects is that flood control benefits to India will not pay for the project. Consequently, these projects will likely be developed for other purposes such as hydropower, navigation, irrigation, or a combination of these.

The Indian portion of the Meghna river basin comprises an area of 45,574 km^2 and, from the point of view of the Northeast Region, it consists of three distinct zones as recognized in the water balance.

In the tabulation (Table 3.3) the areas are expressed as a percentage of the area of the Meghna river basin above Bhairab Bazar under "A%", and compared to the water they yield expressed as a percentage of the total water supply to the basin under "W%". From these percentages it can be understood that:

- The Barak catchment while comprising the largest portion of the Meghna river basin area (38.4%) yields only 18.3 percent of the total water supply. One may conclude from this that damming the Barak and its tributaries will probably not produce very significant flood control benefits for the Northeast Region

Table 3.3: Catchments in the Region

	km^2	%A	%W
Tripura Catchments	6,845	10.4	5.9
Meghalaya Catchments	13,466	20.4	36.3
The Barak Catchment	25,263	38.4	18.3
Total Catchment Area in India	**45,574**	**69.2**	**60.5**
Northeast/Meghna Catchment	20,261	30.8	39.5
Total Meghna Catchment above Bhairab Bazar	**65,835**	**100.0**	**100.0**

- The Meghalaya catchments while comprising only 20.4 percent of the river basin yield 36.3 percent of the total water supply. One may conclude from this that damming the Meghalaya rivers, if it were possible to do so, would produce significant flood control benefits for the Northeast Region. Unfortunately, with the possible exception of a dam on the Someswari, there are no adequate reservoir sites available in the Meghalaya catchment areas.

- The Tripura catchments which comprise 10.4% of the river basin yield only 5.9 percent of the total water supply. Thus, even if the Indians take up the Manu Dam, the flood control benefits to the Northeast Region will be negligible

- The Northeast/Meghna catchment comprises 30.8 percent of the Megna River basin area, and yields the single largest contribution, 39.5 percent, to the total water supply. Thus, the greatest flood control benefits would accrue to the Northeast Region if adequate reservoir sites could be found within the region itself. An assessment has been made of the storage capacity available in the region at Bara Haor, Hakaluki Haor, Hail Haor and Tangua Haor; this assessment indicates that the total storage capacity available is in the order of 3.5 km^3 which is negligible in comparison with the basin water supply, 173.3 km^3/year.

The overall conclusion to be reached from this review is that flood control works will not produce significant flood control benefits to the Northeast Region, and that the way forward must continue to consist of flood protection works, i.e embankments and, possibly, flood relief channels.

Flood Protection Works and Flood Relief Channels. The construction of embankments along river levees of the Northeast Region, so as to protect Boro rice crops on the haors from flash flooding, is now a long-established practice and, it is considered, one which has had overall considerable benefits to the region. The protection from flooding which embankments provide is virtually the only means available to the Northeast Region for large-scale mitigation of the effects of flooding on agriculture. The fact that there are problems and inadequacies with some of the existing embankments is certainly no reason to abandon their construction.

In this connection it is important to note that to date NERP studies have found no evidence to support the view that embankments are encouraging regional sedimentation of the river channels by restricting the overflow of water-borne sediments onto the haors. Concerns expressed on the subject of river channel sedimentation during the public participation meeting held in Sylhet on 26 June 1992 would therefore appear to relate to serious, but localized, sedimentation problems. It was indicated by several local MP's attending this meeting that several reaches of the Surma and Kushiyara rivers which used to be navigable by large passenger vessels are no longer so, and they attributed this to siltation of the rivers. Navigability can, of course, be restricted by river siltation but it can also be restricted by lower water levels. In the case of the Surma for example, it has been observed that mean river water levels at Chhatak are lower than at Sunamganj, downstream, in the dry season; there is no apparent reason to doubt the water level data for either place, and it may be that the water levels between Sylhet and Sunamganj are drawn down by the relatively large offtakes of water from the Surma into the Madhabpur, Bhattakhal, Khajanchi, and Itakhola canals. In the case of the lower Kushiyara, downstream of Markuli, the loss of navigability is due to siltation but the siltation is not caused by the relatively few embankments in the area; rather, it would appear that the siltation is a natural consequence of the ponding of flood waters caused by inadequate discharge capacity of the Meghna river channel at Bhairab Bazar where the channel cuts through denser, less erodible, older sedimentary material. In this case the solution may be to deepen or widen this channel, but industrial developments on the river banks would seem to preclude any widening; alternatively, the solution may be to deepen and/or widen the existing channels through which, as the water balance shows, some 6 percent of flood waters presently by-pass Bhairab Bazar, and pass into the Titas River. Thus, it is apparent that these navigational problems are not due to embankment of the rivers but to other causes.

The relief of flow congestion at Bhairab Bazar is seen to be, potentially, of great significance since it offers possibilities to reduce the area and depth of inundation of the Sylhet Depression in the wet season, and to accelerate its drainage in the autumn. The success of this scheme depends, however, on the significance of backwater effects in the upper Meghna estuary; these remain to be evaluated. Other flood relief channel schemes under consideration by NERP relate to the Manu Project at Moulvi Bazar and to the diversion of the Kangsha River into the Old Brahmaputra; these schemes are under evaluation at present. The Manu flood relief channel offers the possibility to reduce flood water levels both at the Manu Barrage and in Moulvi Bazar town. The Kangsha diversion offers possibilities to reduce flooding in the lower Kangsha valley, and to reduce the volume of water which accumulates in the Sylhet Depression during the wet season.

Hydropower Potential. A preliminary review of the current and forecast energy situation, leads to the observations that:

- the present installed capacity in Bangladesh is 2300 MW of which only 1300 MW was actually capable of generating electricity in April 1992.

- the need for 4000 MW by the year 2015 is now forecast to arise by the year 2000.

Thus, the prospects for electrically-driven pumping for drainage and irrigation do not seem bright; the energy required for this may simply not be available no matter at what cost. It is thus apparent that additional generating capacity will be needed in short order regardless of whether funds are found to complete gas transmission pipelines to gas-fired power stations, or to build the Roopur nuclear power station. It is also noteworthy that, because of Bangladesh's heavy dependence on gas-fired power stations there has been, and will continue to be, a chronic shortage of peak power capacity; this despite the advent recently of a number of gas turbine units.

In this context, there would appear to be a definite role for more hydropower in the system and the critical question is: Does the necessary hydropower potential exist in the Northeast?

This question was addressed a decade ago by a USAID Mission which found with regard to the Northeast Region that:

- while a few sites with some head existed int he areas adjacent to Tripura, available flows were small, and the anticipated power outputs were estimated to be substantially less than 1 MW; these would be of no practical use to the Grid, or for independent pumping.

- irrigation diversion structures would offer a better prospect of generating useful quantities of energy.

The possibility of developing a power station in connection with the existing Manu Barrage is being examined. The results at this time are of a very preliminary nature and definitely need to be revised in the light of more precise and extended information on the barrage tailwater levels. However, the conclusions reached seem favourable and to indicate that further study is justified.

The present study indicates that if a power station was built in parallel with the existing barrage, wet season generation over 8 months would, if sold to BPDB, generate income sufficient to pay for twice the energy presently consumed by the Manu drainage pumping station. It also indicates that if the barrage gates were modified so as to achieve a 3 m. increase in pond level wet season generation over 8 months would pay for six times the pumping station consumption. The annual energy outputs are estimated at 14 and 37 GWH, quite sufficient, it is thought, to be of serious interest to BPDB.

Another interesting possibility exists on the Surma River just upstream of Sylhet. Studies so far show that a run-of-river plant at this site could, with a pond level of 38.8 ft GTS generate 25 MW through the period May to September inclusive. The annual energy output is estimated at 110 GWH, again quite sufficient, it is thought, to be of serious interest to the BPDB. The studies have considered the possibility of augmenting this output by using Bara Haor as a reservoir for the power station but it is clear that there is not advantage to this since the storage available in Bara Haor is negligible in comparison to the volume of flow passing down the Surma at Sylhet; there are also good agricultural and social reasons for not using Bara Haor as a reservoir. The pond level, 38.8 ft GTS, is the minimum required to maintain a head of 2 m on the turbines throughout the wet season, and to achieve this pond level it will be necessary to embank the right bank of the Surma River possibly as far upstream as the Lubha River; the left bank of the Surma is already embanked all the way upstream to Amalshid. The new right

embankment would, of course, provide flood protection to Bara Haor, and the raised water levels between the two embankments would provide a strong dis-incentive to those who would cut the left embankment to drain lands to its south.

Schemes to generate power from the larger rivers entering the region from Meghalaya are also under investigation. These fairly large river flows occur over the alluvial fans at the foot of the Shillong Plateau; these fans lie within Bangladesh territory and offer the possibility of some head. Studies have not yet progressed to the point at which the energy available at the several sites is known. If these possibilities firm up additional wet season power will be available.

Since this energy will be available only during the wet season, and the BWDB's demand for energy for pumping will arise in the dry season, it may not be readily apparent what use the BWDB will have for this energy. The planned use of this energy is as follows:

- The power stations would be connected to the BPDB grid for distribution to BWDB pumping sites; a separate distribution system would be costly, and is perceived to be, basically, unnecessary.

- The BWDB, if the owners of the power stations, would sell the wet season energy to the BPDB which could use it for general supply to the grid; this energy could also be used by the PDB to replace energy lost due to outages of thermal units for reasons of maintenance, etc. The income generated from the sale of this energy to the BPDB could then be used by the BWDB to:

  (i) amortize the capital cost of the power station and all associated works such as the Surma right embankment

  (ii) purchase dry season power from the BPDB for drainage and irrigation pumping in the dry season when these hydropower stations are closed down for lack of water.

Obviously, a high degree of cooperation between the BWDB and the BPDB will be required to make this plan work successfully, and the arrangements for this seasonal exchange of energy may differ from that indicated above. It is clear, however, that such arrangements could be highly advantageous to both parties, and to the Northeast Region.

Tipaimukh Dam Proposal. Present information is that the Indians plan to dam the Barak River at Tipaimukh. Construction is scheduled to start in the 1992-93 dry season. The scheme involves a high dam at Tipaimukh to support hydroelectric generation (1500 MW installed capacity with an annual output of 3600 GWH), provide flood control (9 km^3 of storage), and support irrigation of the Cachar Plain (168,000 ha). Water for irrigation will be diverted by a barrage on the Barak River at Fulerthal into major canals commanding the irrigable area in Cachar.

Concerns about the impact of Tipaimukh on the Northeast Region are that:

- flood control benefits to the Northeast Region, while available, will not be substantial as the dam is located so far upstream that it controls less than half of the Barak River flow.

- irrigation of the Cachar Plain may lead to a water shortage in the Northeast Region during the dry season.

A minimally adequate data base relating to the Tipaimukh scheme has been established and a first attempt has been made to simulate the effect of Tipaimukh Dam on the flow of the Barak River into its two distributaries -- the Surma and Kushiyara Rivers.

Mean annual flows of the Barak River, based on Indian flow records kept in connection with the Tipaimukh scheme and on the NERP water balance are, as follows:

	km^3/yr	m^3/s	%
Tipaimukh Dam	12.5	396	39.3
Fulerthal Barrage	16.9	536	53.1
Amalshid	31.8	1008	100.0

From these figures it can be readily understood that, although Tipaimukh Dam will fully regulate the Barak's flow at the dam site, it can only control 39.3% of the flow at Amalshid and so flood benefits to the Northeast Region will be relatively small. In this connection, it is noteworthy that the Indians originally proposed Tipaimukh Dam as a flood control project but soon concluded that the flood control benefits to the Cachar Plains area could not justify its cost. They then decided to develop the site for its hydropower potential; this involved raising the dam to the maximum feasible height so as to maximize the head available and justify the cost of the scheme.

Table 3.4: Effect of Tipaimukh Dam on Barak River Flows at Amalshid (m^3/s)

Month	Without Dam	With Dam	Change
May	869	923	+56
Jun	1879	1537	-342
Jul	2569	1955	-614
Aug	2332	1812	-520
Sep	1951	1580	-371
Oct	1141	1089	-52
Nov	360	515	+155
Dec	159	393	+234
Jan	102	358	+256
Feb	84	347	+263
Mar	136	379	+243
Apr	444	566	+122
Means	1008	958	-50

Table 3.5: Seasonal Effect of Tipaimukh Dam on Barak River Flows at Amalshid (m^3/s)

Season	Without Dam	With Dam	Change
Wet	1789	1482	-17%
Dry	214	426	+99%

Assuming an irrigation demand arising from the 1680 km^2 of lands to be irrigated in the Cachar Plains of 1 m/year, it can be estimated that water lost to the Northeast Region will be about 1.68 km^3/year; this is equivalent to 100 m^3/s if irrigation is for 6 months of the year (i.e. the *boro* rice season from November through April), and it does not include return flows from

the *boro* rice season from November through April), and it does not include return flows from the irrigated area in Cachar. The mean monthly flows of the Barak at Amalshid will then be as shown in Table 3.5. The calculation assumes that water will be released through the turbines at Tipaimukh at a rate equal to the mean annual flow at the dam (396 m^3/s). The calculation shows that the mean annual flows of the Barak at Amalshid will be reduced by 50 m^3/s, which is equivalent to 100 m^3/s lost to evapotranspiration in the Cachar irrigation district during the six month irrigation season. Table 3.5 shows the mean seasonal flows of the Barak at Amalshid during the flood control and irrigation seasons. The average flow reduction at Amalshid in flood control season is 17%, and the average enhancement of flows there due to the release of water stored in the Tipaimukh reservoir during the irrigation season is 99%. In other words, dry season flows of the Barak at Amalshid will be about twice as great as they will be if the dam is not built.

The benefits to the Region and to Bangladesh would, of course, be much greater if Bangladesh were to receive a fair share of the energy output of Tipaimukh (3600 GWH). Since India is potentially taking 5% of the water for irrigation in Cachar, it would seem reasonable for Bangladesh to receive a percentage of the energy output.

Other schemes which the Indians have in mind for implementation at a later stage are dams on the Sonai and Dhaleshwari rivers, tributaries of the Barak River. These will serve to improve inland navigation within Mizoram, will provide some flood control and hydropower benefits, albeit not on the same scale as Tipaimukh, but, it is thought, will primarily facilitate irrigation of those areas of the Cachar Plains which cannot be commanded from the Fulerthal barrage. While these developments should be watched carefully, it is not considered likely that they will have any effect on the Northeast Region in the near future.

Barak Bifurcation at Amalshid. It will be apparent from the foregoing review that the Barak River is the single most important inflow to the Northeast region from the upper catchment of the Meghna. This river divides at Amalshid on the Indo-Bangladesh border, part of its flow entering the Surma River while the larger part passes down the Kushiyara River. The Surma and Kushiyara Rivers are of course, two of the most important rivers of the Northeast Region; together they drain the entire eastern half of the Region. Any changes in the regime of the flows entering these two rivers may therefore, have far-reaching effects on the flooding, drainage and irrigation, and inland navigation in the eastern half of the Region.

The division of the Barak flow at Amalshid is associated with heavy erosion at the turn-out into the Surma River. This erosion is perceived to be migrating at a rate sufficient to cause some concern. If it is migrating, and this is by no means certain at present, a changed geometry of the river channels at Amalshid could result in a change in the proportions of Barak flow entering the Surma and Kushiyara.

A study of the annual flows indicates the proportions of flow to the Surma and Kushiyara have been remarkably constant throughout the period 1964-89: the proportions of the annual flow of the Barak into the Surma was found to be 35%, while that into the Kushiyara was correspondingly 65%. The variations about these values were plus or minus about 3% only, and were completely random. The present findings suggest that the increased flows in the Kushiyara

which have been widely noted in recent years are simply due to above average inflows from the Barak in these years, and not to a change in apportionment of the Barak flow at Amalshid.

In order to arrest future erosion at Amalshid, river training works of some form would be required. River training works could also be used to re-apportion the Barak flow so as to increase the proportion of inflow to the Surma, thereby making better use of its flood carrying capacity and, correspondingly, to reduce the proportion of inflow to the Kushiyara, thereby enabling it to pass floods without such frequent overtopping of its embankments.

A study of the mean monthly flows indicates that the proportions change seasonally, ie, with stage in the Barak River: in the wet season the proportions were found to be 38% into the Surma and 62% into the Kushiyara, while in the dry season about 5% flows into the Surma, while 95% of the Barak flow passes down the Kushiyara. When the proportions are plotted as a function of flow in the Barak on a month by month basis a distinct hysteresis loop is defined. Thus, the proportions for a given flow in the Barak differ being higher during the rising monsoon flood that during the monsoon flood's recession; this indicates that the proportions also change with the hydraulic gradient prevailing in the Barak. This hysteretic seasonal relationship between the proportions of the Barak flow entering the Surma and Kushiyara rivers can be used to estimate the flows entering them once Tipaimukh dam is in place. As can be seen in Table 3.6, higher dry season flows in the Barak result in a considerable improvement in the Surma's share of the available water.

92

Table 3.6: Effect of Tipaimukh Dam on Flows entering the Surma and Kushiyara River (m^3/s)

	Without Dam				With Dam			
	(1) m^3/s	(2)		(3) m^3/s	(1) m^3/s	(2)		(3) m^3/s
		%	m^3/s			%	m^3/s	
May	869	37.1	322	547	923	37.2	343	580
Jun	1879	38.1	715	1164	1537	37.3	573	964
Jul	2569	37.3	960	1609	1955	38.0	743	1212
Aug	2332	36.7	856	1476	1812	35.0	634	1178
Sep	1951	35.6	693	1258	1580	34.2	540	1040
Oct	1141	32.5	371	770	1089	32.0	348	741
Nov	360	22.2	80	280	515	26.0	134	381
Dec	159	10.6	17	142	393	22.5	88	305
Jan	102	5.7	6	96	358	22.0	79	279
Feb	84	5.1	4	80	347	21.0	73	274
Mar	136	18.5	25	111	379	32.0	121	258
Apr	444	34.4	153	291	566	35.5	35.5	365

Notes: (1) Barak at Amalshid
(2) Surma at Amalshid
(3) Kushiyara at Sheola

3.5 The Regional Economy

Several of the economic characteristics and needs of Bangladesh are related to its population density, which, at 741 persons per square kilometre, is one of the highest in the world. In the project region, population densities vary from 460 persons per square kilometre in the district of Sunamganj, to 2290 in the district of Narayanganj, and more than 3000 in the Dhaka region.

The national population is growing at 2.1% per year, and the regional population grew by 1.8% per year over the past 10 years. Population growth has been declining slightly, but it remains a priority item for government. The current Five Year Plan targets on reducing national population growth to 1.8% per year.

Table 3.7: Economic Indicators

	LDC's	S.Asia	BGD	NE[1/] Region
Population Density (people/km^2)			741	715
GDP per Capita (at Factor Cost)			6229	5600
GNP per Capita (at Factor Cost)			6428	
Consumption (% GDP)	73.9	82.2	99.6	
Domestic Investment (% GDP)	28.5	21.6	12.2	
Domestic Savings (% GDP)			2.0	
National Savings (% GDP)	24.5	16.5	7.1	

Source: IBRD, Selected Issues in External Competetiveness, 1991.
BBS, 1991
1/ NERP Estimates

Average per capita GNP in Bangladesh is one of the lowest in the world, amounting to US $190 in 1990, which ranks it the fifth poorest of 124 member countries of the United Nations. The average per capita GDP in the Region is 10 % less than the national averages, partly reflecting a higher dependence on agriculture. Significant sub-regional differences exist within the study area, and the income distribution is highly skewed both regionally and sub-regionally. The more prosperous residents tend to be urban landlords and those operating their own businesses.

The western part of the study region has a heavy agricultural dominance and intensive rice production. Most of the lands are active flood plains used for single and double cropped rice and other crops. The central part of the region is mostly deeply flooded during the monsoon months, and used for single crop boro rice and fisheries. The eastern part of the study region is a mixture of high lands, active flood plains, and flood basins. The flood basins are used for single crop boro rice and fisheries; the flood plains for single, double and triple cropped rice, and other crops; and the high lands for tea, pineapple and other crops. The economy of the eastern subregion is considerably more developed and diversified than in the balance of the study area.

About half of the regional economy (as measured by Gross Regional Product which is a measure of gross output less intermediate goods from other sectors) is made up of service sectors such as transportation, trade, and housing, and most of the balance of the economy is accounted

for by agriculture. Construction and industry account for only about 6 percent each. Within agriculture, rice production provides half of the gross regional product, and the balance is quite uniformly divided amongst: other crops (including a substantial tea industry), forestry, fisheries, and livestock. The lack of development and balanced diversification of the productive sectors has implications for regional economic risk and performance.

It has been estimated by government that a third of the national economy is outside the formal sector. In the region, the informal sector may account for somewhat less than the national average (due to the substantial foreign remittances), but it remains very large by international standards. The major implication of this is that conventional economic instruments for promoting development are relatively less effective.

One of the fundamental requirements for economic growth is new investment, particularly in the productive sectors, and Bangladesh has been faring badly in this regard. Gross investment in Bangladesh has been averaging only 12% of GDP, which is less than half that of principal competitor countries in South Asia. This lack of investment is considered to be even more pronounced in the project region, particularly in the central and western parts of the region, and is a major consideration in development planning for the region.

Part of the reason for the lack of regional investments is the low rate of public expenditures. The annual development plan for Bangladesh amounts to only 6% of GDP, and a significant portion of this is spent on non-productive investments. While the study region is considered to be receiving its share of the total development expenditures, substantially more will be required to allow the region to keep pace with the balance of the economy. Even at this low rate of development expenditure, government is experiencing increasing difficulties in disbursing the funds due to a general lack of absorptive capacity in the region. This disbursement problem is compounded by the fact that essentially the entire annual development plan is foreign funded and is hampered by cumbersome aid priorization and processing procedures. Government is fully aware of these problems, and remedial actions form a central thrust of the current development strategy.

The low rate of regional investments is also related to the low rate of savings (almost entirely private) available to fund investments. Nationally, domestic savings have amounted to only 2 to 4% of GDP over the past several years. National savings (which include the important foreign remittances) have ranged from 4 to 7%, but this is still less than half that of competing economies in South Asia. The regional situation is considered to be no better in this regard. The lack of savings is partly due to much of the population having no margin of earnings available for saving/investing. There is however, a significant group of residents in the eastern part of the region who have substantial wealth (foreign remittances to the Sylhet region may account for as much as 8% of the national total according to one bank official in Sylhet). Many of these wealthy however, prefer to invest in other regions or other countries where the investment processes are easier and the returns are higher and less risky. Most of the investments which do take place in the area are in housing, land and retail outlets.

In total, regional development has been highly dependent on public investments, almost all of which have been foreign funded. Major constraints to regional investments include: lack of investment capital, lack of market opportunities, lack of infrastructure, and various policy and

institutional constraints. The result has been very modest levels of investment, much of it for non-productive purposes, and substantial difficulties in allocating and disbursing development funds. The intent of government is to encourage a greater participation of the private sector in funding and participating in the regional development process. The national target is to increase domestic savings to 7% of GDP, partly through increased taxation, but also through improved financial services and investment promotion.

The dominance of agriculture in the region, particularly rice production, will make it difficult for the regional economy to keep pace with the national economy. Agricultural output has been growing slowly, and output per capita has been falling. While recent trends in the expansion of boro rice production are encouraging, there is no expectation that agricultural output will grow by the target rate for GDP of 5% per year (the target for national agricultural growth is 3.6% per year, and much of this is intended to come from non-rice production). The implication is that the region must give greater emphasis to non-traditional crops and value-added industries if it is to maintain its position in the national economy.

Industry in the study region is mostly small scale, notably rice milling. There are however, large scale industries in tea, sand and quarrying, oil and gas, and textiles in the Sylhet region; a cement plant and a pulp and paper mill at Chhatak; a fertilizer plant at Fenchugonj; fish processing and export plants at Azmirigonj and Sunamgonj; and, a garment industry in the Dhaka region. The industries are in various states of economic health, and it appears likely that the fertilizer plant at Fenchugonj will be replaced by a new plant at Chittagong. A ball pen manufacturing plant is presently under construction near Moulvi Bazar city, but no other industries are planned. There is little government assistance available to potential investors in the industrial sector, and government procedures continue to be a major impediment to private sector investment.

Major trade goods ***from*** the region include: jute and jute products from the Mymensingh region, tea and pineapples from the Sylhet region (tea accounts for 2.5 percent of total Bangladesh exports), sand and aggregate from the Sylhet region for use in domestic construction, fertilizer and rice for domestic use, and fish for domestic consumption and export. Goods flowing ***into*** the region are substantial, mostly accounted for by capital items, petrol and petrol products, household consumables, wheat for Food For Work programmes, and rice to provide for seasonal shortages. The development of additional inter-regional trade is a priority for the region.

In the project region, as in Bangladesh, the labour force is estimated to be about half of the total population, with 60% being male. This estimate includes about 15% of the population who are females engaged in the care of livestock, threshing, boiling, food processing and preservation, and other activities which are considered to be of economic value. Nationally, almost half of the labour force is classed as unpaid family labour, and only 10% is employed in the formal sector (a quarter of which are employed in the public service).

Agriculture employs 65% of the labour force nationally, and from 70% to 80% of the labour force in the project region, depending on the area. During the monsoons in the deeply flooded areas there is essentially no agricultural employment, and there is a substantial out-migration of

residents in search of employment. During harvest of the boro rice crop there are major shortages of labour, and as much as 80% of the labour for the boro rice harvest is provided by migrant workers. Given that agriculture accounts for less than 40% of the gross regional production, and that a significant part of this is earned by "outsiders", the per capita earnings for those residents engaged in agriculture are clearly very depressed.

Wage rates for agricultural labour average Tk 40 per day in both Bangladesh and in the project region, significantly below that in construction and industry sectors where wages average Tk 50 to 55 per day for unskilled labour. The seasonal variations of agricultural labour requirements in the region cause agricultural wages to vary by up to Tk 20 per day. Skilled labour in Bangladesh earns an average of Tk 60 per day in manufacturing, and Tk 110 per day in construction. Skilled workers in the project region command slightly higher wages, which is considered to reflect the micro-economy created by the foreign remittances.

There are seven major cities in the region, which are the district headquarters of Sylhet, Moulvi Bazar, Habiganj, Netrokona, Kisorganj, Sunamganj, and Sherpur. The primary importance of most is their administrative centres and urban facilities.

Sylhet is different from the other district headquarters, in that it is a major regional growth centre. It is a very old city situated on the Surma river, and it has been the district headquarters for many decades. Since the mid-1960's it has attracted a large number of middle class and wealthy families with ties to family members living abroad. It has several colleges, including a medical college, a women's college and the oldest college in Bangladesh. It also has a polytechnic institute. The only large scale industry in the city is the Sylhet Textile Mills, but the city is expanding fast in terms of residences, retail outlets, business complexes, and small scale industry such as rice mills, saw mills, soap factories, and food processing factories. The city attracts large numbers of seasonal labourers, particularly during the *boro* rice harvest season.

Mymensingh is located outside the study region, but is important to the region in that it serves as the hub of the large and highly concentrated agricultural area on the west side of the region. It is situated on the Old Brahmaputra, and is the location of the Agricultural University of Bangladesh, and the Women Teachers Training College, the only ones of their kind in Bangladesh. The only large scale industry is the Shamugonj Jute Mills, but there are several small scale industries, including a number of rice mills. While the city is not growing significantly, it provides the markets and services required for further developing the agricultural potential in the project region.

Other important centres in the region include Spimangal, Chhatak, and Bhairab Bazar. All are upazila headquarters. Spimangal is important because of its tea and pineapple production, and is growing faster than the district headquarters of Moulvi Bazar. Chhatak is situated on the Surma River, and has the lone cement factory of Bangladesh, a pulp and paper mill, and a centre for loading and unloading sands and aggregate. Bhairab Bazar is an important trading centre situated on the Meghna River and on the railway system, and most goods required by the region pass through this market. With exception of Sylhet, most of the urban centres appear to be in a state of equilibrium, and their growth will be highly dependent on new investments in the productive sectors. All could accommodate new investment initiatives.

3.6 Social Development

The average household size in the region is about 6 persons, slightly more for the Hindus (as they prefer the joint family) and slightly less for the Muslims.

Health

Government health services are divided into two wings: Health and Family Planning, each of which has its own budget and chain of command. In 1988, per capita expenditure was about one $1.00 US for health and $0.50 for family planning. This represented a little over 5% of the Government's total annual development budget.

The health wing administers the teaching hospitals, the district hospitals, as well as the Upazila Health Complexes. Most of the rural and domiciliary health workers operate under the family planning wing which was the first to develop outreach services in the 80's. The administrative division between health and family planning has resulted in an unfortunate duplication of authority which impacts negatively on maternal and child health services.

There is one large teaching hospital in Sylhet and 50 to 100 bed hospitals in all the district headquarters. The town of Mymensingh is not in the Northeast Region itself but its teaching hospital treats patients from Jamalpur, Sherpur, and Netrakona. The large hospitals are relatively better staffed with specialists and are well attended with patients occupying floor space as well as beds. Most Upazila Health Complexes, on the other hand, operate well below capacity. In remote areas, doctors are often absent or busy with private practice; drugs are not in sufficient supply and equipment is below standard.

A survey of Upazila Health Complexes showed that most patients are treated for injury following violent clashes. Unlike western hospitals, where women attend in larger numbers than men, female attendance here is relatively low. Childbirth is not usually referred to hospitals. Female doctors are few, if not absent, in the Upazila Health Complexes and there is a reluctance to entrust women patients to male doctors, particularly for gynaecological and obstetric problems.

In the outreach services, government emphasis has been placed on family planning and immunization. Family planning users in the Old Sylhet District are notably lower than the rest of the country. For example, oral pills, the most popular form of contraceptive in the country, were expended at a rate four times lower in the Old Sylhet District than in Dhaka District during 1988-89. The ratio of contraceptive users in Old Sylhet District was generally one-third of the national average. Immunization follows a similar pattern and lags behind national averages; this is particularly true in the *haor* areas where transportation is difficult during the monsoon.

The poor performance of outreach services in Sylhet is attributed to the following:

- The large *haor* areas are remote with inadequate transportation systems, especially during the monsoon. Women service holders as well as women clients' movements are severely curtailed. It is not socially acceptable for women to travel in boats and in doing so they incur shame and ridicule. Field workers employ boatmen but complain of inadequate

transport allowances. Bad weather also makes boat transport perilous for everyone at certain times of the year.

- Educated women have been slow to take employment as field workers in the Sylhet region. This has hampered the recruitment of female outreach workers.

- National NGOs find it especially difficult to develop community-based activities in areas where there are large numbers of migrants abroad and a level of wealth unparalleled elsewhere. Families with money prefer to go to private practitioners -- qualified or unqualified -- which is an issue of social prestige.

- Sylhet women are seen to observe relatively strict purdah rules which makes it difficult to convince them to attend clinics outside their homes.

Private health services, which are at least as important as those provided by the government, are very unevenly distributed throughout the region. In areas of high out migration, the number of private practitioners is relatively higher. For example, the town of Moulvi Bazar alone has 27 private hospitals with 382 beds while Habiganj has 10 private hospitals with 77 beds. In Sunamganj, on the other hand, where there are very few workers migrating abroad, there are no private hospitals.

Food and Nutrition

Food intake is a primary determinant of health. In Bangladesh, the situation has worsened over the last twenty five years. In 1965, the daily calorie supply represented 91% of requirements whereas in 1988, it had decreased to only 83%. This is a national average. Differences in food consumption between socio-economic classes are important as the Table 3.8 shows.

Gender differences are marked. Girls generally suffer from a higher degree of malnutrition than boys. Wives conventionally eat last and, amongst the poor, they also eat least. The poor nutritional status of wives is reflected in the low birth weight of babies which is a major cause of infant mortality. One-third to one-half of all infants are born weighing below 2.5 kilograms.

In the Northeast Region, malnutrition is endemic but most acute in the pre-harvest months when the prices of all essentials increase. Rice substitutes, such as wheat, sweet potatoes, potatoes, wild tubers (*ghechu* or *khei*) and fish are consumed at this time. Diets are more varied but many families eat only one meal a day and the caloric intake is grossly inadequate.

The basis of the diet remains the traditional rice and fish. With the possible exception of parts of Old Mymensingh District, consumption of wheat has not spread in much of the Northeast Region. In many of the non-wheat growing areas, it is sold and consumed only for two months of the year when labourers involved in earth work are paid in "wheat-for-work". It then disappears from the market. Wheat connotes poverty and hardship, whereas rice means pleasurable food and plenty. In periods of plenty, rural people tend to eat large quantities of rice and very little other foods.

Under social system or issues related to social development one should discuss social system, social structure, social relationships, and social action, & social values.

Cultural preferences and perceptions of foods undoubtedly influence the crop selected for cultivation which in turn dictates market patterns. Farmers in the Northeast Region have been slow to diversify from paddy cultivation and thus the diets are not highly varied.

In the haor area, fish is eaten throughout the year by rich and poor. It is the most important source of protein and compensates somewhat for the lack of pulses and other protein-rich foods. The poor, who must survive during the lean months, catch fish from water bodies rented out to leaseholders.

Meat consumption is low and is extremely rare in rural areas. Milk production has declined considerably in the last twenty years and the consumption of milk and milk products is a luxury for most households. Poultry and eggs which are produced in the rural areas are largely sold in cities. They are more a source of cash than a nutritious food for the poor.

Table 3.8: Adequacy of Food Consumption by Income Groups (grams per capita per day)

	Min Reqts	Lowest 20%	2nd 20%	3rd 20%	4th 20%	highest 20%
Grains	437	370	474	525	561	575
Pulses	40	13	18	22	27	35
Fish	48	18	26	35	48	70
Meat/Eggs	12	3	5	8	12	29
Vegetables	177	120	150	174	207	264
Milk	58	5	11	17	27	55

Consumption as a percentage of requirement

85	108	120	128	132
33	45	55	68	88
38	54	73	100	146
25	42	67	100	242
68	85	98	117	149
9	19	29	47	95

Source: World Bank: Bangladesh Food Policy Review: Adjusting to the Green Revolution. Vol II, p.17

Education

The education base in Bangladesh is inadequate resulting in a very low literacy rate. It ranks 115 in 131 countries assessed by UNDP with only about one-third of the people older than 15 being able to read or write. The situation is worst for the poorest stratum of the population in which illiteracy is almost the norm. The male-female literacy rate is also highly skewed, especially in rural areas where more than 85% of the women are illiterate.

The situation is more acute in rural, inaccessible areas. A recent report states that, in old Sylhet district only 15% of the rural people are literate. The proportion is 33% in urban areas. It further mentions that about 62% of the villages in Sylhet district have no primary schools and the literacy rate is deteriorating fast. The district, which had a literacy rate of 24% in 1951, now has a literacy rate of 14%. This probably represents the level of education in the entire north-east region of the country.

The number of primary schools in the region is estimated at 8100. Less than 40% of school-age children are enrolled in these schools. Even though enrolled, primary students in the region do not attend regularly and in the low lying haor areas, less than 30 per cent of enrolled children

are reported to attend classes regularly. Independent and national studies have found that more than 50% of the children drop out in the first year of school and less than 15% of the children complete primary school. For girls, the primary school completion rate is found to be less than 3%. It is, however, difficult to reconcile these figures with the official statistics on enrolment since they do not provide information on when or how many children drop out of the education system. Consequently, it is also not possible to establish which children move successfully from the primary schools within the region to the secondary schools. The commonly stated causes of school dropouts in primary schools are that:

- children need to assist their parents in economic activities, particularly during peak agricultural periods;
- schools are generally too far from the home and, particularly during the monsoon months, communication facilities are poor;
- parents often provide inadequate support for the children which may be manifested in their failure or inability to provide assistance with homework;
- daughters are required to assist their mothers with household work and there is an additional fear that the reputation and honour of older girls attending schools in distant locations will be damaged;
- teachers are absent from school a high percentage of the time; and,
- there is insufficient supervision of the teachers. They are not held accountable by the local community since the community is not adequately involved in the education system.

The region has an estimated 1250 secondary schools of which more than 20% are located in urban areas. Less than 15% of these are girls schools. The enrolment in rural secondary schools is between 10 and 12% of the corresponding age group. Less than 20% of the rural secondary schools are female only. Though the country ostensibly has a co-education system, female enrolment in mixed institutions is very low and this low level of female enrolment extends into colleges and universities as well.

There are primary teacher training institutions in all the district headquarters of the region. In 1989-90, there were more than 30,500 primary school teachers in the region, of which 16% were in non-government schools. Female teachers comprise 24% of the teaching staff. The number of secondary school teachers is 12,265. The student teacher ratio in the region is estimated to be 63 for primary education and 37 for secondary schools.

There are two teacher training colleges in Mymensingh. One is exclusively for women and in this respect is unique in the country. The only agricultural university of the country is situated in Mymensingh. The old district headquarters of Sylhet and Mymensingh have one medical college in each.

Recently, government is placing increasing emphasis on both formal and non-formal primary education and there is increasing donor support in this endeavour. But if the enrolment is not

increased and the drop out rates are not decreased significantly, a gradual improvement is likely to be offset by population increases.

Human Settlements

Villages are concentrated in the high and medium high land. Configurations vary greatly according to land elevation and local tradition. In the *haor* areas, villages are mainly linearly shaped and built on river levees. Occasionally, villages are found on higher ground towards the interior of the *haor*. The level of the land is usually raised from 1 - 3 metres to avoid flooding during the monsoon. Since high land is scarce, homesteads are often crowded together, a cluster of these homesteads forming a *hati* or *para*. Most villages consist of several *hati*.

Geographical features largely determine the shape that villages take but cultural norms and prescriptions are also important. The need for an enclosure to shelter women from public view, and create an "inside" and an "outside" space determines the way houses and courtyards are built. A value is also attached to the cardinal points. Where land allows, it is said to be auspicious to orient a house so that it faces north while the courtyard faces south. For Muslims, the latrine should be built and garbage should be disposed of preferably on the southeastern side. If households do not respect these customs, it is believed to be inauspicious and will bring misfortune.

In Old Sylhet District, households making up a village tend to be scattered without any apparent regular pattern. Families belonging to the same patrilineage often build their houses attached to each other in a line.

Houses are mostly made of bamboo, thatched with local grasses or paddy straw. The more affluent households have houses made with corrugated iron sheet roofs and bamboo or grass walls. A very small number of the richest households have concrete houses. Houses constructed with bamboo need repairing every year or two, particularly the thatching. Thatching with a special grass, *chhon*, can withstand rain for two to three years.

Homesteads located on higher lands are not frequently damaged by floods except for some erosion resulting from heavy rainfall. However, homesteads in the low lying haor areas are regularly threatened by monsoon floods and waves. Erosion of these homesteads typically takes place every monsoon, and inhabitants try to protect the earth mound on which the homesteads are constructed with bamboo, soil and a locally available long grass, called *chailya*. Very rich farmers in the haor area use concrete or stone to protect the homesteads from wave erosion.

Domestic Water Supply and Sanitation

The number of tube wells has increased substantially in the last 20 years. In 1990, the number of persons per well was estimated at 141 for the four districts of Sylhet, Dhaka, Jamalpur and Mymensingh. The benefits of drinking tube well water is generally recognized in the Region and where tube well water is not consumed, it is usually because of difficult access. In some parts of Old Sylhet districts, women whose responsibility it is to collect domestic water, observe strict puadah which prevents them from collecting water from neighbouring areas.

The statistics mask large disparities between as well as within parts of the region. In the Sylhet basin, where tube wells must be sunk some 350 to 450 feet deep -- increasing considerably the cost born by the villagers -- tube wells are remarkably scarce. Entire *para* (neighbourhoods) are without tube wells. During the dry season, women must often walk to adjacent neighbourhoods to fetch water. There are long queues then and conflict often results. When these tube wells use break down, villagers are asked to contribute for their repair. The water is then not considered as a free resource.

During the monsoons, villages become small islands. The women who normally collect the water do not travel in boats so men are tasked with retrieving potable water. Given the difficulties of obtaining drinking water during the monsoon, many families simply drink water from the flooded *haor*.

Public tube wells distributed by UNICEF are subsidized but the installation cost is the responsibility of the applicant. Tube wells thus tend to be located in wealthier and influential households of the community.

3.7 Agriculture

Cropping Systems

The total area of the Northeast Region is 2.4 million hectares of which the net cultivable area is 66%. The cropping intensity ranges from: 134% - 219% in the western part of the region; 101% - 133% in the Sylhet basin; and, 115% to 165% in eastern part of the region. An estimated 51% of the region's net cropped area is double-cropped. About 39% is single-cropped and 10% is tripled-cropped. There are about 1.6 million hectares of cultivable land for the 17.5 million people, or an average of less than 0.1 ha per capita.

More than 100 crops are grown in Bangladesh, but rice, jute, and wheat, occupy about 91% of the project region. Rice is the most important crop, covering almost 86% of the total cropped area in the region. Cropping patterns and land uses are shown in Figures 3.7 and 3.8

Rice

Total rice production in the region increased from 2.2 million tonnes in 1960-61, to 2.7 million tonnes in 1970-71, 3.2 million tonnes in 1980-81, and 3.3 million tonnes in 1990-91. In 1983-84, 1985-86 and 1988-89 production was lower as a result of severe floods.

An estimated 59% of the total cropped area in the region is under local rice varieties. High yielding rice varieties were introduced in the mid-1960s and so far 26 high yielding varieties have been introduced. The high yielding varieties require a more stable water regime to respond well to fertilizers, so they are best suited for irrigated conditions. Local varieties have lower yields and usually do not respond to nitrogen application as favourably as do high yielding varieties.

Rice production increases during the last decade have come about mainly because high yielding varieties were introduced for *boro* rice production under irrigated conditions. *aus* production in the region increased from 0.5 million tonnes in 1960-61, to 0.6 million tonnes in 1983-84, then decreased to 0.4 million tonnes in 1991-92. *Aman* production increased from 1.4

million tonnes in 1960-61, to 1.6 million tonnes in 1986-87, and dropped to 1.3 million tonnes in 1990-91. *boro* production increased from 0.3 million tonnes in 1960-61 to 1.4 million tonnes in 1990-91, a five fold increase.

Adoption of high yielding varieties in *boro* production is much higher than in *aus* and transplanted *aman* production. High yielding varieties occupied about 67% of the area under boro, compared to 25% of the area under *aus* and 17% of the area under aman. Adoption of high yielding varieties in *boro* production by region is 93% in Dhaka, 90% in Jamalpur, 79% in Mymensingh, and 46% in Sylhet. No HYVs are available for broadcast *aman* and lowland *boro* rice. Adoption of high yielding varieties of rice is higher by medium farmers (44%) than the small farmers (33%) or large farmers (23%).

Bangladesh has been experiencing a shortage of rice for several decades. A comparative statement in respect of the rice production in 1960-61, 1973-74, 1980-81, and 1990-91 shows that rice production per capita has been decreasing. Rice production has been lower than the normal requirement of 16 ounces (453.6 g) per day per person. Using the guideline of 16 ounces per day per person, the Ministry of Food in 1984 identified 15 of 36 upazilas in Sylhet, 48 of 49 upazilas in Dhaka, 4 of 12 upazilas in Jamalpur, and 9 of 35 upazilas in Mymensingh as foodgrain deficit areas.

Jute

Jute is Bangladesh's most important crop after rice, however, the area cultivated to jute has declined over the past two decades. The main jute areas in the Northeast Region are the Meghna floodplain and Jamuna chars. This area accounts for 11% of the total jute area in the country (Mymensingh alone accounts for 8%).

Jute production decreased from 1.2 million bales in 1978-79 to 0.6 million bales in 1991-92. The production dropped by 40% in Mymensingh alone. The share of Sylhet, Dhaka and Jamalpur in jute production in 1991-92 was 0.7%, 16.0% and 26.2%, respectively. Jute production is declining because of depressed prices.

Wheat

Wheat represents about 2% of the total cropped area within the Region. It is mainly grown in the Old Brahmaputra floodplain and the Meghna floodplain. About one-third of the wheat produced is of high yielding varieties.

Sugar Cane

Sugar cane in the region accounted for about 7% of the total area in the country. In 1989-90 production in the Region was 0.4 million tons.

Tobacco

Mymensingh, Dhaka, Jamalpur are major tobacco growing regions accounting for 6% of the total tobacco area in the country. The area used for tobacco cultivation in the Region was 3600 hectares. The share of small and medium farmers in tobacco cultivation was 40% and 43%, respectively. Production has been declining since 1981-82.

Tea

Greater Sylhet District is the only tea producing area in the Northeast Region. Of the 152 tea estates in the country, 130 are in Sylhet. These estates account for 93% of the total tea area and produce 96% of the total tea production in the country. In 1989-90 the production of tea in Sylhet was 37,470 tons.

Other Crops

About one-fifth of the total jackfruit production of Bangladesh comes from the region. A significant percentage of Bangladesh's citrus fruit originates in the region including: oranges (50%), limes and lemons (22%), and pineapples (34%). The pineapple production was 49,000 tonnes in 1987-88.

Livestock

Within the study region, there are an estimated 3.8 million head of cattle, 0.1 million buffalo, 1.0 million goats, 0.1 million sheep and 11 million poultry. The most important livestock in terms of working animals are cattle which provide the necessary draught power for ploughing, threshing, road and farm transport, and crushing of sugar cane and oilseed. About 55% of the cattle and buffaloes are considered to be working animals.

Over the past 25 years poultry increased by 6% per year, goats by 2-4%, and cattle by 0.5%. The buffalo, duck and sheep populations seem to have stagnated. On a per capita basis, only poultry are increasing.

Agricultural Considerations

The following summarizes a series of considerations which currently impose severe restrictions on agricultural development in the Northeast Region (Brammer *et al.*, 1988):

- Early flash floods can destroy maturing *boro* paddy or young *aus* and deepwater *aman*;
- Deep or very deep flooding, often with rapidly rising water levels due to the entry of flash floods from adjoining regions. This prevents deepwater *aman* from being grown over much of the region. Deepwater *aman* can also be uprooted by waves on open water surfaces and swamped by large rafts of water hyacinth.
- There is very heavy rainfall and persistent cloudiness in the pre-monsoon and monsoon seasons, which hampers harvesting, drying and storing of *boro* and *aus* paddy;
- There is a predominance of heavy clays which are difficult to cultivate either wet or dry;
- There is slow drainage of the basin centres. Large areas remain wet throughout the dry season; some have mucky top soil with low bearing capacity and some soils grow troublesome weeds;
- Road communications are poor. The clayey soils are poor construction materials for road embankments foundations. The communication network is frequently disrupted by flash

floods. Internal communication is mainly by water, which severely restricts the movement of Government officials and commercial agents responsible for providing development support services;

- There are many large landholdings held by absentee landlords;
- River channels are shifting and eroding cultivated land and settlements.
- There are occasional high floods and late floods which damage aus, jute, broadcast or transplanted aman, and sometimes *boro* or early rabi crops.

3.8 Fisheries

Fisheries is a major economic sector in the Northeast Region worth about 500 crore taka annually. It provides significant employment, income and food to the population. Fish production data collected from 1983 to 1989 indicates a general trend of increase in capture fishery production in the Region, averaging 3.0% per annum. The species composition of the catch has shown an increase in miscellaneous species (mostly small species used for subsistence consumption) and in Hilsa. But decreases have occurred in carp and big shrimp landings and many fishermen and fisheries personnel maintain that a long term decline in overall catch is taking place in the Region. Certainly for carp this appears to be the case. Two previously widespread species (NANDINA and ANGROT) are now practically extinct in the region. Other species have become rare in areas where they were formerly abundant. The future of the fisheries sector would appear to be under threat from a number of human activities. Fishermen generally attribute declines in fish abundance to three main causes: BWDB projects, various types of degradation of the environment, and overfishing.

Impacts of FCDI Projects on Fisheries

Regulators built across khals are a major impediment to fish migration during the early monsoon breeding season. The result is a reduction in spawn and recruitment, and a decreased abundance of some fish stocks. Full flood embankments reduce the area of water available for fish for spawning, nurseries and grazing. Submersible embankments allow flooding, but delay it (thus reducing the hectare-months of inundation). The combined result is a shrinking of fish habitat in time and space, and this will normally lead to a reduction in fish abundance.

Various possible mitigation solutions are being assessed. Loss of fish production due to reduced flood hectare-months can be compensated to some degree by increasing the capacity of dry season water bodies, which allows more fish to survive the dry season and spawn during the early monsoon. This would require converting seasonal beels to permanent beels by building embankments around individual seasonal beels and re-excavation of khals and silted up river beds. Replacing fall boards with manually operated steel gates at regulators would facilitate opening and closing of gates against hydraulic head. This would benefit fisheries when coupled with embankments around beels, as it would allow the gates to remain open for the early part of the pre-monsoon flood, thus creating a 'window' for fish migration in and out of the haor. Closing of the gates during flood recession would allow conservation of the largest possible

volume of water in the beels over the dry season (and some of this water could be used for boro irrigation). Another structural option is to compartmentalize beel clusters and paddy lands within an embanked haor, by constructing an internal embankment with regulators inside the haor which separates the beel cluster and poorly drained high risk land from easily drained low risk paddy land. The beel compartment would be allowed to revert to full fishery and wild natural products usage. Yet another option is to route embankments so that they bypass beel clusters altogether, thus maintaining free and unimpeded hydraulic connections between beels/high risk floodland and the adjacent rivers.

Degradation of Fisheries Environments

Fishermen have attributed direct and indirect losses in fish production to three forms of environmental degradation in the Northeast Region. *Water pollution* from industrial effluent causes fish kills in the large rivers during the dry season. Contamination of fish flesh renders it unfit for human consumption, not to mention lowering its market value. The worst offenders are the Fenchuganj fertilizer plant on the Kushiyara River (which discharges toxic ammonia) and the kraft pulp mill at Chatak (which discharges chlorinated phenolics, mercury and other toxins). The Fenchuganj plant is scheduled to be closed, but the Chatak mill requires installation of a tertiary effluent treatment system.

Conversion of haors to paddy cultivation has led to extensive and rapid *deforestation* in the region over the last 50 years. Dense stands of trees and brush harbour large fish populations during the flood season, and there is generally a direct relationship between forest/brush cover and fish abundance. Large scale clearing of wetland forests of hizal, koroch and other inundation tolerant tree species, as well as brush and reeds, has undoubtedly reduced the quality of the floodplain environment and its capacity to produce fish. There is an urgent need to reverse the trend of haor deforestation in the Northeast Region. The potential benefits of haor reforestation are many and varied and extend far beyond the fisheries sector.

Sedimentation is filling in many beels, reducing their mean depth and volume and converting some from permanent to seasonal status. Fishermen are well aware that this is reducing fish production. The sort term solution to the problem is of course re-excavation, and the proposal to build embankments around beels would be compatible with re-excavation. In the long term however, it is not clear if there exist any structural solutions to this problem. Studies at the regional and international level by the NERP sedimentology team will allow assessment of the possible long term impact of sedimentation on fisheries and the prospects for structural mitigation.

Overfishing

Overfishing of many fish stocks is widespread in the region. Beels that in the past were harvested only once in every three years are now being harvested every year (thus tripling fishing effort in this one habitat type alone). Reconnaissance of virtually any river in the Region will reveal a plethora of katha, liftnets and fish fences, as well as active and passive nets of all dimensions and possible specifications. Many nets are of illegally small mesh sizes which suggests a decline in the mean length of fish caught and the harvesting of juveniles (all conventional signs of overfishing). The reasons for overfishing are clear. 99% of all jalmohals in the Region are still under the *jalmohal leasing system* which inherently promotes resource mining and

overexploitation. Although it is imperfect in some respects and requires modification of some of its components, the *New Fisheries Management Policy* represents the main hope for instituting a new fisheries tenure, access and management regime in Bangladesh capable of achieving socially and economically sound resource management and conservation. Unfortunately, government has yet to restructure and implement NITIMALA, and focuses instead on generating tax revenue (which in itself is unlikely to achieve sustainable development and equity in the open water capture fisheries sector.

Effective management of artisanal fisheries has several key elements. Foremost is the *community-based management* (CBM) approach which is very successfully used in Japanese coastal fisheries. Many countries are now instating CBM. Its low cost and effectiveness cannot be matched by conventional central authority-based management regimes. Of fundamental importance to CBM is the recognition that the fishery resource must be owned by the fishermen themselves, and that the fisherman is the real manager of the resource. Long term tenure of the resource, control over access to the resource and management authority must all be in the hands of the genuine fishermen. To further strengthen CBM, there is a need to establish fish refuges. In the Northeast Region there exist certain deepwater localities known locally as "*mother fisheries*". These are major overwintering refuges for broodstock and control fish abundance over wide areas. Local fishing communities themselves curtail fishing effort in mother fisheries in order to protect the resource. Such locally initiated CBM needs to be supported by government and NGOs. Government itself has also designated certain areas as "*fish sanctuaries*", but enforcement is lax as insufficient finance has been allocated.

Large amounts of development capital are being spent on floodplain stocking of selected native and exotic carp. However, such efforts may be less successful than expected for two reasons: 1) it would be financially prohibitive to replace the entire natural broodstock and spawn with hatchery outputs, and 2) unless effective management of fishing effort is achieved simultaneously, all stocked fish are likely to be fished out within three years. No effort is being made to address the problem of declining biodiversity by rehabilitating seriously depleted stocks of native *NANDINA, ANGROT, SARPUNTI and MOHASEER.*

Future Prospects

Findings to date suggest that the floodplain fisheries of the Northeast Region probably do not have a secure and sustainable long term future if present trends in FCDI implementation, water pollution, deforestation, sedimentation and lack of effective fishing effort management continue. Solutions to most of these problems exist, or can probably be devised. There appears to be no shortage of development finance to implement viable mitigative solutions. Manpower would also not appear to be an intractable constraint. There are over 4,000 staff in the DOF alone, and NGO's could perhaps be mobilized. Re-training and re-targeted deployment of manpower to more important tasks would not seem to be impossible to achieve.

The most serious constraint would appear to be a lack of a decisive political programme to override vested interests in the current jalmohal leasing system, and to implement a community-based NITIMALA whose primary aim is not to generate revenue for government but to achieve economically sound and sustainable fishery resource utilization and significantly increase the net incomes of genuine fishermen. Whether or not such a scenario becomes reality will depend on

the interplay between the policies that local and national political leaders are interested to pursue and what actions the fishing communities themselves will chose to undertake to further their own best interests.

3.9 Wetlands

The wetlands of the Northeast Region provide many valuable goods and services to local residents, to the region as a whole, and to the nation, including:

- *Hydrological and physical values*. Flood control, sediment trapping, groundwater recharge, water purification, swamp forest trees that protect homesteads from erosion.

- *Economic production and employment*. In addition to fisheries production, local people harvest wild (undomesticated) plants for fuel, animal fodder, and housing materials. Some wetland plants make a critical contribution to the diets of the poor, especially in seasons when employment is low and after poor harvests. Trees and brush also play an extremely important role in providing shelter and food for fish. Industries based on wild plants have been proposed - for example, making paper pulp. A number of animal species are harvested, legally or illegally, for consumption, use, and export in the form of food products, skins, etc.; these include frogs and lizards. Some animals play an important role in keeping insect pest populations under control.

- *Biodiversity conservation*. Biodiversity refers to the variety of types of plants and animals. To conserve biodiversity means to help threatened species survive - usually by providing suitable habitats - that would otherwise disappear forever. Ongoing field studies under the Northeast Regional Project are determining what threatened animals and plants are surviving in the wetlands of the Northeast. The region still supports internationally important numbers of ducks and other water birds. Despite the ban on hunting, these animals also provide food and income for local people - in addition to sport hunting by rich locals and urban visitors.

- *Social and cultural values*. The wetlands of the Northeast have current or potential value for education, research, recreation, tourism, etc.

A wetland, as we use the term here, refers to an area that supports wild aquatic and semi-aquatic animals and plants while it is under water, which can be for all or part of the year.

Key Wetland Sites

Under the Northeast Regional Water Management Project, extensive field reconnaissance studies of the Northeast region were carried out to identify and characterize wetland sites that are of special national and international importance in terms of the wetland values mentioned above. Six internationally important sites have been identified, and field studies are being carried out to characterize these. In addition, sites of national importance for overwintering of fish broodstock ('mother fisheries') are being identified and studied. Each key wetland site identified is unique

in terms of overall physical characteristics, plant and animal communities, and human activities. The key wetland sites are shown in Fig. 3.9.

The Government of Bangladesh has, within the last few months, signed the Ramsar Convention and - at the recent Global Earth Summit in Rio di Janeiro, Brazil - the Biodiversity Convention. These agreements include measures to promote wise use and protection of wetland habitats and their biodiversity.

In signing these agreements, the Government of Bangladesh is signalling that it values the abundance and wide variety of valued goods and services that the country's wetlands and other biodiverse habitats provide to local people and to the nation. In turn, the Government of Bangladesh can ask the other countries that signed these agreements to help preserve and enhance Bangladesh's valued habitats.

Planning for various aspects of wetland management is divided amongst several government agencies, including the Departments of Agriculture, Fisheries, and Forests, the Ministry of Land, and the Bangladesh Water Development Board. The Ministry of Environment and Forests plans to bring representatives from these agencies together at a conference in November 1992 to exchange views on wetland issues.

In the future, as in the present, intensive rice cultivation will continue to be the wisest and most beneficial primary use of vast areas of the Northeast Region. But for other areas, where rice cultivation is too risky or yields are too low, other primary uses such as open water fish production, harvesting natural products, swamp forests provide greater economic and social benefit to the region's people. Enhancing conditions for secondary and tertiary uses can yield additional benefits. The challenge is to integrate the varied knowledge and efforts of local people, technical experts, and national policy makers, so as to enable each wetland system and site to be used as wisely as possible.

4. REGIONAL ANALYSIS

4.1 Regional Development

The population density in the Northeast Region is one of the highest in the world and half of the people are poor, disadvantaged, and living below the recommended nutritional levels. The Region has fertile land, but more than one-third of it is flooded for more than half of each year. In spite of the need for additional food and the population pressure, significant amounts of good agricultural land sit idle even during the monsoon months because of the poor economics of agricultural production.

The present environment bears little resemblance to its original state. To accommodate the need for social and economic development, forests on the hilly areas have been cleared and replanted to tea and citrus fruits; *Hijal* forests in the low lands have been cleared to make way for paddy and other crops, and many of the numerous rivers and water bodies have been controlled with water management infrastructure (such as embankments and regulators).

The transformation of the region from forests and uncontrolled rivers and flood plains to its present state has come at an environmental cost. There has been a loss of bio-diversity, and there are basically no "natural" areas left. There are however, certain areas which bear some semblance to the original state, and which continue to support various forms of the traditional biological systems. These have been identified as "key sites" and are recognised by government as being important environmentally. There is an intent to factor this importance into future development considerations.

Total agricultural production in the region is increasing gradually, but not as fast as population. The declining production per capita is impacting most seriously on the poor people. There is some inter and intra-regional movement of foods, but it appears that the poor are becoming worse off nutritionally. In Bangladesh, daily calorie supply represented 91% of 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.

The economy of the region is based almost entirely on agriculture and fisheries. However, both are poorly paid (70% of the labour force accounting for less than 40% of the regional GDP), and the regional product per capita is about 10% below the national average. The high dependence on agriculture and fisheries has also made it difficult for the region to keep pace with growth in the balance of the economy, eg. the target for national economic growth is 5% per annum (which the region would like to keep up with), while that for agricultural and fisheries growth is 3.6% per annum.

There are significant differences in the level of development at the sub-regional level. The western part of the region has an unusually high population density (750 people per sq km) and a high dependence on rice and jute. Its per capita GDP is 20% below the national average. The

eastern part of the region is relatively better off due to having a more diversified economy and higher foreign remittances. Development in the central part is almost entirely water related, reflecting the fact that almost all of it is deeply flooded for half of each year.

There is a perception that the region's economy is dominated by foreign remittances (from Sylhet people living in London and elsewhere) and accordingly, is wealthier than other regions of Bangladesh. In fact, foreign remittances are estimated to amount to about 5% of the Regional Domestic Product as compared to approximately 4% nationally. The remittances are mainly used for highly visible investments such as housing and business complexes in a few urban areas. In a regional context they have much less significance then is frequently assumed.

Government expenditures for social services in Bangladesh amount to less than 20% of the development budget, of which one quarter is for health and family planning. It is recognised by government that there is a considerable need for direct welfare oriented programmes, but such efforts have been hampered by a lack of an operational delivery system. The intent of Government is to target development efforts on the lower 50% of the population, and supplement this with increased direct welfare programmes. In the study region it is likely that at least 10%, and possibly 20%, of the population can only be assisted with direct and targeted programmes.

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 is envisaged in the national development strategy. The general problem of absorptive capacity in the region is also found in the health services. The larger health facilities in the larger urban areas tend to be over-utilized, whereas most Upazila Health Centres operate well below capacity. The use of health services will grow with the development of the region, but this will be a gradual process. It will require more than simply providing physical facilities.

The region is making good progress in education, but its literacy rate (21%) is lower than the national average (24%) and Bangladesh still ranks only 116 out of 131 countries assessed by UNDP. However, school enrolment has been increasing rapidly and, at present, about 40% of school age children are enrolled in school. Many of the schools are privately funded, and this trend is continuing. Principal deterrents to schooling appear to be economic (need to assist the family in economic activities) and distance to school.

There has been a major increase in the number of hand tube wells installed for drinking water in the region. This has resulted in significantly improved supplies of potable water in the affected areas. Because there is a cost associated with tube wells however, they tend towards the wealthier and more influential households. Parts of the region essentially does not have access to hand tube wells, and potable water is scarce, difficult to obtain, and of poor quality.

One of the principal needs related to water management in the study region is protection of shelter and personal property. While this objective is frequently voiced by residents of larger urban centres and villagers alike, methods for incorporating the objective in the planning process are poorly developed. Projects which are justified primarily on the basis of impacts on rice

production are often viewed by those affected as being equally important for protection of shelter and personal property, improved rice drying areas, and other "non-crop" benefits.

4.2 Development Trends

Development of the Northeast Region must be accelerated to keep pace with its expanding population and to remain in balance with the nation. The region is becoming relatively worse off economically, and the poor are becoming absolutely worse off. As well, the poor are becoming increasingly vulnerable to external vagrancies such as weather, food transportation systems, and other factors which affect their basic needs. The inequities between "haves" and "have nots" are growing. The situation is becoming urgent, and government is aware of this urgency.

The tendency has been to look to traditional agriculture as the main vehicle to improved regional development. It seems clear that a broader perspective will be required if the region is to keep pace with the balance of the nation. There is a particular need for job creation in the productive sectors and there appears to be some potential for expansion in fisheries and citrus, and value added industry related to several products. There has been limited industrial development, and the major constraints appear to be institutional and infrastructure. Both of these can be relaxed with a concerted effort by government.

Government is however, experiencing difficulties in increasing the rate of public investments in both the productive and social sectors. The problems are partly due to a lack of public funds, but also to a lack of absorptive capacity, and a multitude of institutional constraints (including those of foreign funding agencies). Simply increasing the budget does not translate into new development. Government programmes are hampered by the unavailability of materials and labour. Obtaining the required land for implementation is often a slow and difficult process. Initiatives often can not proceed because other parallel initiatives have failed and there are several "partially completed" projects in the area. The development approach must be balanced between sectors, and this takes time and comprehensive regional planning.

Private sector participation is one way to increase regional development. There are several examples in the region of successful joint public-private participation in social services such as schools and health clinics. While domestic savings in the region are only slightly above zero (both public and private), there are significant amounts of foreign remittances available for investment. However, private sector participation has long been curtailed by government policies and procedures. There are now positive trends in this regard, but private sector participation will only occur if all of the essentials are available, including infrastructure, communications, transportation, and all other factors which affect profitability. At present, there are relatively few good investments available to the private sector in the project region. The current direction is favourable, but it will take time to achieve significant results.

Traditional economic instruments have proven to be relatively ineffective for promoting regional development because a substantial portion of the population are unaffected by such measures (perhaps one half of the people are poor and disadvantaged, and one-third of the economy is outside the formal sector). At the same time, these groups represent a major potential resource for development of the region because of their relatively high efficiency. This

is recognised in The New Economic Perspective, but including these groups in the development process has proven to be extremely difficult. Targeted efforts (such as FFW and NGO activities) are reaching the poor, but the programmes are small in comparison to total needs. As well, due to institutional constraints, the resultant efforts are not necessarily associated with the most productive use of the resources, eg. there has been much construction of non-functional infrastructure.

Regional development expenditures have typically reflected a high priority to the construction of new infrastructure, a lesser priority to operation and maintenance of the infrastructure, and a relatively low priority to human resource development. The result has been a gross overestimation of the usefulness of much of the new infrastructure, and a substantial amount of the investments are under utilized. This situation has resulted, in part, from the rush by government and foreign funding agencies to disburse funds, particularly for highly visible projects.

The bias resulting from the pressure to disburse funds has extended into the planning process. Project planning has typically been carried out without adequate reference to the intended objectives, or the objectives have been restricted to agricultural impacts. In part this has been due to a lack of participation at the local level. Projects have resulted which do not serve the needs of the community for whom they were intended. More realistic plans would have resulted in different investment patterns.

There is also evidence that planning has suffered to a degree from inadequate technical information, particularly related to drainage. A common symptom of drainage problems is public cuts, many of which seriously compromise the viability of the schemes. As well, projects typically take longer to implement than was planned. This problem manifests itself in many ways, not the least of which is that projects appear better than they should at the planning stage.

A frequently cited shortcoming related to water development projects is the inadequacy of operation and maintenance, which leaves many of the projects in a poor state of repair and dysfunctional. Central reasons appear to include: lack of public participation which has also lead to project concepts which are inappropriate, resource constraints, and poor quality of workmanship.

Because of the complexity of the bio-physical, social and economic environment, it is almost impossible to identify (and thereby apportion) the impacts of any particular water development intervention. However, it is clear that the benefits of water projects have not always gone to the intended beneficiaries. Some of the unexpected results of water development are listed below.

- In various cases, beneficiaries disengage themselves from association with completed projects because; the projects do not fulfil expectations, or they have become dysfunctional without a repair mechanism.

- More than anticipated amounts of good agricultural land have been removed from production due to FCDI.

- Bovine populations have been adversely affected by FCDI projects due to lost grazing opportunities including lower crop losses.

- Demand for draught power which is already in short supply has increased, and this has impacted badly on small farmers.

- There has likely been some net negative impact on fish production and social conflicts have been generated between fishermen.

- Benefits and dis-benefits in the transportation sector have been about the same, not accruing to the same groups.

- Water development has not improved the nutritional status of the most vulnerable, especially women or children.

- Tensions have been exacerbated between insiders/outsiders, farmers/fishermen, farmers/boatmen, and farmers/farmers.

- In certain instances, development has resulted in increased damage to personal property due to higher flow rates and the false sense of security which sometimes accompanies new flood protection measures.

4.3 Development Constraints

There are constraints which must be viewed as only partially, if at all, controllable in the planning for regional development.

Land Acquisition

Seemingly small requirements for land for development purposes can, in the project region, translate into a complete loss of livelihood and living space for a large number of families. A large percentage of the residents are landless, and expropriation of lands simply adds to this number. The economic consequences are manageable, but the social consequences are large and very difficult to mitigate. This situation will not change until opportunities are created which allow those affected to re-establish themselves.

Investment Capital

The chronic shortage of domestic savings is not going to change rapidly. There is very limited scope for government to increase tax revenues, the private sector requires almost all of its earnings for consumption purposes, and there is no well organized financial system for encouraging savings.

National savings (which include the important foreign remittances) is an important source of investment capital for the project region, but there is no reason to assume that this will increase substantially from present levels. The plan should make a concerted effort to make full use of these funds, but recognise that this will amount to only a fraction of the total investment required in the region.

In consequence, the regional development will be heavily dependent on foreign aid for much of the development investment. This poses problems in terms of counterpart funding, and institutional and administrative requirements. The need is to continue to streamline the planning and disbursement process for aid funded projects.

External Influences on Water Resources

Most of the region's surface water originates in the upper catchments which are located in India, over which Bangladesh has little control. Various developments in these catchments are under active consideration and have the potential to have dramatic negative impacts on the livelihood of millions of people in the northeast region. A major consideration from a planning perspective is that there is very incomplete information on how Indian initiatives will impact on the region. Potential impacts are in the area of water supply during the winter and summer months, sediment supply, transportation systems, severity of floods, and almost every aspect of regional development. The planning process must factor in the incompleteness of information as a risk consideration.

4.4 Development Issues

The Northeast Region has a number of major needs, and decision makers will be faced with some difficult choices in selecting a development strategy. The more important of these considerations are discussed below.

Economic versus Social Development

Government has attached a high priority to economic development in the current development plan. This objective reflects the realities that it will be impossible to achieve significant social development without prior economic development. At present basically all tax revenue goes for consumptive (versus development) purposes and there seems little room to collect additional taxes without further economic development. National savings and domestic investment are chronically low, and almost the entire annual development programme is foreign funded. While there is no shortage of development aid available, government is experiencing growing difficulties in disbursing the aid, reflecting, in part, the lack of economic development. In total, failure to achieve improved economic growth will result in continued difficulties in improving the quality of life of the people, not simply due to a lack of social investment capital - but also because it will not be possible to expend the funds in a way which helps.

Potential investments in the study region vary widely in terms of economic and social benefits and costs. For example, investments in export crops (such as tea) may have large direct economic benefits whereas increased investments in rice production to fill the hunger gap would be very attractive socially, but less attractive economically. Choices will need to be made, i.e. it will not be possible to pursue all options.

Government hopes to achieve some complementarity in its economic and social objectives by including the poor and disadvantaged in the development efforts (although this would be supplemented by increased and better targeted welfare oriented programmes). If feasible, such an approach would clearly be desirable. Even with such "win-win" situations however, the basic question of trading off economic with social objectives will remain as long as two or more potential initiatives have dissimilar economic and social characteristics. The way the two

objectives are traded-off is a major point of debate and one which must be answered by policy makers.

Appropriate Recognition of Cultural Values

Cultural traditions will play a significant role in determining the acceptability of alternate development approaches. For example, the importance of rice to certain people of the region extends well beyond the nutritional value; rice connotes pleasurable food and plenty, whereas wheat connotes poverty and hardship. There are numerous examples of societies opting for certain types of development for cultural reasons. Such cultural choices in the planning process are necessarily highly subjective.

Appropriate Bio-physical Protection/Enhancement

Government has stated an intent to give adequate consideration to the environmental impacts of any proposed development. This may result in some sacrifice by the current generation in favour of future generations. A major case in point in the study region is the protection of the six "key sites" which have been identified as being important environmentally. It is unlikely that the environmental attributes of these sites can be fully maintained without some loss in their potential to produce food.

Dependence on Rice

The importance of rice to the people of the region is well known. It accounts for about 50 percent of the total agricultural and fisheries output of the region, it is the staple of choice, and it has deep rooted cultural significance. The heavy dependence on rice however 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 economy has been growing at up to double this rate, implying that the region is becoming worse off relative to the balance on the economy. Furthermore, rice production per capita appears to be decreasing in the region, implying that many people in the region are not only relatively worse off, they are absolutely worse off. The situation is worsening, and the greatest impact is likely on the poor and disadvantaged.

In total, predicating a development strategy purely on increased rice production would not be advisable. Yet, to shift from this approach would be to break with tradition and introduce new dimensions of risk.

Improved Planning versus Early Action

One of the most frequently criticized aspects of water development in Bangladesh is the planning phase. Undoubtedly many of the shortcomings are real, and the entire planning process needs re-examination.

It is also necessary to recognise however, that improved planning takes time, and benefits are foregone during this interval. The need is to find the right balance between the correctness of the plan and the time it takes to formulate, and this balance will be determined in large part by the availability of data/information and the consequences of erring.

In a NERP context, the planning involved relates mostly to the centralized planning function (water flows, infrastructure costs, etc.), and local level planning (village objectives, target

participants, etc.). Of the two planning levels, local level planning is by far the most difficult to achieve. It is a time consuming and very inexact process, and a process for which there are no ready made techniques. In the mean time, the population is growing, as are the disparities, and the quality of life for the poorest people in the region is declining. Failure of local level planning, however, can have severe implications (breaches, abandonment, etc). The challenge is to search for an appropriate balance.

Involving the Poor and Disadvantaged

The poor and disadvantaged account for up to half of the regional population, and 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 improvement in basic quality of life. Such an undertaking, however, would require a new approach, and it would require an investment (financial, human resources, administration, delayed development, etc.). As well, there would be a risk due to the unknowns involved, and a well intentioned approach could result in a worsening of the situation. Specification of the best "risk-benefit" combination can only be made by those who are directly affected.

Spatial Distribution of Benefits

In development planning, benefits accruing to the poor and disadvantaged are typically accorded a higher value than those accruing to the better off. However, there are distributional questions involving rural versus urban, and regional versus national. There is not a good way to compare the plight of the urban versus rural poor. As well, many of the poorest people of Bangladesh live outside the project region and certain types of initiatives will yield a greater proportion of the benefits to these external people, eg. the Region has a rice surplus , but it also has a large group of hungry people. The issue is whether these various groups should be accorded equal consideration in the evaluation of initiatives.

4.5 Regional Planning Units

A regional analysis was carried out to classify the land according to major landform type, soils and geology, and topography. On the basis of this analysis, six dominant landform classes and 12 physiographic units have been delineated. The classification provides a rational basis for dividing the region into homogeneous planning units. These planning units will become the basis for assessing variations in resource use, development, and development impacts. A detailed description of the planning units is provided in Annex B.

Most landforms in the study area are of fluvial origin, although some have been modified as a result of tectonic processes (subsidence or uplift). The most dominant feature in the region is the Central Sylhet Basin, which extends 60 km west-east and 120 km north-south. This unit, which makes up 25% of the region, consists of *haors* flood basins and *beels* inter-connected by an intricate network of river channels and *khals*. The basin is bordered by Surma/Kushiyara River floodplain on the east, Old Brahmaputra River floodplain on the west, Meghna River floodplain on the south and by a fringe of alluvial fans along the north.

Comparison of the land units shows there is a close relationship between topography, soil characteristics, depth of flood inundation and land-use. For example, maps of major land use activities show that boundaries for tea and forests correspond to the steep uplands, rabi crop areas correspond to the areas of raised terraces (Madhupur Tract), *aus* rice and transplanted *aman* rice are grown on the major floodplains and *boro* crops are mainly found in the low-lying deeply flooded basins and haors.

ANNEX A

FLOOD ACTION PLAN COMPONENTS

FLOOD ACTION PLAN Plan Components and Supporting Activities	Executing GOB Agency	Donor(s)
1 Brahmaputra Rt.Emb. Strengthening	BWDB	IDA
2 North West Regional Study	FPCO	UK, Japan, FRG
3 North Central Regional Study	FPCO	EEC, France
3.1 Jamalpur Priority Project	FPCO	France, EEC
4 South West Regional Study	FPCO	ADB/UNDP
5 South East Regional Study	FPCO	IDA/UNDP
6 North East Regional Study	BWDB	CANADA
7 Cyclone Protection Project	BWDB	EEC
8a Greater Dhaka Protection Project	BWDB	Japan
8b Dhaka Integrated Town Protection Project	FPCO	ADB
9a Five Towns Protection Project	FPCO	ADB, IDA
9b Meghna LB Protection Project	FPCO	IDA
10 Flood Forecasting & Early Warning	BWDB	UNDP, Japan, ADB
11 Disaster Preparedness	BWDB	UNDP, USA
12/13 FCD/I Agric. Review and O&M Study	FPCO	UK, Japan
14 Flood Response Study	FPCO	USA
15 Land Acquisition and Resettlement	FPCO	Sweden
16 Environmental Study	FPCO	USA
17 Fisheries Study and Pilot Project	FPCO	UK
18 Topographic Mapping	FPCO	Finland, France Switzerland
19 Geographic Information System	FPCO	USA
20 Compartmentalisation Pilot Project	BWDB	NL, FRG
21/22 Bank Protection & AFPM Pilot Project	FPCO	FRG, France
23 Flood Proofing Pilot Project	FPCO	USA
24 River Survey Programme	FPCO	EEC
25 Flood Modelling/Management Project	FPCO	Denmark Netherlands France, UK
26 Institutional Development Programme	FPCO	UNDP

ANNEX B

REGIONAL LAND CLASSIFFICATION

ANNEX B

REGIONAL LAND CLASSIFICATION

1.0 BACKGROUND

A review of the northeast region's physiography has been carried out in order to delineate areas which display relatively similar physical characteristics (such as landforms, topography, soil characteristics). The land classification analysis was conducted to help provide a rational subdivision of the region into homogeneous planning units. These planning units will become the basis for assessing variations in land-use and development activity within the region.

It is recognized that physiography is only one of the important parameters that can be used to help establish planning units within a region. Other parameters include social and environmental criteria. In Bangladesh, where the pattern of land-use seems to be so closely related to the physical characteristics of the land and rivers, it is expected that these other factors may be inter-related.

2.0 BACKGROUND INFORMATION

2.1 Previous Studies

Several previous studies have reviewed the physiography of Bangladesh including Morgan & McIntire (1959), Rashid (1991), Davidson (1986) and Geological Survey of Bangladesh (GSB, 1991). These studies have divided the entire country into several different regions. However, the geographic boundaries have generally been displayed on very small scale maps (1:1,000,000 or less) which makes it difficult to apply these results at a regional or local scale. Furthermore, a comparison of the various classifications showed there are considerable differences in defining physiographic boundaries and land units. Therefore, it was considered that additional detailed work was warranted to refine these previous efforts and to develop a classification that would be most appropriate for the northeast region.

2.2 Methods

The main sources of information are:

- 1:50,000 scale colour SPOT satellite imagery of the region (45 sheets) and 1:100,000 scale black & white photo mosaics;
- digitized spot elevations on a 1 km grid throughout the region (from MPO);
- 1:15,840 scale topographic maps with spot heights;
- 1:1,000,000 scale geological mapping (GSB, 1991);

- information on annual flood levels at hydrometric stations (MPO, 1987),;

The colour SPOT imagery was carefully reviewed to identify landform types and to delineate geomorphic features. Tentative physiographic boundaries were then transferred onto 1:100,000 photo mosaics.

A generalized map of the region's topography was prepared using the digitized spot height data for the region (about 35,000 points). A BASIC program was used to analyze the spatial distribution of land elevations. Output from the program was then displayed and plotted using AUTO-CAD.

All of the rivers and haors were digitized from the 1:50,000 colour SPOT imagery to produce a set of AUTO-CAD drawing files. Information on surficial geology was also digitized from the available mapping provided by Geological Survey of Bangladesh.

Since the information on land topography, channel patterns and soils could all be displayed at any desired scale and superimposed on the computer, it was all incorporated in the process of delineating landforms and sub-region boundaries. A final decision on physiographic boundaries was then based on both visual interpretation of the satellite imagery and the use of the digital mapping data.

3.0 REGIONAL ANALYSIS

The region was then divided into six major landform units:

- haors and flood basins
- lowland floodplain
- piedmont floodplain
- alluvial fans
- terraces
- uplands

With the exception of the uplands, these units are a product of relatively recent fluvial processes. In the case of terrace lands, fluvial processes have been modified as a result of ongoing tectonic processes (uplift, which has raised some floodplain land above the level of present-day flood levels).

The proposed land classification boundaries are shown in Figure B.1 Dominant landform types have been distinguished by different shading patterns. In some cases, landform units have been sub-divided into two or more physiographic units (for example, lowland floodplains have been sub-divided into Surma/Kushiyara, Meghna, Old Brahmaputra and Jamuna).

The following notes describe the basis for delineating each unit.

3.1 Haor and Basins

The single most dominant topographic feature of the Region is the Central Sylhet Basin, a "bowl-shaped" depression that extends roughly 60 km east to west and 120 km in a north-south direction. The mean elevation in this basin is about 5.5 m (PWD datum) and substantial areas are below El. 3 m.

The origin of this regional scale feature has not been fully explained. Its low topography indicates the basin has not received as much sediment as other areas to the west and east. For example, in earlier Holocene times the basin may have been an embayment, with deltaic sedimentation occurring to the west from the ancient Brahmaputra River and to east from the Barak River. In addition, land in this area is believed to be experiencing the highest rates of subsidence in Bangladesh (Coleman, 1969). As a result, any long-term aggradation that occurs in the basin may be offset by subsidence of the surrounding land.

Aside from this large regional-scale basin there are several smaller features such as *haors* and localized flood basins. These features are not permanent, but evolve over time as a result of nearby fluvial activity. For example, an active channel on a large river may be cut off and become isolated from sediment sources as a result of other channel shifting. If the land near this cutoff is actively subsiding, it may gradually evolve into a haor (examples of this process can be seen near Sylhet). Similarly, some former haors may be infilled as a result of increased sedimentation and eventually become part of the active floodplain.

The boundary between basins and floodplain land is gradational and can not be distinguished on satellite photos or maps. Therefore, in this study, the extent of the basin/haor unit was defined in terms of ground elevation and depth of inundation. It was decided that lands inundated to a depth of more than 1.8 m by a mean annual flood would be included in the basin/haor unit. The choice of 1.8 m as a criteria for inundation was made to be consistent with the definition of MPO's "deeply flooded areas".

Table B.1 lists some mean annual flood levels at hydrometric sites in the central part of the Region (MPO, 1987). The estimated flood levels reach around El. 9.3 m - 9.8 m in the north part of the basin, around El. 7.5 m - 7.7 m along the southern side. Based on the criteria described above, the unit's boundary was found to vary between approximately El. 5.7 m - 8.1 m.

The haor and basin unit was sub-divided into three physiographic sub-units:

- the Meghalaya depression on the north side of the Surma River. This area contains several large haors that abut against alluvial fans. Periodic channel shifting causes the large amounts of sand to be deposited in the haors.
- the Central basin, which continues south of the Surma River as far as the Meghna River.
- Sylhet lowland, which contains several large haors (such as Hail Haor)

Table B.1: Mean Annual Flood Levels at Selected Hydrometric Stations

Hydrometric Station	Gauge Number	Water Level (PWD m)
Surma R. at Chattak	268	9.88
Surma R. at Sunamganj	269	8.55
Jadukata R. at Saktiarkhola	131	9.31
Kushiyara R. at Manamuk	175	9.17
Dhanu R. at Kaliajuri	72	7.77
Kangsha R. at Mohanganj	36.1	7.66
Surma/Meghna R. at Markuli	270	7.73
Surma/Meghna R. at Ajmiriganj	271	7.45
Meghna R. at Bhairab Bazar	273	6.60

Note: All values from Table 2-2 of MPO (1987) "Floods and Storms", Technical Report 11

3.2 Lowland Floodplain

Floodplains are landforms created as a result of fluvial deposition and erosion. Floodplains include channel deposits such as point bars and channel fills, bank deposits such as natural levees and crevasse splays and fine grained flood basin deposits. Floodplain land consists of silts and clay with organic rich clays in low lying areas (GSB, 1991). Channel fills contain more fine sand and silty sand material.

Most of the large rivers in the region display a meandering or anastomosed channel pattern[1/] As a result, the most common floodplain features that can be readily identified from the satellite imagery include natural levees, oxbows and abandoned channels that have been partially infilled.

There are four major lowland floodplains in the region and each has been identified as a separate sub-unit:

- Surma/Kushiyara River floodplain
- Old Brahmaputra River floodplain
- Meghna River floodplain

1/. Anastomosed channel patterns are found when a river splits into two or three meandering distributary channels which then re-join into a main single channel after a short distance downstream.

- Jamuna River floodplain

3.3 Piedmont Floodplain

Piedmont streams issue from tributary valleys and join larger lowland rivers. Gradients of piedmont streams are typically steeper than the larger trunk rivers and the floodplains contain appreciable amounts of sand.

Important piedmont streams include the Juri, Manu, Dhalai Lungla, Khowai and Sutang Rivers which flow north from the Tripura Hills in India. These streams can be distinguished from the alluvial fans of the Meghalaya Plateau since they flow in defined valleys and do not exhibit the same pattern of lateral channel shifting.

The downstream boundary between piedmont and lowland floodplain is gradational and not always easily distinguished on satellite imagery. Therefore, the boundary was defined on the basis of topographic elevations.

3.4 Alluvial Fans

Alluvial fans are produced when steep mountainous streams exit from their canyons and spread over flat unconfined lowlands, depositing gravel and sand in a "fan-shaped" or "conical" delta. Alluvial fans are characterized by sudden, irregular channel shifts (avulsion) caused by local channel aggradation which results in overspilling of banks and development of new channels across the fan surface. Sediments in the fans draining the Meghalaya Plateau generally consist of boulders and cobbles at the canyon apex and coarse sand or pea-gravel within a few kilometres downstream of their canyon.

A key feature of the Meghalaya fans is that they appear to be dominated by sand transport and the incoming sediment loads appear to be very high.

Fan surfaces were distinguished on the SPOT imagery by the presence of braided channels, recently abandoned spill channels and sandurs (sandy outwash plains).

3.5 Terrace

A terrace is usually considered to be land that was originally created by fluvial activity but is no longer subjected to inundation by normal flood events. Floodplain lands turn into terraces either as a result of river degradation or by uplifting of the floodplain land (due to tectonics and faulting).

Uplifted Pleistocene age deposits of the Madhupur Tract outcrop in isolated areas on the east side of the Old Brahmaputra River, within the study area. The sediments consist of silty clay to sandy clay and have an oxidized upper surface layer as a result of weathering. The deposits have been dissected by small streams and gullies which produces a very distinctive, and easily identified dendritic drainage pattern.

Land elevations within the unit typically range from 8 m - 13 m. A review of recorded water levels on the Old Brahmaputra River at Motkhola indicated flood levels have ranged between El. 7.8 m and 9.72 m over the period 1964 - 1983 and averaged around El. 8.5 m. On this basis, all land above El. 9 m was considered to be terrace and land below 9 m was considered as floodplain.

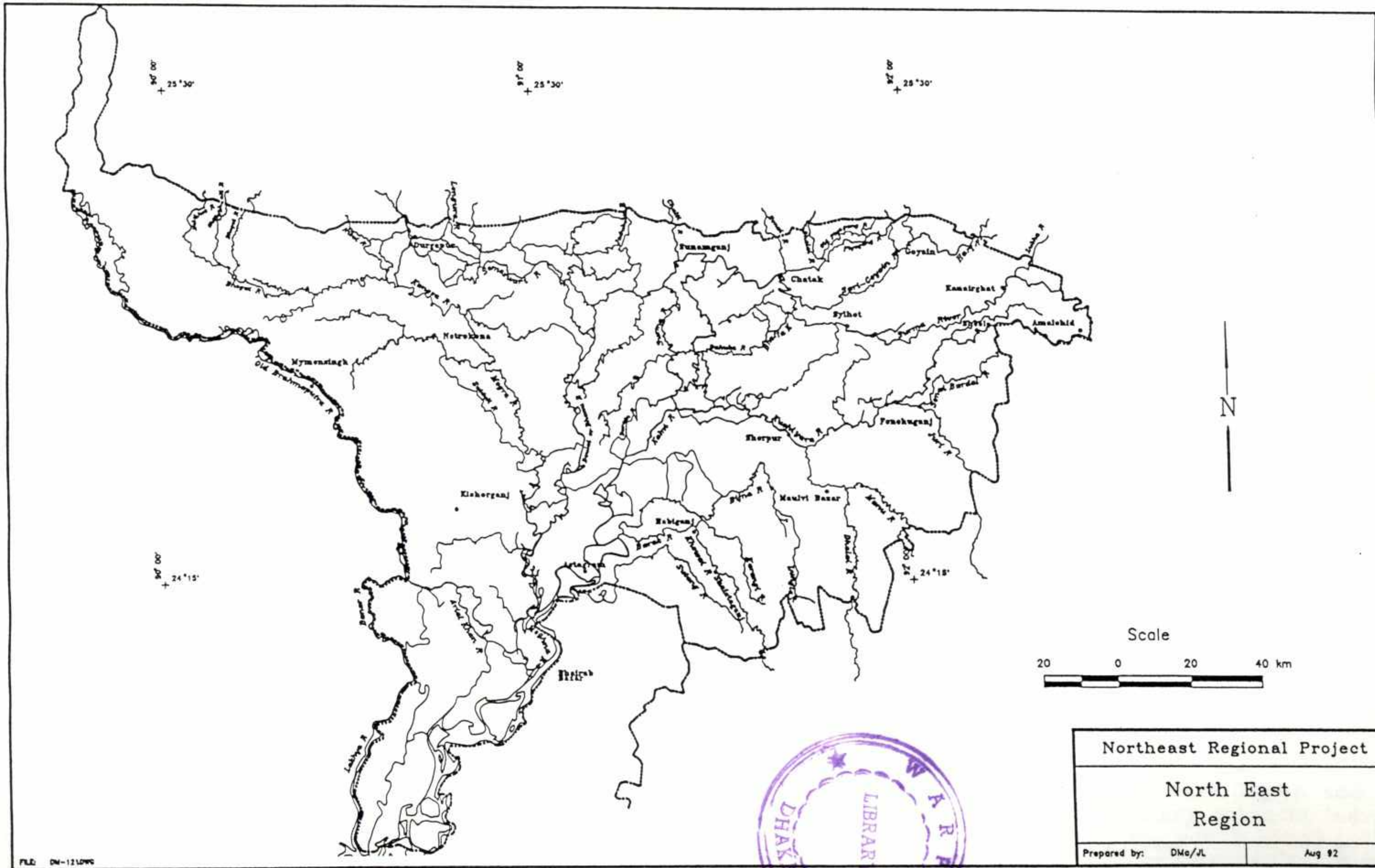
3.6 Uplands

Upland areas were digitized from the SPOT imagery and were delineated visually. At lower levels, the uplands generally consist of Dihing and Dupi Tila Formation rock (Pleistocene and Pliocene age) composed of weathered, poorly consolidated sandstone, siltstone and conglomerate (GSB, 1991). These deposits are modified by gullying and slumping and it was sometimes difficult to distinguish the materials from colluvium and piedmont stream deposits. At higher elevations the rock is mainly Tipam sandstone and shale, siltstone and sandstone of the Surma Group.

Uplands have been sub-divided into two physiographic units, following the convention of Rashid (1991):

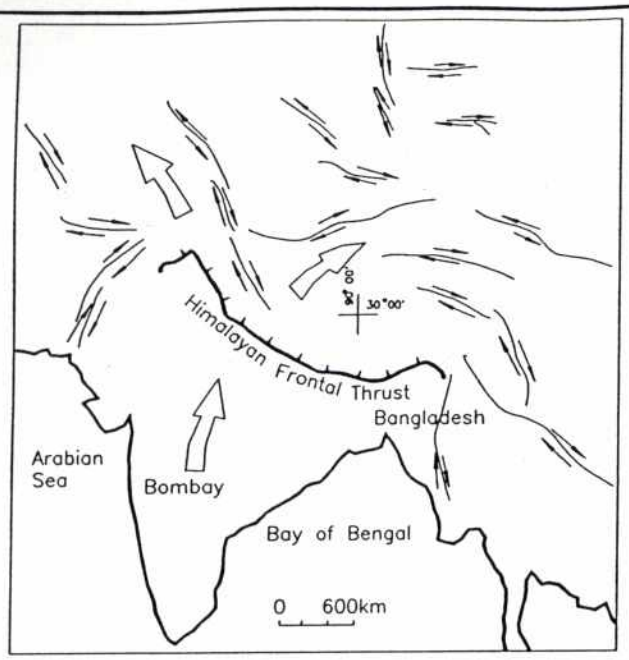
- Susang Hills along the north west corner of the region;
- Sylhet Hills along the east and southern portions of the region;

FIGURES



Northeast Regional Project	
North East Region	
Prepared by: DMo/JL	Aug 92

Figure 3.1



LEGEND

Thrust fault

Strike Slip fault

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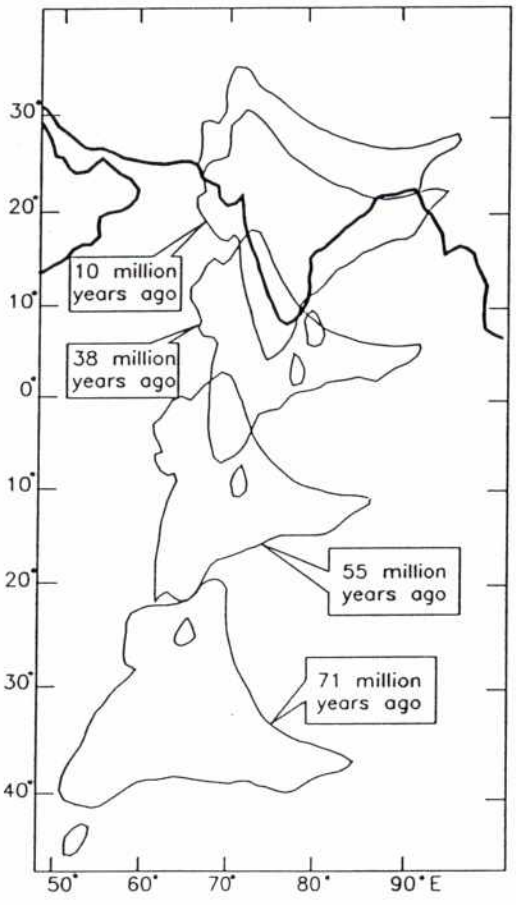


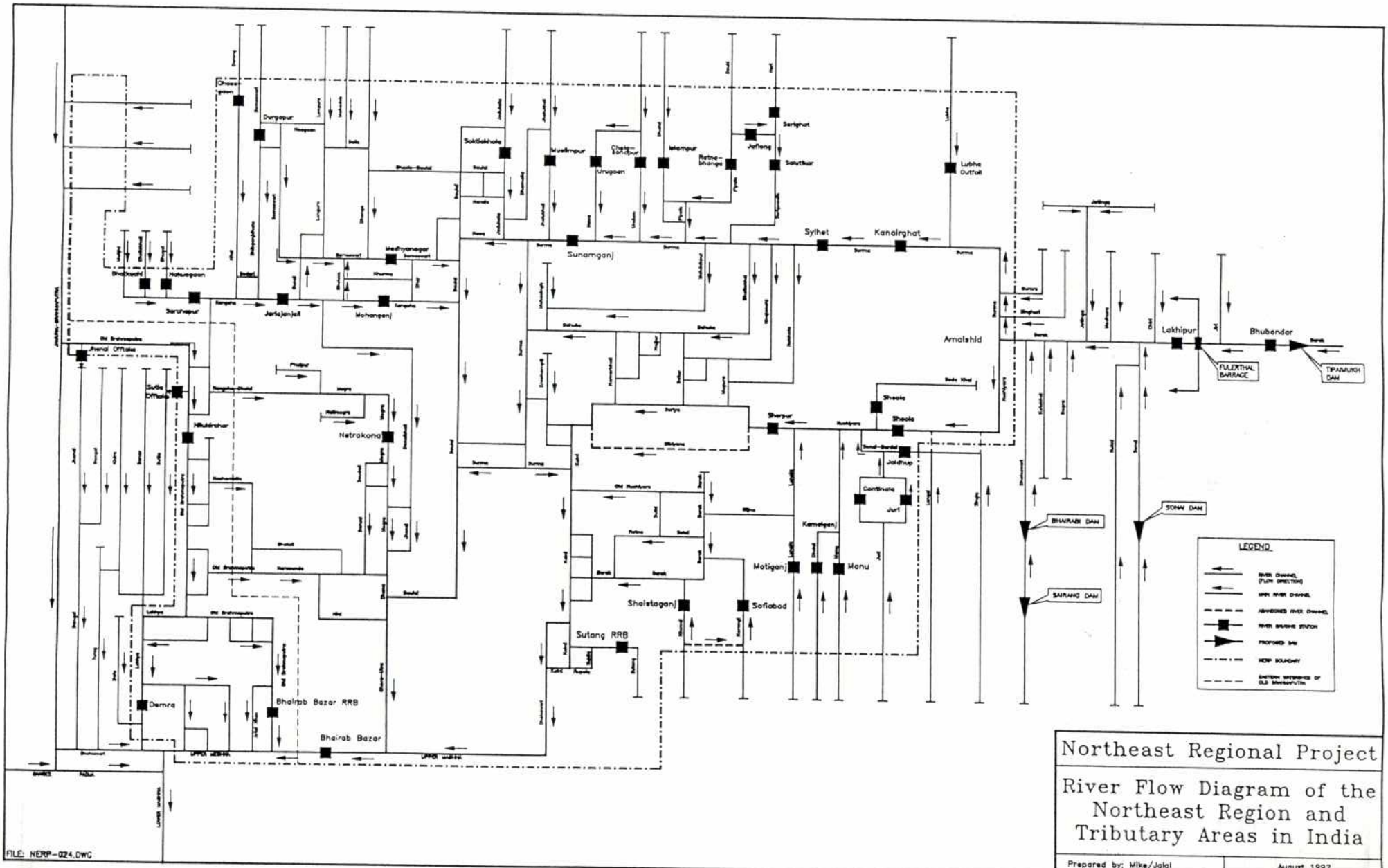
Northeast Regional Project

Geological Evolution of Bangladesh

Prepared by: DAVE/SJ	April 1992

FILE: NERP-021DWG

Figure 3.2



Northeast Regional Project

River Flow Diagram of the Northeast Region and Tributary Areas in India

Prepared by: Mike/Jalal | August 1992

Figure: 3.3

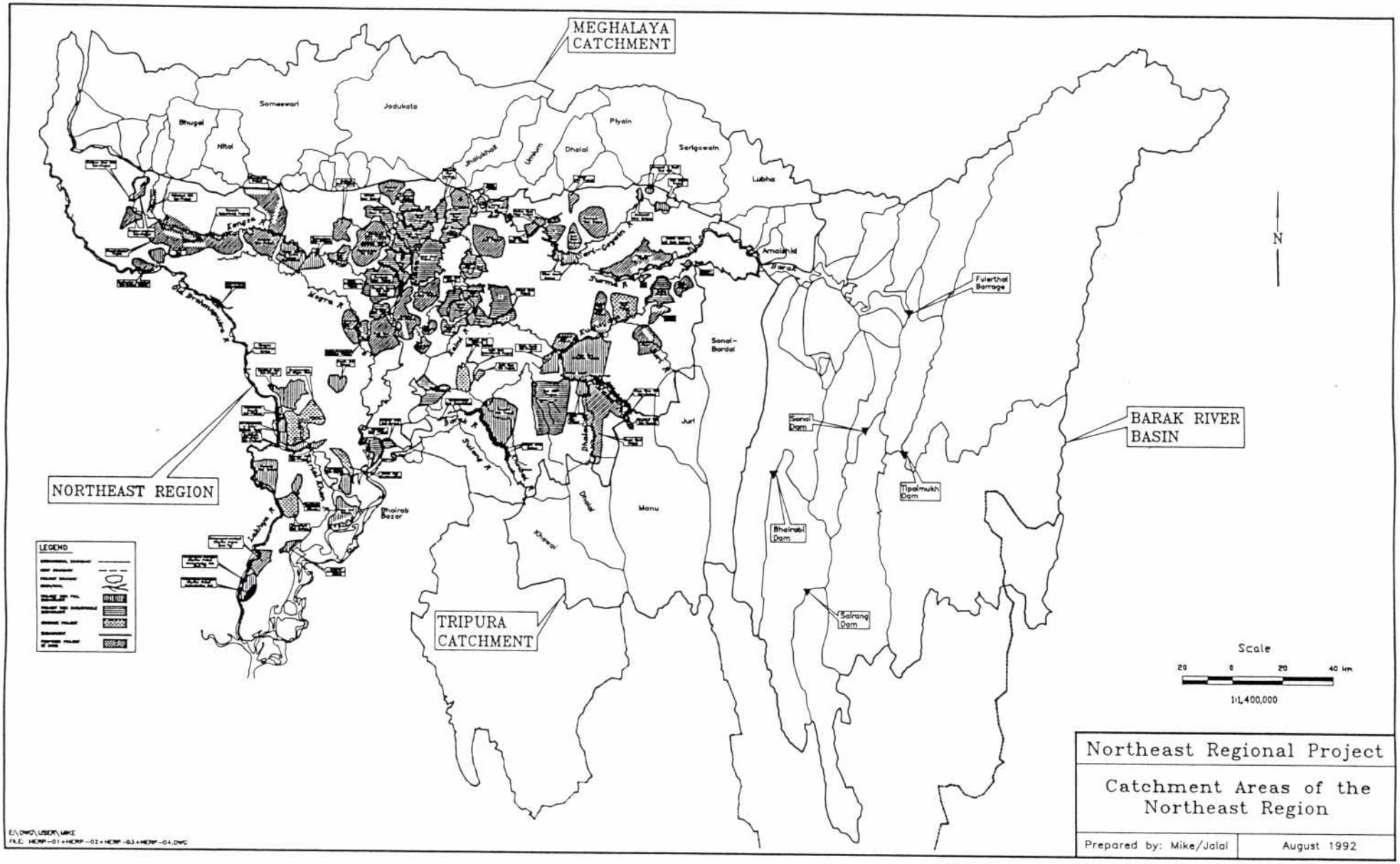

MEGHALAYA CATCHMENT
NORTHEAST REGION
TRIPURA CATCHMENT
BARAK RIVER BASIN
Someswari
Jadukata
Bhugal
Nitai
Dhalai
Piyain
Serigowain
Lubha
Sonai-Bardal
Juri
Manu
Khowai
Fulertal Barrage
Sonai Dam
Tipaimukh Dam
Bhairabi Dam
Salsang Dam
Bhairab Bazar
N
Scale
20 0 20 40 km
1:1,400,000
LEGEND
Northeast Regional Project
Catchment Areas of the Northeast Region
Prepared by: Mike/Jalal
August 1992

Figure: 3.4

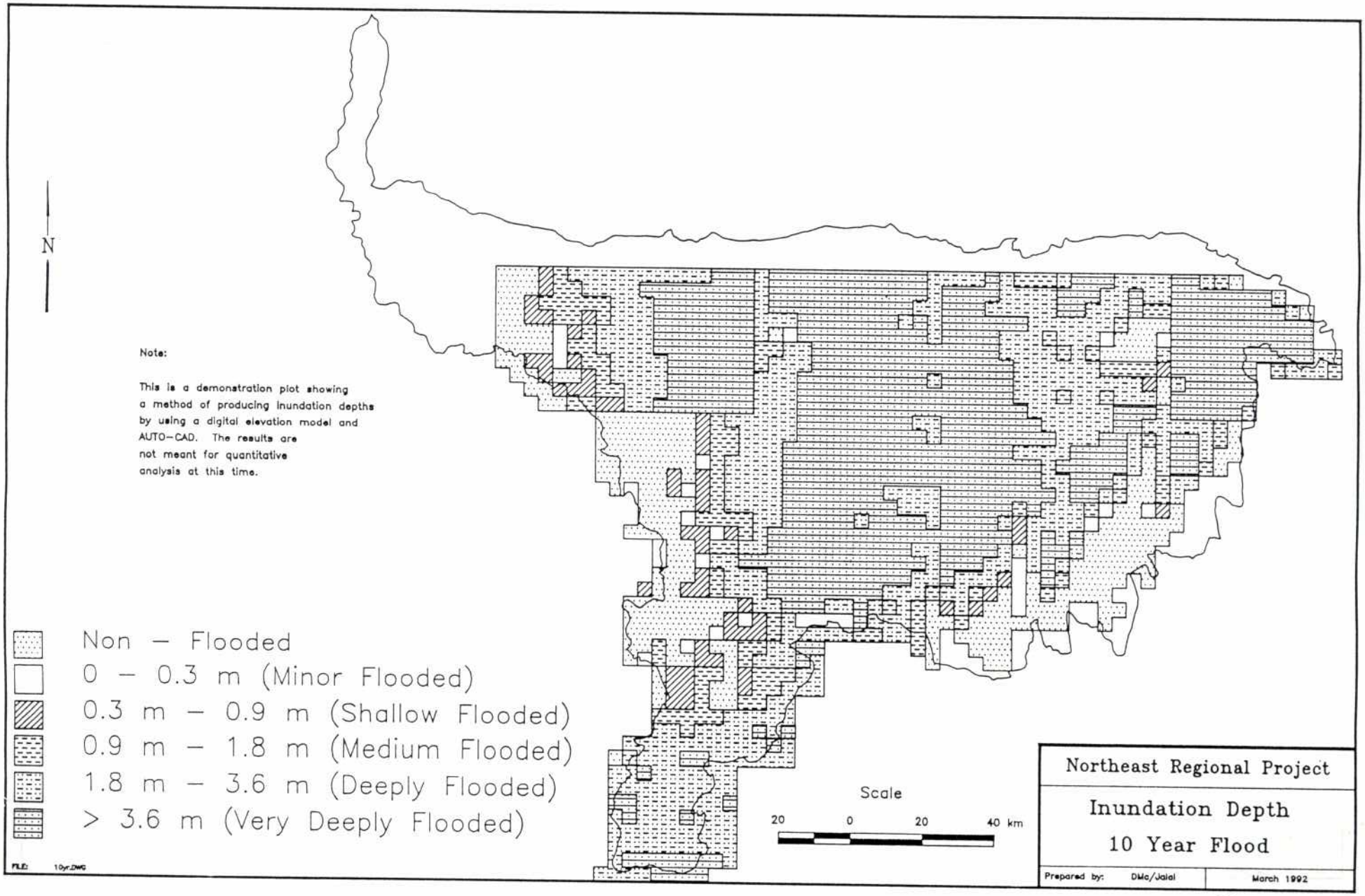
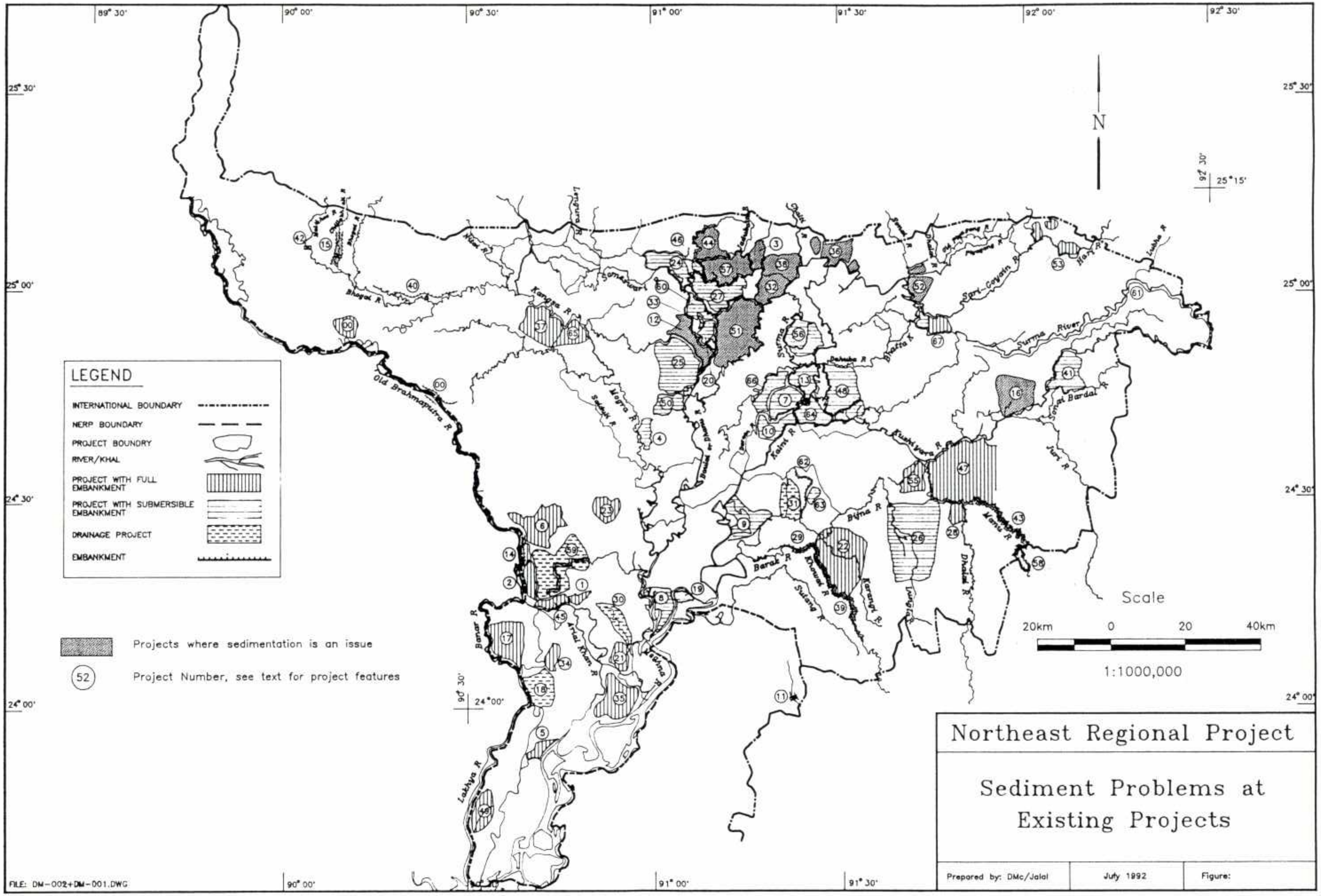

N
Note:
This is a demonstration plot showing a method of producing inundation depths by using a digital elevation model and AUTO-CAD. The results are not meant for quantitative analysis at this time.
Non - Flooded
0 - 0.3 m (Minor Flooded)
0.3 m - 0.9 m (Shallow Flooded)
0.9 m - 1.8 m (Medium Flooded)
1.8 m - 3.6 m (Deeply Flooded)
> 3.6 m (Very Deeply Flooded)
Scale
20 0 20 40 km
FILE: 10yr.DWG
Northeast Regional Project
Inundation Depth
10 Year Flood
Prepared by: DMc/Jalal
March 1992

Figure 3.5



Northeast Regional Project

Sediment Problems at Existing Projects

Prepared by: DMc/Jalal	July 1992	Figure:

Figure 3.6

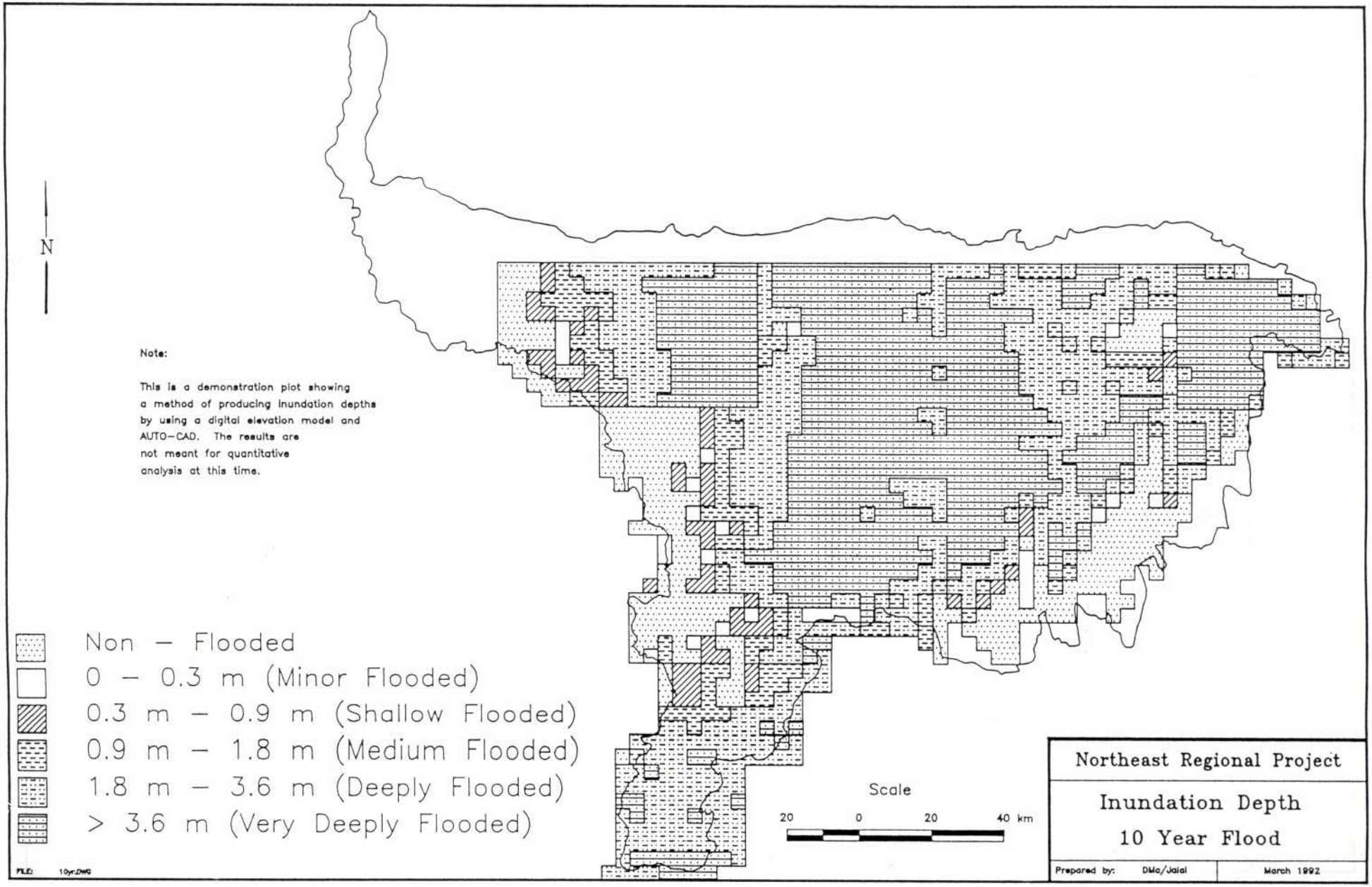
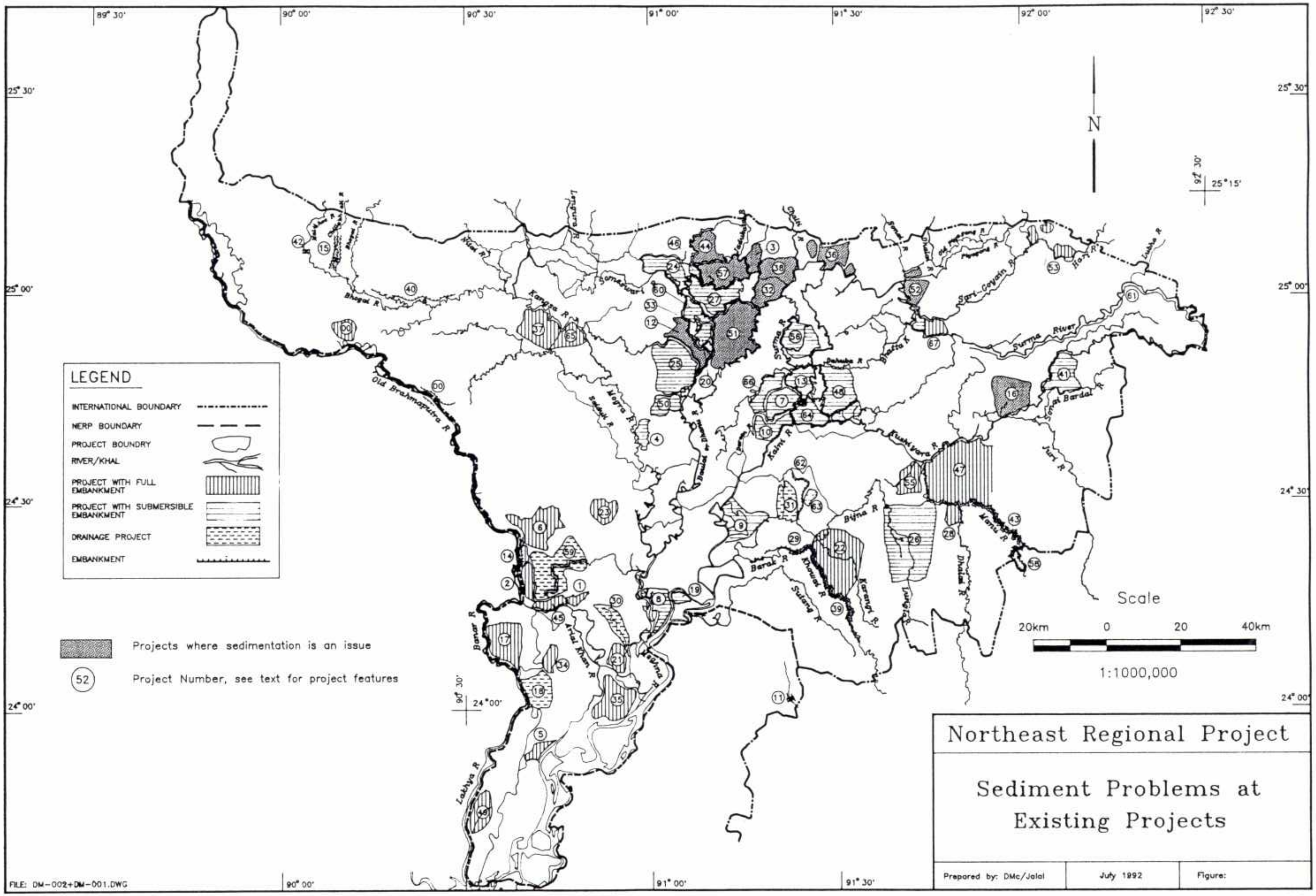

N
Note:
This is a demonstration plot showing a method of producing inundation depths by using a digital elevation model and AUTO-CAD. The results are not meant for quantitative analysis at this time.
Non - Flooded
0 - 0.3 m (Minor Flooded)
0.3 m - 0.9 m (Shallow Flooded)
0.9 m - 1.8 m (Medium Flooded)
1.8 m - 3.6 m (Deeply Flooded)
> 3.6 m (Very Deeply Flooded)
Scale
20 0 20 40 km
FILE: 10yr.DWG
Northeast Regional Project
Inundation Depth
10 Year Flood
Prepared by: DWa/Jaial
March 1992

Figure 3.5

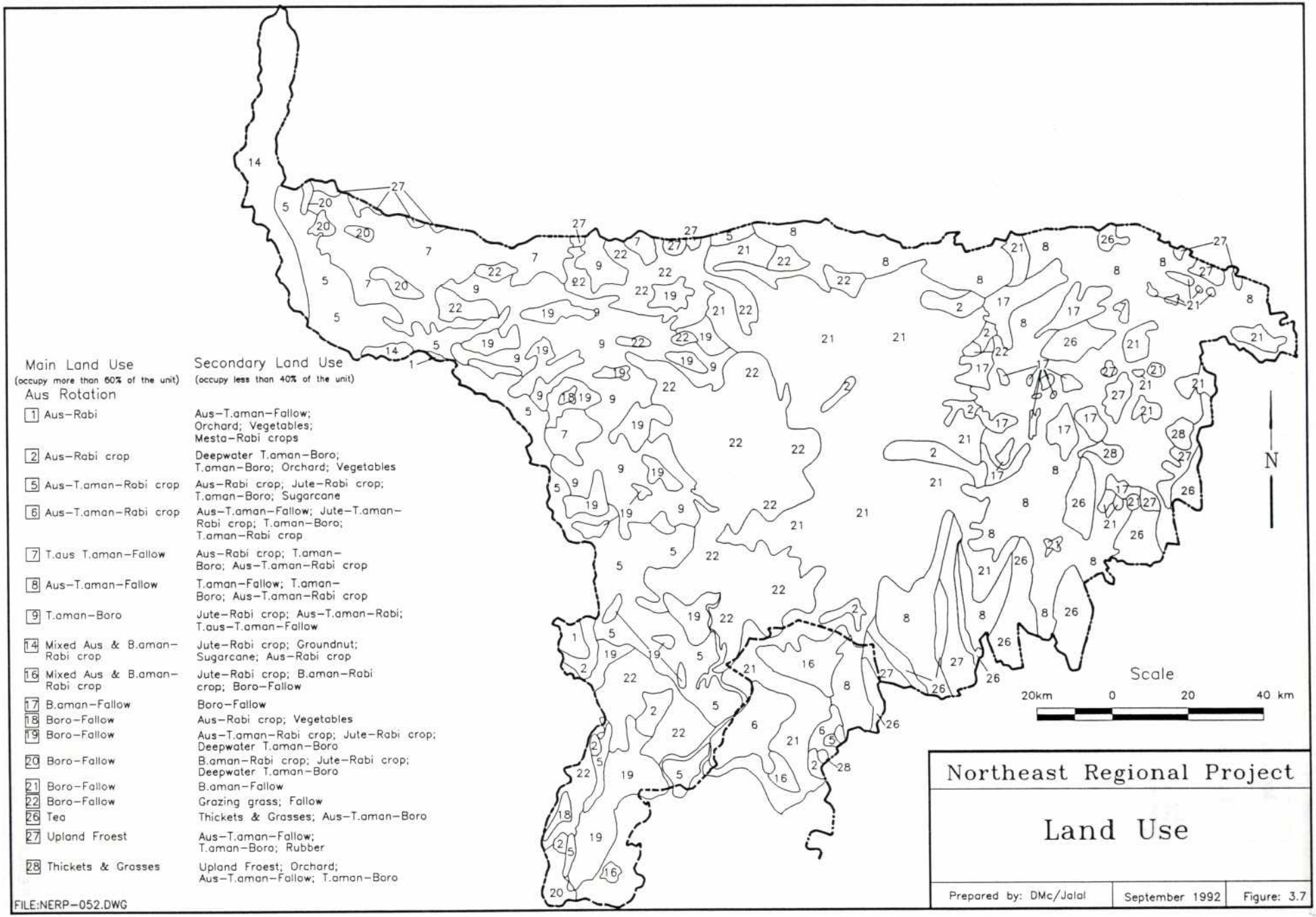


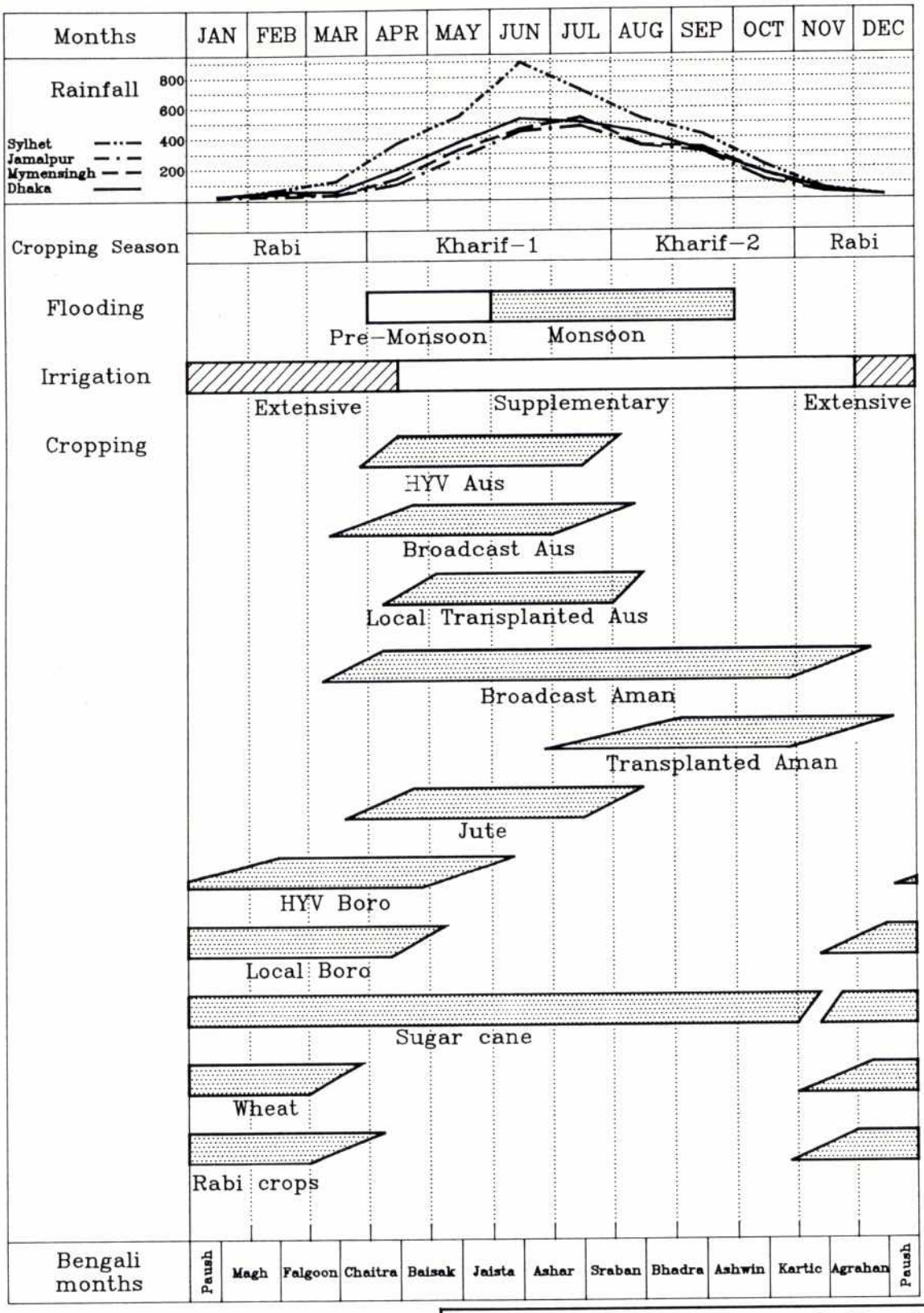
Northeast Regional Project

Sediment Problems at Existing Projects

Prepared by: DMc/Jalal	July 1992	Figure:

Figure 3.6


Main Land Use
(occupy more than 60% of the unit)
Aus Rotation
Secondary Land Use
(occupy less than 40% of the unit)
1 Aus–Rabi
Aus–T.aman–Fallow; Orchard; Vegetables; Mesta–Rabi crops
2 Aus–Rabi crop
Deepwater T.aman–Boro; T.aman–Boro; Orchard; Vegetables
5 Aus–T.aman–Rabi crop
Aus–Rabi crop; Jute–Rabi crop; T.aman–Boro; Sugarcane
6 Aus–T.aman–Rabi crop
Aus–T.aman–Fallow; Jute–T.aman–Rabi crop; T.aman–Boro; T.aman–Rabi crop
7 T.aus T.aman–Fallow
Aus–Rabi crop; T.aman–Boro; Aus–T.aman–Rabi crop
8 Aus–T.aman–Fallow
T.aman–Fallow; T.aman–Boro; Aus–T.aman–Rabi crop
9 T.aman–Boro
Jute–Rabi crop; Aus–T.aman–Rabi; T.aus–T.aman–Fallow
14 Mixed Aus & B.aman–Rabi crop
Jute–Rabi crop; Groundnut; Sugarcane; Aus–Rabi crop
16 Mixed Aus & B.aman–Rabi crop
Jute–Rabi crop; B.aman–Rabi crop; Boro–Fallow
17 B.aman–Fallow
Boro–Fallow
18 Boro–Fallow
Aus–Rabi crop; Vegetables
19 Boro–Fallow
Aus–T.aman–Rabi crop; Jute–Rabi crop; Deepwater T.aman–Boro
20 Boro–Fallow
B.aman–Rabi crop; Jute–Rabi crop; Deepwater T.aman–Boro
21 Boro–Fallow
B.aman–Fallow
22 Boro–Fallow
Grazing grass; Fallow
26 Tea
Thickets & Grasses; Aus–T.aman–Boro
27 Upland Froest
Aus–T.aman–Fallow; T.aman–Boro; Rubber
28 Thickets & Grasses
Upland Froest; Orchard; Aus–T.aman–Fallow; T.aman–Boro
N
Scale
20km 0 20 40 km
Northeast Regional Project
Land Use
Prepared by: DMc/Jalal
September 1992
Figure: 3.7
FILE:NERP–052.DWG

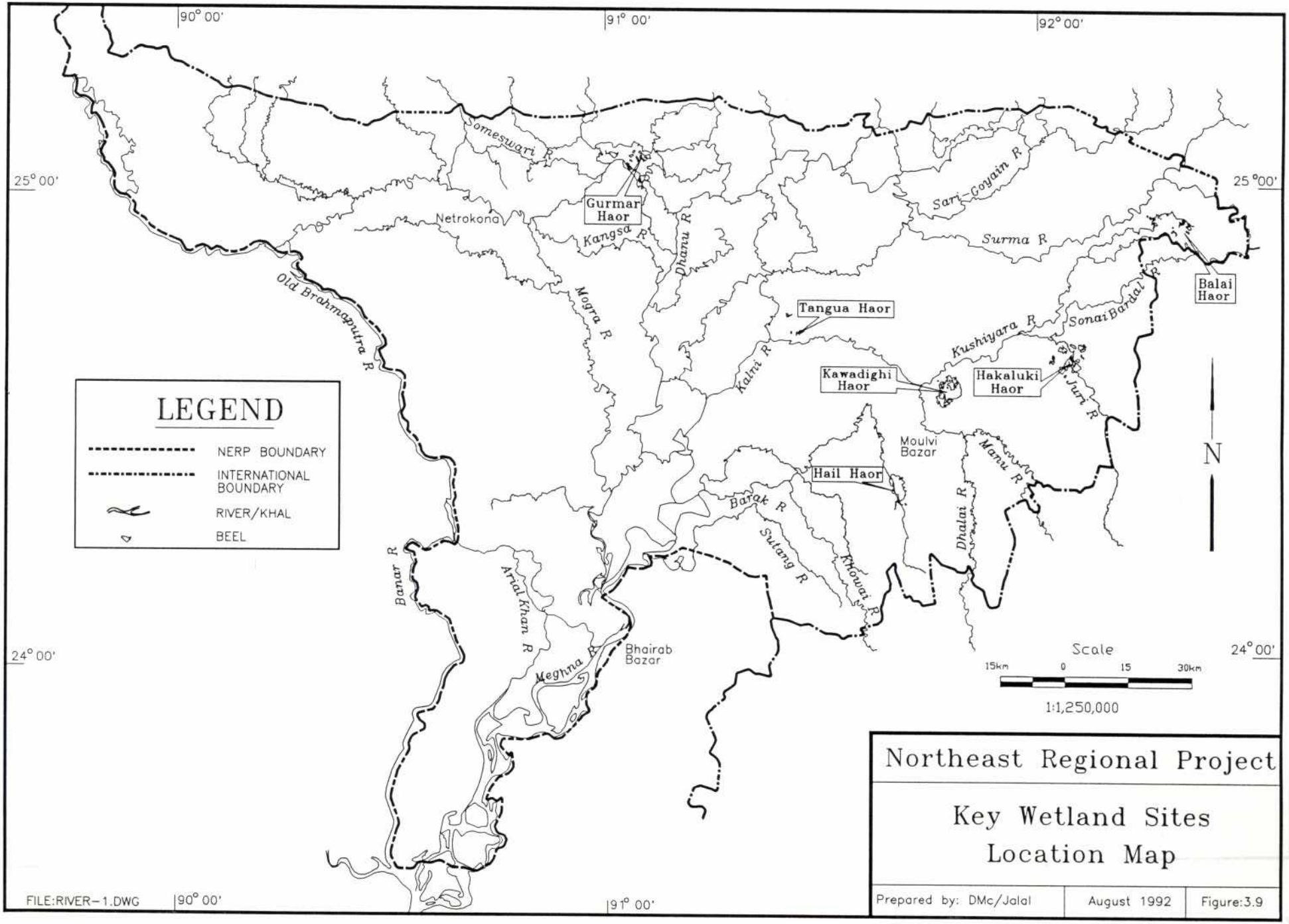


Northeast Regional Project

Major Cropping Pattern and Crop Calendar showing Relationship between Rainfall, Flooding and Irrigation

Prepared by: QRI/Jalal	September 1992	Figure:3.8

FILE:NERP-051.DWG


90° 00'
91° 00'
92° 00'
25° 00'
24° 00'
Someswari R
Gurmar Haor
Netrokona
Kangsa R
Dhanu R
Sari-Goyain R
Surma R
Balai Haor
Old Brahmaputra R
Mogra R
Tangua Haor
Kalni R
Kushiyara R
SonaiBaradal R
Kawadighi Haor
Hakaluki Haor
Jun R
Moulvi Bazar
Manu R
Hail Haor
Barak R
Sutang R
Khowai R
Dhalai R
Banar R
Arial Khan R
Meghna R
Bhairab Bazar
N
LEGEND
NERP BOUNDARY
INTERNATIONAL BOUNDARY
RIVER/KHAL
BEEL
Scale
15km 0 15 30km
1:1,250,000
Northeast Regional Project
Key Wetland Sites
Location Map
Prepared by: DMc/Jalal
August 1992
Figure:3.9
FILE:RIVER-1.DWG

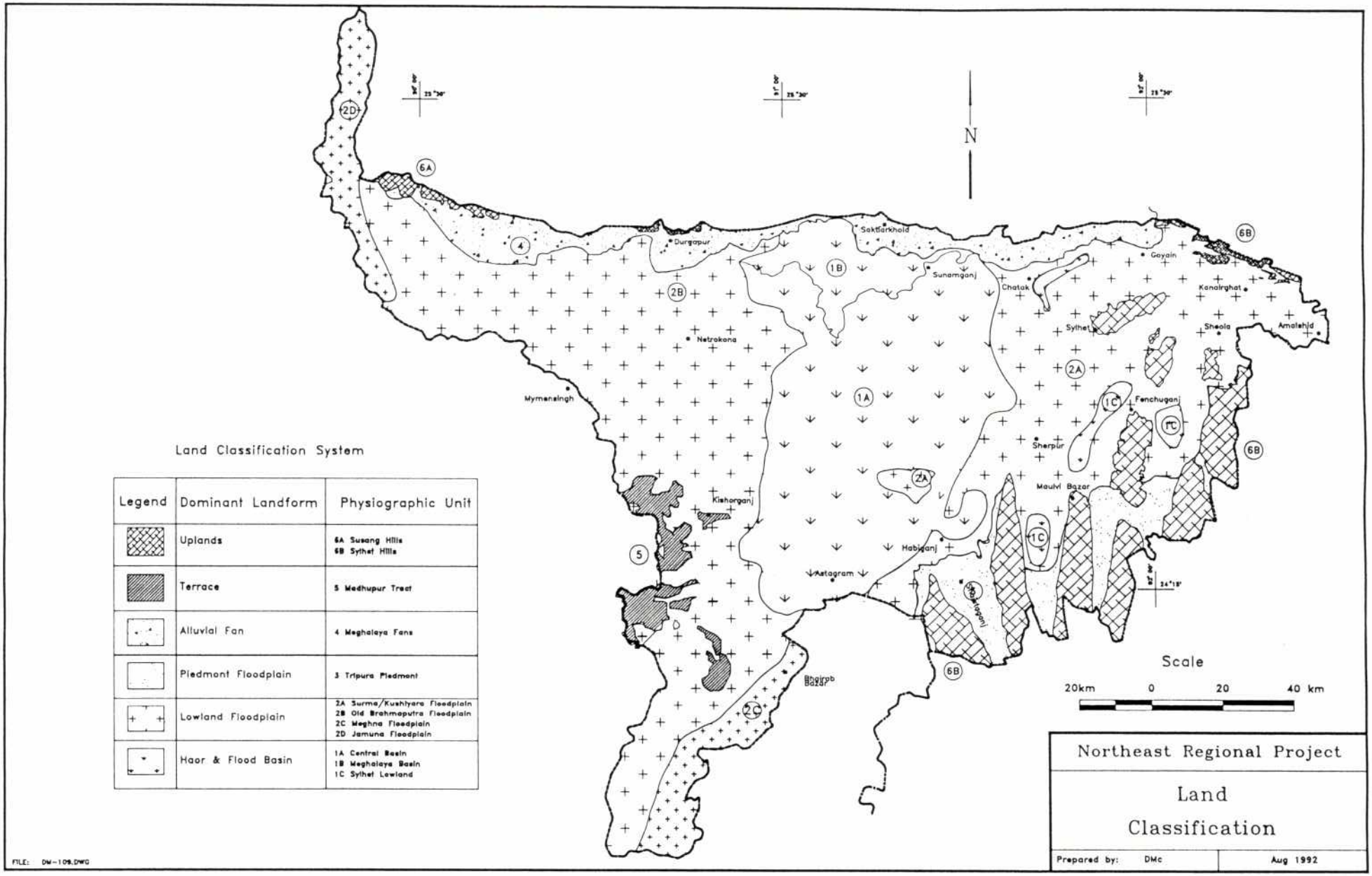

N
Durgapur
Saktiarkhola
Sunamganj
Chatak
Goyain
Kanairghat
Sylhet
Sheola
Amalshid
Netrokona
Mymensingh
Kishorganj
Fenchuganj
Sherpur
Maulvi Bazar
Habiganj
Astagram
Scale
20km 0 20 40 km
Land Classification System
Legend
Dominant Landform
Physiographic Unit
Uplands
6A Susang Hills
6B Sylhet Hills
Terrace
5 Madhupur Tract
Alluvial Fan
4 Meghalaya Fans
Piedmont Floodplain
3 Tripura 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
Land
Classification
Prepared by: DMc
Aug 1992
FILE: DW-109.DWG

Figure B.1