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Government of the People's Republic of Bangladesh
Bangladesh Water Development Board
Water Resources Planning Organisation

FLOOD ACTION PLAN

NORTHEAST REGIONAL WATER MANAGEMENT PROJECT
(FAP 6)

KANGSHA BASIN WATER MANAGEMENT PLAN

Final Report
April 1997

SNC ♦ LAVALIN International
Northwest Hydraulic Consultants

in association with

Engineering and Planning Consultants Ltd.
Bangladesh Engineering and Technological Services

Canadian International Development Agency

COVER PHOTO: A typical village in the deeply flooded area of the Northeast Region. The earthen village platform is created to keep the houses above water during the flood season which lasts for five to seven months of the year. The platform is threatened by erosion from wave action; bamboo fencing is used as bank protection but often proves ineffective. The single *hijal* tree in front of the village is all that remains of the past lowland forest. The houses on the platform are squeezed together leaving no space for courtyards, gardens or livestock. Water surrounding the platform is used as a source of drinking water and for waste disposal by the hanging latrines. Life in these crowded villages can become very stressful especially for the women, because of the isolation during the flood season. The only form of transport from the village is by small country boats seen in the picture. The Northeast Regional Water Management Plan aims to improve the quality of life for these people.

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VOLUME I : MAIN REPORT

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ACRONYMS AND ABBREVIATIONS

ADAB	Association of Development Agencies in Bangladesh
BAU	Bangladesh Agricultural University
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BIWTMAS	Bangladesh Inland Water Transport Master Plan
BMD	Bangladesh Meteorological Department
BFRI	Bangladesh Forest Research Institute
BFRSS	Bangladesh Fisheries Resource System Survey
BLRI	Bangladesh Livestock Research Institute
BRAC	Bangladesh Rural Agricultural Cooperative
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BSS	Destitutes' Cooperative Society
BWDB	Bangladesh Water Development Board
CARITAS	a Non-governmental organization
CIDA	Canadian International Development Agency
CITES	Convention on International Trade of Endangered Flora and Fauna
CLF	Civilian Labour Force
CO	Community Organizer
DAE	Department of Agricultural Extention
DANIDA	Danish International Development Agency
DC	Dictrict Commissioner
DLS	Department of Livestock Services
DOL	Department of Livestock
DOF	Department of Fisheries
DPHE	Department of Public Health Engineering
DSK	Dustha Shastha Kendra
DSSTW	Deepset Shallow Tube Well
DTW	Deepset Tube Well
EIA	Environmental Impact Assessment
EPCB	Environmental Pollution Control Board
FAO	Food and Agriculture Organization
FAP	Flood Action Plan
FCDI	Flood Control, Drainage, and Irrigation
FEAVDEP	Flood- and Erosion-affected Villages Project
FP	Family Planning
FPCO	Flood Plan Coordination Organization
FSR	Farming Systems Research
GDP	Gross Domestic Product
GO	Government Organization
GOB	Government of Bangladesh
HTW	Hand Tube Well
HYV	High Yield Variety
IEC	Important Environmental Component
IEE	Initial Environmental Examination

ISPAN	Irrigation Support Project Asia Near East
IUCN	International Union for the Conservation of Nature
KRIP	Kangsha River Improvement Project
KSS	Farmers' Cooperative Society
LGED	Local Government Engineering Department
LGRD&C	Local Government Rural Development and Cooperatives
LLP	Low-lift Pump
MIWT	Mechanized Inland Water Transport Fleet
MP	Member of Parliament
MPO	Master Planning Organization
MSS	Women's Cooperative Society
NEMREC	Northeast Regional Environmental Management, Research, and Education Centre
NERP	Northeast Regional Water Management Project
NGO	Non-governmental Organization
NHC	Northwest Hydraulic Consultants
NIDP	Netrokona Integrated Development Programme
NMIDP	National Minor Irrigation Development Project
O&M	Operation and Maintenance
OFRD	On-farm Research Division
PCC	Project Coordination Committee
PDEU	Population Development and Evaluation Unit
PRA	Participatory Rural Appraisal
PVDO	Private Voluntary Development Organization
PWD	Public Works Department
RDB	Red Data Book
RMP	CARE Bangladesh Rural Maintenance Programme
SLI	SNC-Lavalin International
SMEC	Snowy Mountains Engineering Corporation
SOB	Survey of Bangladesh
SRP	Systems Rehabilitation Project
SRDI	Soil Research Development Institute
STW	Shallow Tube Well
SWMC	Surface Water Modelling Centre
TNO	Thana Nirbahi Officer
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UP	Union Parishad
WARPO	Water Resources Planning Organization
WFP	World Food Programme
WHO	World Health Organization
WRS	Water Retention Structure
WUG	Water User Group
XEN	Executive Engineer

GLOSSARY

aman	late monsoon rice crop
arat	open space especially for wholesale transaction/warehouse
aus	early monsoon rice or rice grown in *Kharif I* season
bari	several *ghar*s having kinship lineage
beel	depression land
bhita	raised area used as a homestead
biri	indigineous cigarette
boro	rice grown during the dry (winter) season
bundh	earthen dam, closure
chorra	small streams from the hills
current jal	a kind of gill net
doon	manually operated traditional irrigation tool
duar	deep scour hole in a river
ghar	the equivalent of a nuclear family
hizal	a species of tree (Barringtonia acuntangula)
haor	land depression on a floodplain
Jatiya Sangsad	Bangladesh national parliament
katha	0.08 acres of land
khal	drainage channel
kharif I	early monsoon season (March-June)
kharif II	late monsoon season (July-October)
koroch	a species of tree (Pongamia pinnata)
mouza	governmental revenue administrative unit
para	a cluster of *bari*s socially recognizable as a neighbourhood
purdah	seclusion
rabi	dry season crops
samaj (*mallot*)	informal social institution
sangstha	organization
t. *aman*	transplanted *aman*
Tara pumps	improved hand pumps that abstract water upto 15 m deep
thana	geo-administrative unit under a district comprising several unions
thana parishad	local government council at the *thana* level
union	geo-administrative unit under a *thana* comprising several villages
union parishad	elected local government council at the *union* level
zila parishad	local government council at the district level

US $1 = Tk 40

MPO Land Classification Terminology

Class	Depth of Land Inundation
F0	0.0 m - 0.3 m
F1	0.3 m - 0.9 m
F2	0.9 m - 1.8 m
F3	> 1.8 m
F4	> 1.80 m; deepwater *aman* cannot be grown

Executive Summary

The Kangsha Basin

The Kangsha Basin, located in the Northeast region of Bangladesh covers an area of 2,300 sq.km. The river system originates in a 4,100 sq.km catchment area located in India's Meghalaya Hills.

The basin covers parts of three districts - Sherpur, Mymensingh and Netrokona. It is located some 150 km north of Dhaka City. About 1.6 million people (1991 census) live in the basin, 86% of them, in rural areas. The basin is easily accessed by road from Dhaka.

The Environment of the Kangsha Basin

Agriculture is the main source of income of the local population. More than 76% of the population depends on it as their main source of income, including 24% as agricultural labour. Fishing is the next source of income with more than 4% of the population depending solely on it for employment. Other major sources of income are non-agricultural/fisheries labour 3%, business 8%, and various 3%.

In the Kangsha Basin, like in most of Bangladesh, water plays a central role in people's life and consequently, rational development and exploitation of the available water resources is the key to the basin's socio-economic development.

The purpose of this water management plan is to assess the availability of water and related natural resources in the study area, to quantify their current use, to identify constraints to their exploitation, and to assess the prospects for their further development.

In the monsoon season, there is a large surplus of surface water in the study area causing flooding almost every year. More than 60% of the basin's area is flooded at least once annually. Floods are flashy, and may occur with little warning at any time during the monsoon, damaging crops, homesteads and infrastructure.

Conversely, there is a scarcity of surface water during the dry season. Available surface water is mostly used for irrigation. The total area irrigated from surface water is about 9,100 ha. The analysis of streamflow data indicates that sustainable river flows are generally fully used for irrigation in most areas where soil is suitable for irrigation.

In the study area, about 1,100 Mm^3 of groundwater is available for irrigation. the current groundwater usage for irrigation is about 300 Mm^3. In view of the limited scope for extensive low cost surface water development in the area, groundwater would be the prime source for future irrigation expansion.

The study area with a net cultivated land of 150,000 ha (65% of the gross area) produces annually 150,000 tons of *boro* rice, 130,000 tons of *aman* rice, 38,000 tons of *aus* rice and 35,000 tons of vegetables. Presently, only about 14% of the *t.aman* crop consists of high yielding varieties (HYV) and only 75,000 ha of land are under irrigation. Another 70,000 ha could eventually be irrigated. This indicates that there is potential for increasing HYV monsoon crop cultivation through the expansion of irrigation coverage in the dry season. There is also much potential for a substantial increase in monsoon crop production through flood protection.

The study area yields approximately 5,000 tons of fish annually from its 140,000 ha of inundated floodplain, 600 ha of *beels* and 12,600 ha of channels. The average production is low compared to other parts of the Northeast Region. Production could be increased to more than 7,000 tons in the area's open waters. The annual yield from the area's 24,000 ponds and ditches is estimated at 2,000 tons. DANIDA data indicate that the production rate could be increased three to four folds in ponds through flood protection and investments for feed.

Most people have access to safe water for drinking but a large percentage of the population uses polluted water from ponds and rivers for other domestic purposes. Expansion of safe water supply networks will increase the use of potable water for all domestic purposes.

Sanitation conditions are also very poor. Only 40% of the urban population and 3% of the rural population use sanitary latrines. Sanitation conditions can be improved through the installation of low cost hygienic facilities and couple this measure with social motivation.

The area has a dense river network. But most rivers are only navigable four months of the year. Because upland flows are low in the dry season, it is not possible to improve the river reaches in the upper area to make them navigable during this season. However, there is scope to improve dry season navigability of some of the lower river reaches, utilizing backwater from the Baulai River. This improvement, which would provide better access to the area, would require localised dredging.

It is urgent to replant trees in order to meet the biomass needs of the ever increasing population. Homestead trees have been the largest source of fuel, timber and house construction material and this source meets some 70% of the demand. Moreover continuous fragmentation of homestead platforms, rapid urbanization, changing land use patterns and demand for fuel wood and house construction material have caused a sharp decline in the tree cover. There are also hundreds of kilometres of roads and embankments which are devoid of trees. These can be afforested to increase both regional income and improve the state of the environment. Moreover, significant income can be provided to landless people and destitute women by associating them with a reforestation programme.

There are more than 230 ha of wetlands. Many wetland plants and animal species are used by destitute people for subsistence. The project area supports 265 species of wildlife representing amphibians, reptiles, birds, and mammals. There has been wide-spread alteration of the habitat, and loss of wetland area; there is also a shortage of vegetation cover and perching/roosting areas for colonial birds and large raptors. There is also a general lack of public awareness of the importance of wildlife in the ecosystem. There is much scope to protect and enhance the area's biodiversity through conservation, management and training.

Water Management Issues

Despite the fact that there are much water related resources and there is also significant potential for their development, several constraints prevent their optimum utilization.

In general, the study area suffers from two water related problems - excess water during the monsoon season and acute shortage during the dry season. The risk of flooding and the related uncertainty affect the local population in every aspect of their daily lives. Flooding damages homesteads, road infrastructure and monsoon season crops. *T.aman*, one of the area's major

crops is re-transplanted after flooding, sometimes twice or more. This results in extra costs and lower yields. Risk of loss and uncertainty both discourage farmers from planting higher yield varieties of *t.aman* and also from making other investments in their farms, thus limiting the potential for economic growth within the basin. Monsoon crop losses force farmers to cultivate in the lower areas during the dry season. The practice destroys the seed beds of wetland vegetation and inhibits the regeneration process.

Groundwater is also not available everywhere at economic depths, especially in the northern part of the basin. Due to this water shortage, only 50% percent of the cultivated land is presently under irrigation during the dry season. Because surface water is in short supply, groundwater, where available, is abstracted for irrigation. This abstraction causes a lowering of the water table which in turn impacts on domestic water supply as the presently used suction mode hand tube wells cannot lift water by more than 7.0 m. People then resort to using polluted surface water even for drinking, thus resulting in high incidence of water borne diseases.

Moreover, the quality of the groundwater is not routinely monitored for bacterial contamination when it is used for domestic purposes nor for toxic contamination when it is used for both domestic purpose and irrigation.

During the dry period, farmers use all the surface water available in rivers and beels for irrigation, leaving no overwintering grounds for fish. As a result, broodstock cannot survive for recruitment during the monsoon, thus depleting the fisheries resources.

With little or no water left in rivers and channels during the dry season, water transportation ceases at a time of maximum economic activity. To meet the transportation needs, the road infrastructure is being developed while water transport is in decline, even though it is the most economical mode of transportation and it requires little maintenance.

The natural environment of the study area has experienced serious degradation due to increasing pressure of human use. Wetlands are virtually extinct and a large number of plant and animal species are under serious threat.

Many of the existing water resources projects do not function as planned. The reasons are complex but are largely related to the fact that project implementation and operation are the responsibility of a remote institution; they do not adequately respond to local conditions or to the needs of the people. Local organizations also operate *ad hoc* and are too small to play much of a role in regional water management. Non-governmental Organizations (NGOs) cannot be assumed to take on the role of regional water management coordinators. Their role is limited because elements of water management may not be compatible with their priorities and their project implementation time frame.

Water management Initiatives

In order to address the above-mentioned problems and issues and to optimize the exploitation of the area's available water resources, a series of water management initiatives are proposed. These were identified through a process that included:

- consultation with the local population on their current life conditions, their environment and the problems they were facing;

- formal meetings where representatives of the local population presented their perception and understanding of water resources related problems. Organizations and individuals who had attempted to alter the environment through specific project initiatives were consulted as well as beneficiaries of those projects;

- formal studies on particular areas of the study area or particular sectors such as agriculture, etc.;

- integration of the perspectives of NERP professional specialists.

The water management plan identifies 9 thrust areas with a total of 29 specific initiatives. Some of the initiatives address more than one thrust. The thrust areas are:

1. institutional strengthening and development (one initiative, the Kangsha Basin Water Management Project, is intended to provide an overall coordinating role in water planning and management of the basin);

2. protection of homesteads and agricultural land against flooding (eight specific initiatives);

3. protection and enhancement of fisheries (seven specific initiatives);

4. Improving the management of surface water use (two specific initiative);

5. Improving the management of groundwater use (one specific initiative);

6. Expansion of domestic water supply and sanitation facilities (five specific initiatives);

7. Protection and enhancement of natural areas (two specific initiatives);

8. Expansion of agricultural production (two specific initiatives); and,

9. Improvement of water transport (one specific initiative).

The initiatives identified in the plan are the more obvious and important water management actions that would improve socio-economic conditions in the basin. Many others, of a smaller scale and having more limited benefits can follow in due course once the Kangsha Basin Water Management Project is implemented.

An Initial Environmental Examination (IEE) has been carried out for reviewing the impacts of plan as a whole and to identify the likely impacts, both positive and negative, of each specific initiative. Important environment components (IEC), their potential impacts and consequences, and level of significance have been identified for different activities under each of the initiatives and feasible mitigative measures have been suggested. The goal of NERP's environmental approach has been to minimize negative project impacts on people, fisheries, wetlands, and other components of the natural ecosystem.

The plan involves a total investment of US$ 69.0 million to be spent over 10 years, corresponding to an average annual expenditure of US$ 4.3 per person living in the Kangsha Basin.

The initiatives have been prioritized into three categories, those which can be implemented immediately, those which can be implemented in the medium term and those which can only be implemented on the long term, generally because of their cost.

Of the 29 initiatives, 13 projects involving a cost of US$ 31.4 (Table S-1) have been prioritized for immediate implementation. The priority projects meet all or most of the following criteria:

- small project with clear concept and scope;
- project which provides direct benefits to poor or landless people;
- project required urgently to protect infrastructure, homesteads, and environment from further degradation;
- project not dependent on nor affected by other projects;
- project urgently needed by the area people;
- project with low risk of negative impacts;
- project which can be implemented immediately with a minimum of study;

In conclusion the plan as been developed to contribute to the improvement of the physical, social, and economic environment of the Kangsha Basin. Also the plan has been developed and should be implemented to conform to the following water development principles: social and gender equity, resolution of conflicts, integration of resources development and environmental protection, maintenance and sustainability.

Table S-1: List of Early Implementation Projects

Project	Purpose	Cost (US$)
Konapara Embankment	Flood protection to crops, homesteads, infrastuctures and fish ponds.	1.5
Dampara Water Management Project	Flood protection to crops, homesteads, infrastuctures and fish ponds.	3.3
Someswari River Hazard Management	Flood protection to crops, homesteads, towns, infrastuctures; check channel avulsion.	1.3
Homestead Raising and Erosion Protection	Reduction of flood impacts on homesteads.	0.5
Kangsha Basin Water Management Project	Coordination of the development of the water management projects in the Kangsha Basin	1.7
Fish Sanctuaries and *Beel* Improvement	Enhancement of floodplain fisheries production	1.0
Open Water Fry Release	Enhancement of open water fishery resources.	2.0
Piped Water Supply in Urban Areas	Improvement of urban water supplies	4.0
Domestic Water Supply in rural areas	Improvement of rural water supplies	5.2
Kangsha Basin Urban Sanitation	Expansion of sanitation facilities in urban areas	0.5
Kangsha Basin Rural Sanitation	Provision of one sanitary latrine for each homestead.	1.4
Baseline Groundwater Quality Survey	Test for groundwater quality for drinking and irrigation use	2.0
Social Forestry	Enhancement of natural areas	2.0
Dredging in Lower Kangsha Basin	Improvement of navigation on the Updakhali and Ghulamkhali Rivers	5.0
Total		**31.4**

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1. INTRODUCTION

1.1 Background

The Kangsha Basin Water Management Plan is a study conducted under the second stage of the Northeast Regional Water Management Project (FAP-6), under the sponsorship of the Canadian International Development Agency (CIDA). Its objective is to prepare a proposal for the optimal, equitable, and sustainable development and management of the Basin's water and related natural resources within Bangladesh to enhance the productivity of agricultural lands, fisheries and wetlands.

It is one of three studies that were conducted simultaneously in the Kangsha Basin. The other two projects involve feasibility studies for flood control in the Dampara Project and the Someswari Project areas. Conceptual plans for these two projects are included in this report.

1.2 Study Area Location

The Kangsha Basin is located in the northwest portion of the Northeast Region of Bangladesh (Figure 1). It covers an area of about 2,310 km^2 in the districts of Sherpur, Mymensingh, and Netrokona. It lies at the foothills of the Meghalaya region where rainfall is intensive and causes frequent flash flooding. Consequences include:

- monsoon-season flooding and damage to crops,
- inundation of agricultural lands by sand deposits,
- damage to homesteads and infrastructure,
- disruption to pond aquaculture, and
- overloading of drainage systems.

Over half of the study area is flooded one or more times each monsoon season. Paradoxically the Kangsha Basin, like most of Bangladesh, also suffers from water shortage. Rainfall during the five-month dry season is negligible and river flows are low. The available surface water is fully exploited during the driest months for irrigation water supply. Groundwater is used extensively for irrigation compared with other areas of Bangladesh and further increase threatens to exceed the capacity of the groundwater systems with.

Much of the area, and particularly the Sherpur area, has been identified by the World Food Programme (WFP) as a "distress area". This indicator takes account of selected socio-economic indicators of poverty: agricultural production, foodgrain prices, agricultural wage rates, and the incidence of natural disasters. A major factor in the Basin is the occurrence of flash floods; these floods occur frequently, at any time during the monsoon season, and with little warning. The risk of flooding and the related uncertainty affect the people in every aspect of their daily lives.

1.3 Study Objectives and Terms of Reference

The Terms of Reference require that the Consultant shall establish a comprehensive proposal for the optimal, equitable, and sustainable development and management of the water resources and related natural resources of the programme area. The proposal is to be based on:

- the availability of these resources;
- their current use, and
- an estimate of the potential for their further development.

It shall be characterized in physical, environmental, economic, and institutional terms.

It is assumed herein that water resources includes both surface and groundwater resources. "Related" resources are those which depend on the presence of water (e.g. fisheries, wetlands) and those whose productivity may be enhanced by the availability or management of water (e.g. agricultural land).

Although not specifically mentioned in the Basin plan's terms of reference our purview includes considerations of public consultation, community participation in project development as well as a review of environmental concerns in accordance with Flood Planning Coordination Organization (FPCO) guidelines and procedures. The environmental and necessary mitigation measures are considered to be an integral part of water management. Mitigation of damages caused by floodwater (to crops, transport, infrastructure, urban infrastructure, and homesteads) is also an integral part of the Water Management Plan.

The study covers the entire annual cycle; that is to say, dry conditions as well as flood conditions.

1.4 Scope of Report

The Water Management Plan is conceptual in nature and is intended to lay out a broad strategy for water resource development in the Basin. A few of the project initiatives have been analyzed in pre-feasibility and feasibility studies and are fairly well understood - others have been defined at only a conceptual level. In the case of the Malijhee lowlands three alternatives representing a range of scope have been presented. In all cases, further consideration by policy makers and local residents is required and in that sense the report can be thought of as a discussion paper to help focus the discussion of water management issues.

This report contains only the proposed Water Management Plan. Another report presents a detailed feasibility evaluation of the Greater Dampara Project. Following some outside intervention, done during the execution of the Someswari Project feasibility study, the project was deemed unfeasible and at the recommendation of CIDA was wrapped-up. It is presented in Annex D of the report.

1.5 Methodology

Field observation and interviews formed the basis for the understanding of water management issues, social power structure, and people's perceptions. Each of NERP technical disciplines collected qualitative and quantitative information on pertinent issues through observation and formal and informal interviews. The Community Organizers (COs) visited as many as 219 villages in the districts of Sherpur, Mymensingh, and Netrokona. Information was sought on a range of issues, processes, and dynamics.

The table below summarizes the villages that were visited by the Cos during the preparation of this Plan:

Table 1.1: Public Consultation

Area	Number of villages visited and public consultation held by COs
Malijhee catchment	45
Chillakhali catchment	10
Bhogai catchment	9
Nitai catchment	3
Someswari catchment	50
Konapara-Kodalia area	11
Greater Dampara	66
Kangsha River project	18
Thakurakona project	7
Total	219

The analysis of the social dynamics has been substantiated with the help of case studies. These studies were done adopting a Participatory Rural Appraisal (PRA) method.

Formal and informal meetings were held with special interest groups to help understand the perception of the people. This included staff of selected NGOs, government officials, community leaders, members of committees involved in managing water projects, and cross-sections of the population affected by these projects.

Initial studies were conducted within each discipline to develop an understanding of the problems and water management issues of the Basin. Secondary data were used extensively, including Bangladesh Bureau of Statistics (BBS) data, *thana* agricultural data, BWDB and Surface Water Modelling Centre (SWMC) hydrometric data (discharges, water levels, and rainfall), fisheries, etc. In addition a limited sampling program was conducted to define the social and economic conditions and to collect additional data on water levels and discharges. A computer model of the river/floodplain system was developed from the regional model and was expanded using additional cross-section data collected as part of this program. The model was used to simulate the impacts of proposed flood-control projects on flood levels and discharges. A hydrometric monitoring program was conducted in 1994 to collect additional data on discharges and water levels at selected locations needed to improve the understanding of flood conditions and to help calibrate the computer model.

Integration of these inputs was achieved through a series of group interaction meetings or workshops and circulation of working papers among NERP professionals. That helped to define the water management issues and development objectives. Based on this understanding a preliminary set of project interventions was developed by the respective disciplines; these were reviewed by the project team to select the projects for inclusion in the Basin plan. Resulting from this analysis a set of development strategies was drawn up and a summary was developed for each project outlining the scope and concept of the proposed project.

An initial analysis of benefits and impacts was made in the project evaluation process and has been included in the project descriptions. An environmental assessment was made to define the anticipated impacts of the various projects and the Water Management Plan.

The study team consisted of specialists in the following disciplines:

- water resources planning
- water resources engineering
- river morphology and river engineering
- river modelling
- social anthropology
- gender
- agronomy
- livestock
- fisheries
- navigation
- environment
- wetland resources
- economics.

1.6 Structure of Report

The study is presented in two separate volumes - Volume I and Volume II. Volume I contains the 'Main Report' which is supported by five annexes. These annexes are included in Volume II.

Broadly speaking the first part of the Main Report provides a description of the Basin and its resources with a view to understanding the water management problems and how they affect the people of the Basin. This is followed by an analysis of issues and alternatives and then by a summary of the interventions that are proposed to address the needs of the people of the Basin. Projects have been developed to a conceptual level and these are described in sufficient detail to enable the planning process to proceed. This general structure is reflected in the detailed layout of the Main Report chapters as follows:

- ***Chapter 1***, the present chapter, provides an introduction to the report;
- ***Chapter 2, The Environment of the Kangsha Basin,*** provides an overview of the Kangsha Basin synthesized from a more detailed analysis provided in Annex A;
- *Chapter 3, Water Management Issues in the Kangsha Basin,* reviews the water management issues in the Kangsha Basin - problems, constraints, and opportunities;
- *Chapter 4, Past and Future Trends,* looks at trends in social conditions, resource use and problems, and attempts to predict the future conditions if no intervention is made;
- ***Chapter 5, Water Resource Development Objectives and Principles***, describes the goals and objectives of the Water Management Plan and the underlying principles which guide its development;
- ***Chapter 6 - Water Management Strategy,*** describes water management strategies or strategic thrusts, each of which contains one or more specific project proposals which are detailed in Chapter 9;
- ***Chapter 7 - Initial Environmental Examination*** provides an initial analysis of the potential environment impacts and their mitigation that may occur with the implementation of the projects proposed under the plan;
- ***Chapter 8 - Specific Water Management Initiatives*** contains a brief description of each of the initiatives that are prepared under the Water Management Plan. Each project relates to one or more strategies outlined in chapter 6;
- ***Chapter 9 - Plan Implementation*** provides guidelines for the process of implementing the plan and identifies the priority projects, those which can be implemented immediately, and those which require further planning and consideration.

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The five Annexes contained in Volume II provide detailed information on specific topics:

- ***Annex A - Resource Base and Present Use*** provides a description of the Basin and its resources with a view to understanding the water management problems and how they affect the people of the Basin;

- ***Annex B - Hydrologic Data*** contains additional hydrologic data - rainfall, flood elevations, and crop water requirements;

- ***Annex C - Modelling*** is a report on the modelling of flood control alternatives using the Mike 11 hydrodynamic river model;

- ***Annex D - Someswari River Stabilization Project***. Work commenced on the Someswari River Stabilization Project feasibility study in January 1995 and progress on the investigation was reported to CIDA in June 1995. At that time it was indicated that a number of developments had taken place on the fan (including construction of embankments) since the pre-feasibility study. As a result, conditions on the fan had changed to the extent that the interventions proposed in the pre-feasibility study could no longer be recommended. Consequently, CIDA instructed that the feasibility be terminated and alternative flood control concepts should be included as an element of the Kangsha Basin Water Management Plan. This Annex has been prepared in accordance with that instruction.

  The Annex contains a description of the Someswari River channel shifting and flooding problems and a recommended program for management;

- ***Annex E - Groundwater Resources*** contains a detailed analysis of groundwater resources in the basin from which salient data has been abstracted for the main report.

Tables and Graphs are found within the volumes wherever they are first referenced.

2. THE ENVIRONMENT OF THE KANGSHA BASIN

This chapter provides an overview of the environment of the Kangsha River Basin. It provides a basis for understanding the important issues related to management of the Basin's water and related natural resources. Further details are provided in Annex A of the report.

2.1 Biophysical Environment

2.1.1 Location and Physiography

The project area is located in the northwest corner of the northeast region of Bangladesh (Figure 1). It is bounded on the north by the international border and the Meghalaya hills, on the south by the Sherpur-Nakla-Netrokona-Thakurakona Road, on the east by Thakurakona-Kalmakanda Road and on the west by the Sherpur-Kurua-Balijuri Road (Figure 2). It is comprised of parts of thirteen *thanas* of Sherpur, Mymensingh, and Netrokona Districts and covers an area of 2,310 km^2 (Figure 3).

Figure 4 indicates the four main landform units of the project area and these are described in Table 2.1. Lowland floodplains are the dominant landform, covering almost two-third of the Basin area. These floodplain deposits were laid down by the Old Brahmaputra River before its avulsion in the 18th century. Piedmont floodplains and alluvial fans comprise one third of the project area. These are formed of outwash deposits of sand and silt carried from the Meghalaya hills. The fans are characterized by sudden, irregular, channel shifts (avulsions) which result in periodic abandonment of some channels and the formation of new channels across the fan surface. A small upland area consisting of siltstone and sandstone represents about 2% of the project area at the base of the Meghalaya hills.

Table 2.1: Major Landform Units of the Project Area

Landform	Description	Percent of Project Area
Lowland floodplains	fine sandy and clayey silt deposits	64.0
Piedmont floodplains	along tributary streams	24.0
Alluvial fans	sand/gravel deposits	10.0
Uplands	sandstone, siltstone and conglomerate	2.0

Soils of the project area are varied. Generally, though, they are deep, low in organic content, and without high natural fertility. Significant constraints to cropping include flooding and drainage congestion in the floodplain soils during the monsoon season, low moisture-holding capacity of the piedmont soils, and lack of residual moisture throughout the area in the dry season. The map of the Basin's surficial geology (Figure 5) gives an indication of the variation in the soil's texture.

The topography of the Basin slopes in a southeasterly direction with land elevations varying from 34.0 m PWD to 0.5 m PWD (Figure 6).

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2.1.2 Climate

Maximum temperatures vary from about 22.9°C to 34.7°C with the high temperatures experienced during the period between March and October. Monthly minimum temperatures range between 9.8°C and 26.4°C with the lowest occurring during January.

Annual potential evapotranspiration as measured at Mymensingh is 1,506 mm with the lowest monthly amount in December (87 mm) and the highest monthly amount in April (162 mm).

Rainfall over the study area is characteristically variable in both space and time. Figure 7 shows the variation in rainfall over the region while Figure 8 shows its variation over time. Rainfall generally increases from southwest to northeast and the mean annual rainfall varies from 2,200 mm near Sherpur to 4,400 mm near Kalmakanda. About 84% of annual rainfall occurs during the monsoon months of May to September.

During the monsoon season and occasionally at other times of the year, rainfall in the catchment causes extensive flooding with resulting crop damage. Scarcity of rainfall during the dry season normally results in a need for irrigation.

2.1.3 River System and Characteristics

The project area is drained by a major river network that includes the Kangsha, Malijhee, Chillakhali, Bhogai, Nitai, Someswari, and Lengura River. An outline of the Basin and its tributary catchment is provided in Figure 9 and a summary of the drainage areas is provided in Table 2.2. Generally, over sixty percent of the catchment lies within India. This area consists of small steep catchments which in association with high rainfall of the area produce high, rapid runoff and flashy flood peaks. The remainder of the catchment consists mostly of floodplain within Bangladesh.

The Basin's rivers are characterized by:

- high, flashy flood peaks in the tributary rivers, periodically throughout the monsoon season;
- extensive flooding caused by accumulation of overbank spills in the floodplains to the north and south of the Kangsha River;
- high sediment loads in tributary streams and deposition of this material along the piedmont streams and in the Malijhee lowlands where the river slope decreases; and,
- instability and shifting of alluvial fans.

Table 2.2: Drainage Area of the Kangsha Basin

Catchment	Drainage Area (km^2)		
	In Bangladesh	In India	Total
Upper Malijhee	224.1	341.6	565.7
Chillakhali	6.4	104.5	110.9
Bhogai	5.9	421.7	427.6
Nitai	6.3	334.9	341.2
Someswari	30.6	2377.1	2407.7
Someswari/Lengura Floodplain	499.1	273.1	772.2
Lower Malijhee	557.4	0.4	557.8
North Floodplain	742.8	151.2	894.0
Dampara Project	148.0	0.0	148.0
Kangsha River Improvement Project	112.2	0.0	112.2
Thakurakona Sub-Project	30.9	0.0	30.9
Total	**2363.7**	**4004.5**	**6368.2**

River Morphology

River channels on the Someswari fan and the Lengura fan are subject to high rates of deposition, a high degree of lateral instability, and periodic large-scale shifts in channel location, or avulsion. Significant avulsions have occurred in the Someswari River in the 1960s and more recently in 1988. A newly formed avulsion, Atrakhali Khal, is growing and threatens to become the main branch of the Someswari River. Figure 10 illustrates some of the channel changes which have occurred since 1768.

Future channel instability of the Someswari River can be expected during the next five to ten years. A complete avulsion down the Atrakhali Channel would seriously affect about 38 km^2 of land on the fan, threatening villages, crop lands, and fishery habitats. The Shibganjdhala Channel which is the present course of the Someswari is in the process of developing a wider, shallower channel. The active channel and floodplain zone will extend over a width of about 3000 m. This zone will be subject to high-velocity overbank spills, bank erosion, and sand deposition. A complete description of the river system and its hydrology is given in Annex D.

Upstream reaches of the Kangsha, Malijhee, and Bhogai Rivers experience deposition of bed material transported by the tributary streams, which causes problems of flooding and drainage congestion. Sedimentation is also occurring in lower reaches, downstream of Jaria, due to sand and silt carried down by the Someswari River and its present main distributary, the Shibganjdhala River. Sedimentation has caused increased shifting of the Kangsha River channel near Jaria, in-filling of the original main channel near Mohanganj, and formation of a new channel, the Ghulamkhali channel.

These conditions create a highly dynamic environment which exerts a strong influence on land use and the people of the Basin.

Flooding
Flooding is a major problem in the Kangsha Basin. Over half of the land area in the Basin is flooded annually, mostly to a shallow depth but reaching 3 m in places. Figure 11 shows the depth of flooding in a 2-year (median) flood. Figure 12 depicts the general distribution of flooding in the Basin and the causes of flooding in different areas. These figures were developed from NERP's hydrological data base. Flooding tends to be flashy in the border reaches but is more prolonged and sustained in the mid-to-lower reaches. Flooding directly damages homesteads, infrastructure, and farmland and generally contributes to the uncertainty and high distress levels in people of the area.

Comparable maps for dry season water surfaces, while they would be useful, have not yet been developed. They cannot be obtained from the current hydrological database; they require mapping of surface water remnants, ponds, *beels* etc. from aerial photographs.

2.1.4 Terrestrial Resources

Agricultural Ecosystem
The dominant ecosystem of the area is manmade as a result of migration and settlement and the conversion of most of the original natural systems to cultivation. The agricultural ecosystem in place is reasonably well managed and is dominated by monoculture production of a few crops, principally rice. Agriculture covers 83% of the area.

In the past the project area supported large areas of grassland. With the exception of a few small remnants, these areas have been converted to crops.

Upland Ecosystem
The existing natural forest cover of the project area is a remnant of the natural moist deciduous forest which ran along the foothills of the Himalayas. The remaining forest consists of irregular patches of Sal forest and other miscellaneous forest species groups located on the ridges and higher lands of the Garo Hills. The total forest cover is 11,500 ha which includes 4,400 ha of natural high forest and coppice cover and more than 5,000 ha of artificial forest, mainly exotic species.

Wetland Ecosystem
Perennial and seasonal wetlands are found throughout the project area. During the monsoon period these areas become an integral part of the freshwater ecosystem, providing habitat for aquatic species, particularly migrating fish. The wetlands play a vital role in the fishery of the area and provide habitat for a number of amphibious and other fauna. Wetland plant communities are submerged, free floating, rooted floating, sedges, and meadows. These reflect the various physical conditions which occur in the project area.

Most of the wetland area drains after the monsoon season, with the result that perennial wetland areas or *beels* make up less than 0.1% of the Basin area.

Homestead Vegetation
Homestead vegetation is important both for its diversity and economic output. Much of the vegetation grown in the homestead reflects natural plant communities of the past. Total area of homestead vegetation is estimated at 12,600 ha or five percent of the project area.

Terrestrial Fauna
The above four broad ecosystems support a wide range of fauna even though 83% of the area is classified under the agricultural ecosystem which is highly monoculture in nature. The area supports a rich diversity of wildlife with more than 265 species of amphibians, reptiles, birds and mammals. In addition, there are innumerable species of invertebrates.

The project area also supports a large resident avian (bird) population that relies on the habitat provided by all four ecosystems. Over 192 resident species and 88 migratory species have been recorded. The area supports more than 31 mammalian species including elephant (migratory from the hills) and the Gangetic Dolphin. Tiger and leopard, although present, are rarely seen; a direct result of the loss of forest and grassland habitat.

Biodiversity
At one time the project area had a very high biodiversity. As settlement increased, particularly over the past 100 years, this diversity has declined with the loss of natural habitat and the pursuit of many species for economic gain. Large mammals including Asian elephant and tiger are seldom seen. The Gangetic Dolphin is indicated in the IUCN Red Data Book as vulnerable, and populations of other species are generally attenuating. The area's faunal populations are still varied, although considerably less than former levels. Corridors linking islands of habitat together have been lost. As a result, populations have become isolated and in the future it is probable that at least some local faunal populations will suffer a loss of genetic diversity leading to collapse.

With the declining populations and reduction in diversity caused by settlement and conversion to agriculture, the economic importance of wildlife is declining. Amphibians and reptiles continue to play an important role in both the agricultural and homestead ecosystems by controlling the level of pests that impact agriculture and humans. As well, certain frogs, turtles, and snakes are important economically.

Ecologically Sensitive Areas
Little remains of the area's original ecosystems. Most upland and many wetland ecosystems have been converted, or at the least are in a heavily degraded state. The one remaining area where there is opportunity for protection is the remnant moist deciduous forest in the north of the project area near the border with India. Since this forest could provide habitat for a number of rare mammal species that were originally found throughout the area in large numbers, it would be worthwhile recognizing this area as ecologically sensitive and one which deserves management attention.

2.1.5 Freshwater Resources

Surface Water Availability
Overall in the Kangsha River floodplain and the part of the Basin in Bangladesh, there is too much water during the monsoon season and not enough during the dry season.

During the winter months, while Piedmont streams usually carry a small amount of flow most of this water is often captured in the upstream reaches and used for irrigation. Further downstream many of the channels are virtually dry. The one exception is the Someswari River where winter discharges are a bit larger due to the greater size of the catchment. In the past not much of the Someswari water has been used for irrigation although this is changing. Especially as the channel shifts towards the Atrakhali more water will get used because there is more of a tradition for dry season irrigation. The Someswari River is the main contributor to the Kangsha dry season flow and as the shift to the Atrakhali progresses winter flow in the Kangsha will reduce further.

Open Water Capture Fisheries

Approximately 140,000 ha of floodplain are inundated annually; however, in the dry season only the deeper *beels*, which represent only 0.1% of the total project area, are available for fishery. Shallow floodplains are important feeding grounds, producing high levels of plankton and benthos during the monsoon season. There are 112 seasonal and 30 perennial *beels* in the project area. The largest of these are the Rajdhola *beels* which have an area of 47 ha. Total area of the *beels* is about 580.0 ha of which area of perennial *beels* is 230.0 ha (see Table 2.3). *Thana*-wise name of the *beels*, their areas and locations are given in Annex A.

Table 2.3: *Thana*-wise No. of Perennial and Seasonal *Beels* and Their Areas (within Basin)

Thana	*Beel*				Total	
	Perennial		Seasonal		No.	Area (ha)
	No.	Area (ha)	No.	Area (ha)		
Sribardi	-	-	1	4.2	1	4.2
Jhenaigati	-	-	15	23.1	15	23.1
Sherpur	2	6.5	6	18.0	8	24.5
Nalitabari	6	36.1	16	26.9	22	63.0
Nakla	3	39.5	5	11.9	8	51.4
Haluaghat	-	-	14	60.5	14	60.5
Phulpur	5	25.2	24	55.1	29	80.3
Dhobaura	-	-	12	46.6	12	46.6
Durgapur	3	19.8	5	36.6	8	56.4
Purbadhala	11	103.0	7	36.1	18	139.1
Netrokona	-	-	3	11.1	3	11.1
Kalmakanda	-	-	4	21.2	4	21.2
Total	**30**	**230.1**	**112**	**351.3**	**142**	**581.4**

The major rivers are also important for fish production but many of them virtually dry up during the dry season, partly due to the extensive use of surface water for irrigation.

Dominant fish species found in the project area include Rui, Lachu, Calibaus, Boal, Aor, Foli, Gajar, Sing, Magur, Koi, Tengra, Puti, Khalisa, Baim, Baila, Chela, Mola, Chanda, Gutum, Balichata, and small prawn.

The Kangsha and Someswari Rivers are important breeding waters for the carps and large catfish. Generally carp and catfish migrate from the deeper Sylhet Basin into the project area. Some species are also carried down from India with monsoon floods in the Someswari River.

Riverine fish species migrate to *beel*s and floodplains during the monsoon when water connection is possible. Many perennial *beel*s become isolated from the main migratory routes due to siltation of connecting channels.

In general the productivity of the floodplain is lower than in other parts of the Northeast Region, largely due to the lack of overwintering areas, compounded by the long migration routes from the Sylhet Basin. Productivity is higher in the deeper-flooded areas near Kalmakanda.

Culture Fisheries

About 24,000 ponds and ditches are present throughout the project area (see Table 2.4). They have a total surface area of 2,500 ha and an average size of 0.1 ha. Most ponds receive minimal management and input. The dominant species of fish are rui, catla, and mrigel, mostly supplied from nurseries.

Biodiversity

Species diversity and fish population of the area are directly related to the hydrological cycle. A high aquatic biodiversity is present in a number of water bodies in the southern part of the project area. However, due to relatively heavy siltation, the waters of the northern portion of the area display a lower biodiversity. Approximately 100 fish species have been observed in the project area although several species, including Veda, Sarputi and Pabda, are becoming rare. A lesser fish diversity has been observed in winter.

Ecologically Sensitive Areas

A number of *beel*s should be brought under sanctuary status because of their importance to the fishery. These are discussed in subsequent chapters of this report.

Table 2.4: *Thana*-wise No. of Ponds and Their Areas (within Basin)

Thana	No. of Ponds	Area (ha)
Sribardi	209	17.4
Jhenaigati	1050	120.0
Sherpur	1561	70.6
Nalitabari	6000	685.6
Nakla	349	50.6
Phulpur	3340	202.6
Haluaghat	3155	380.5
Dhobaura	1280	179.9
Purbadhala	1547	173.7
Netrokona	1022	114.7
Barhatta	275	33.5
Durgapur	2293	257.1
Kalmakanda	1652	185.4
Total	**(say) 24,000**	**(say) 2,500**

2.1.6 Groundwater Resources

Groundwater Quantity

Generally the Basin is blessed with abundant groundwater resources owing to its favourable soil conditions and high rainfall. However in some areas, principally in the higher land toward the north, the groundwater table is too deep for economic development. Use of groundwater for irrigation is widespread and in some places it causes the groundwater levels to fall below the depth capacity of hand tube wells used for domestic water supply, which causes these wells to go dry for some portions of the dry season. Except for the problem of depleting domestic water supplies, and in the piedmont portion of the Basin, the available groundwater resource is adequate to supply the foreseeable irrigation needs. Development of this potential will cause further deterioration of the supply to domestic wells unless these wells are deepened and fitted with Tara pumps which can draw water from a greater depth.

Soil conditions are less favourable, and groundwater tables are lower, in the piedmont plain. Consequently there is limited capacity for increased irrigation from groundwater supplies and greater need for more efficient management of the resource. These conditions imply a need to promote growing non-rice crops which require less water.

Groundwater Quality

The presently available analytical data is insufficient to produce a comprehensive and meaningful picture of the groundwater quality in the Kangsha Basin. Results of the two sample analyses for Sherpur and Netrokona (see Table 2.5) show that except iron contents, the water quality is well within the permissible limits of the drinking water standards as prescribed by World Health Organization (WHO).

Table 2.5: Drinking Water Quality

Item	Unit	WHO Standard	Water Quality	
			Sherpur	Netrokona
pH	mg/l	6.5-9.2	6.32	7.22
TDS	mg/l	1500	280	221
Iron	mg/l	1.0	12.8	1.43
Nitrate (NO_3)	mg/l	45	1.6	3.3
Chloride	mg/l	600	32	16

Source: BWDB

Analysis of samples taken from four hand tube wells in the Mymensingh and Netrokona Area for arsenic contamination found that the samples contained levels of arsenic below permissible limit of 0.01 mg/l.

2.2 Socio-Economic Environment

2.2.1 Institutional Considerations

The institutional setting of the Kangsha Basin is described in some detail in Annex A. Significant characteristics of the institutional setting are:

- the administration is highly centralized with most major decisions made in Dhaka, resulting in limited coordination between line ministries at the local level,
- political, administrative, and project boundaries do not coincide, which complicates the coordination and implementation of projects,
- there is no existing institution than can effectively coordinate the work of various ministries, NGOs, and local organizations involved in water management at the Basin level.

A more detailed description of the institutional framework is presented in Annex A.

2.2.2 Demographics, Settlement and the Social Context

Migration and Population

The area has been subjected to migratory processes for almost a century and most people who have moved into the area have done so from areas where population has been high and land resources have been scarce. In the past 50 years farm families have moved in from different

districts, forcing out the tribal groups. Currently, temporary migration takes place to other rural and urban areas for the pursuit of both employment and educational opportunities.

Population of the project area is estimated at 1,600,000 (694 persons/sq km) based on 1991 enumerated census data. This represents more than a doubling of population since 1961. Population density and the extent of urbanization are lower than in the rest of the country. Major urban areas and their population are presented in Table 2.6. There are 103 males for every 100 females in the project area, a ratio that is lower than the national average.
In the project area there are 1,560 villages with an average of 189 households each. The average household size of 5.09 persons is lower than that for the Northeast Region and for Bangladesh.

The population in urban areas is growing more rapidly than that in rural areas as a result of net in-migration of people from the villages and smaller urban centres.

Table 2.6: Urban Population, 1991

Thana	No. of Hhs	Population			People per HH (Average)	Gender ratio
		♂	♀	Total		
Sherpur	12,410	32,764	30,064	62,828	5.06	109
Netrokona	8,416	24,254	21,420	45,674	5.43	113
Nalitabari	4,486	13,055	12,043	25,098	5.59	108
Purbadhala	3,148	8,481	7,515	15,996	5.08	113
Durgapur	2,516	6,672	6,327	12,999	5.17	105
Phulpur	2,251	6,469	5,823	12,292	5.46	111
Sribordi	1,775	4,583	4,219	8,802	4.96	109
Haluaghat	1,763	5,062	4,665	9,727	5.52	109
Kalmakanda	1,680	5,048	4,337	9,385	5.59	116
Nakla	1,424	3,891	3,441	7,332	5.15	113
Barhatta	1,124	2,968	2,634	5,602	4.98	113
Jhenaigati	901	2,191	2,113	4,304	4.78	104
Dhobaura	696	1,572	1,455	3,027	4.35	108
Total	42,590	117,010	106,056	223,066	5.24	110

Social Context
The village is the main social unit and it is comprised of several clusters of homesteads. The smallest social unit is the *ghar* which is the equivalent of a nuclear family (members belonging

to one economic unit sharing the same kitchen). Several *ghar* having kinship lineage form a *bari*. Members of a *bari* usually share some resources among themselves: a common courtyard (for threshing and drying of rice and similar other purposes), a pond, and a graveyard. A cluster of *bari* form a *para* which is socially recognizable as a 'neighbourhood'. One or several *para* form a village.

A large proportion of the cultivable land is owned by a few households. Land is acquired through both inheritance and the market place; often land will be purchased by the wealthy when others become destitute with debt. About 55% of the households are landless. About 2.7% of the landless have no homesteads; many of them, along with some of the small land-owners, have a tenant arrangement with the large landowners.

Rural people are predominantly engaged in agriculture, trading, services, and farm labour. The landless people constitute the pool of farm labourers. When employment is scarce, particularly in the pre-harvesting period, they out-migrate to find work. The very poor people, particularly women and children, live on common property resources and collect and sell wild products in the market.

2.2.3 Urban Areas

In Bangladesh only officially constituted municipalities were originally considered to be urban areas. However since 1981 the BBS has widened the definition to include other "development centres and *thana* headquarters having distinct urban characteristics ...". Listing a place as an urban area, however tells us little about its level of development.

In the three municipalities, Sherpur, Netrokona and Durgapur, a group of cleaners are engaged on contractual basis by respective municipal authorities to perform necessary conservancy work. Other than municipalities and *thana* headquarters, no other growth centre in the study region has been considered as urban area in the 1991 census, although there are few places which possess characteristics similar to some of these *thana* headquarters in terms of physical infrastructure or facility.

Among the urban centres in the study region, Sherpur is the largest having more than 60,000 population, followed by Netrokona and Nalitabari with 45,000 and 25,000 respectively. Among the urban centres, three are recognized as municipalities. These are Sherpur, Netrokona and Durgapur. Sherpur is one of the oldest municipalities in the country which was formed in 1869. Netrokona municipality was formed in 1887. Durgapur is a new municipality constituted in 1994.

Even in the rural areas the urban population is growing faster than the rural population. While the whole population grew at an annual rate of 2.2% in Bangladesh during the period from 1974 to 1991, population growth rate during the same period was 3.42% in Sherpur municipal area and 3.33% in Netrokona municipal area.

In recent years, many people migrated to Sherpur district headquarters from adjoining *thanas*, mainly from Sribordi, Jhenaigati and Nakla. Among the recent immigrants in Netrokona town are the people from Khaliajuri, Madan and Atpara. People tend to migrate to urban areas as these provide more opportunities for off-farm employment. Facilities for education, particularly at the secondary and higher secondary levels, also work as a pull factor in this regard. It may be mentioned that almost all government secondary schools and colleges are located either in *thana* or in district headquarters.

2.2.4 Quality of Life Indicators

Literacy
The literacy rate for both sexes in the project area is lower than the national average, ranging from 18% to 28% by *thana* compared with the national average of 32.4%. The rate is highest amongst those in the urban areas such as Netrokona, and amongst Hindus and Christians. School attendance for ages 5-24 varies from 26 to 33% which is below the national average of 37%.

Health
The area has two 50-bed hospitals, one is at Sherpur and the other is at Netrokona. Another 500-bed medical college hospital is located at Mymensingh, just outside the project area. A health complex is located in each of the *thanas* and Family Welfare Centres are located in some of the unions. The government has an ongoing immunization programme for six major diseases and this is focussed on children up to one year of age.

The people of the region have ready access to potable water, however, due to the fall in the groundwater table in the region during the dry season, many hand tube wells have become inoperative. This has resulted in the use of pond water and canal water, and digging for water in dry river beds. Very few households possess sanitary latrines.

Water Supply
Groundwater which is considered safe for domestic purposes is used by most residents of Netrokona and Sherpur towns for drinking purpose. Among the people of *thana* centres and rural areas this percentage is eighty five and seventy eight respectively. But most of them living both in urban and rural areas use pond and river waters for other domestic purposes.

Piped water supply is limited to Netrokona and Sherpur towns. By 1991 its coverage was only 15% in Netrokona and 3% in Sherpur. The low cost No. 6 suction pump hand tube wells are widely used in the area for lifting groundwater for domestic use. The No.6 hand pump cannot lift water from more than seven metre below the ground. Because of this limit, many hand tube wells have become inoperative in the dry season due to the fall of the groundwater table as a result of heavy groundwater withdrawal for irrigation. This has resulted in the use of pond and river waters also for drinking purpose. The situation is growing worse as more and more groundwater is being used for irrigation. These inoperative pumps are being replaced slowly by the forced mode pump (TARA) which can draw water from fifteen metre below the ground.

Sanitation
Sanitation conditions both in urban and rural areas of the Kangsha Basin are appalling. There is no sewer line in any of the area's urban centres. Sanitation facilities are limited to septic tanks, sanitary pit latrines, pit latrines and surface water latrines installed over water bodies.

A survey conducted in 1991 in Netrokona and Sherpur towns revealed that only 38% of Netrokona Town people use hygienic sanitary latrines (sanitary pit latrine or septic tank). In Sherpur, the survey found that only 40% of the population uses safe sanitary facilities. According to the 1991 BBS data, only 18% of the population of the *thana* centres avails safe sanitary facilities and in the rural areas it is less than three percent.

The Department of Public Health Engineering (DPHE) produces and sells low cost concrete pit latrines to the poorer section of the people at a subsidized rate. However, the utilization

rate is still low because many people are not aware of the sanitation issue and many poor people cannot afford even the subsidized price.

2.2.5 Coping with Floods

Substantial damage to housing is caused in the Basin by flash floods from the Malijhee, Chillakhali, Bhogai, Nitai, Someswari and Kangsha Rivers. While flash floods usually recede in the western and northern areas within a week or so, monsoon flood water remains in the low-lying eastern area for a period of about five months starting in early June.

In the higher area, homestead platforms are usually raised by one meter or more to avoid flash floods. If there is severe flooding, villagers will make platforms inside their houses or shift their belongings to safer places. However, in low-lying areas, homesteads are raised even higher as much as 3 or 4 m to avoid monsoon flooding. In the low areas, necessary measures are taken to protect against erosion of homesteads against monsoon flooding. Generally, this involves constructing a seasonal protection wall around the homesteads with soil, bamboo, and locally available grasses.

Community initiatives focus on local organization for crisis intervention arising as a result of flash floods and drainage congestion. Initiatives include dam construction and re-excavation of canals. People also construct earthen cross-dams at several places on upland rivers and streams for irrigating *boro* fields. This work is generally organized by influential people in the locality and is carried out on a voluntary basis by the villagers adjacent to a particular canal or field.

2.2.6 Land Use and Economic Activities

General Land Use

Agriculture is the dominant sector of the Basin's economy. Approximately 65% of all land is under cultivation. The current breakdown of land under various types and uses is summarized in Table 2.7.

Table 2.7: Summary of Land Use

Land type	% of Total
Cultivated	65.0
Culturable	4.3
Homesteads, infrastructure, rivers, etc	28.6
Forest	2.1
Total	100.0

Agriculture and Livestock

Under present conditions, a little more than one-third of the region's net cultivated area can be considered to be free from flooding and about two-thirds is subject to major constraints to cropping during the monsoon season. Two-thirds of the total cultivated area is vulnerable to prolonged or late rains and floods which delay *aman* transplanting. Late monsoon floods after the *aman* is transplanted also damage the crop. More than 85% of the total cropped area is under rice production and the major cropping patterns in the project area are rice based. Rice is grown in a multitude of environments, either solely or in rotation with dryland crops (Figure 13). Cropping patterns are dependent upon a number of biophysical and socio-economic factors and change constantly from farm to farm, but the generalized cropping pattern is shown in Figure 14.

The Basin produces an average of 150,000 tons of *boro*, 130,000 tons of *aman*, and 38,000 tons of *aus* rice per year. Total rice production is 318,100 tons per year. The given production figures are for paddy.

While the local rice cropped areas have declined significantly, the high-yield variety (HYV) rice cropped area, particularly the *boro* crop, has increased significantly as a result of the expansion of irrigation facilities. Cropped areas for wheat, vegetables, pulses, and to some extent, potatoes, have increased significantly over the past ten years. There has been a general increase in planted area of fruit trees.

The price of agricultural land varies from Tk 42,000 to Tk 250,000 per ha depending on the quality of the land and the intensity with which it can be cropped.

Livestock plays an important role in the farming system of the project area. It provides essential draught power for crop production and farm transport, high quality animal protein for the daily diet, and cash income for the farm household. It is also an important source of domestic fuel and fertilizer. Small animals including goats, chickens, and ducks are a ready source of protein and income.

Fisheries

Two types of fishery exist in the project area: open water capture and pond fish culture. Most of the project area is shallowly flooded during the monsoon season. The south and southeastern portions of the project area are rich in open water fisheries. The northern area is most suitable for fish culture although a large number of ponds are situated in the southern portion of the area as well.

Estimated annual production of the capture fishery is between 30 and 45 kg/ha of water body, giving a total annual production in the order of 5,000 metric tons. Fish production can not meet the rising demand.

Most perennial *beels*, a number of seasonal *beels*, and some river portions, are under lease. Due to continued silt deposition the physical condition of some *beels* in the Malijhee depression are being modified, and as a result, production is dropping and leases are not being renewed.

Water quality for fish production is affected by siltation and increased use of agricultural chemicals. Existing flood control activities generally have an adverse impact on fisheries production. Fisheries management by GOB is limited to sporadic spawn/fry releases and there is no enforcement of regulations.

Local fishermen sell most of their catch through 200 fish markets throughout the project area. A portion of the catch is brought directly to the *thana* or district level markets and another portion is exported out of the area by train or truck.

Pond culture is semi-intensive and traditional. Most pond owners stock their ponds with fingerlings of various species, the most common being rui, catla, mrigel, grass carp, silver carp, minor carps, thai sarputi, and tilapia. Very little management is carried out and only a few commercial owners use feed and fertilizer. Total pond production is estimated to be 2,000 metric tons annually.

Both DANIDA and World Vision are involved in pond fish culture in the area.

Navigation

Transportation and communication facilities throughout the project area are inadequate. Although road and rail have been extended into the project area, many of the road links are impassable in the monsoon season. River transportation is a vital means of transport and communication.

The rivers of the area have been used as a means of transporting both cargo and passengers for ages. The river system provides an economic means of transport to Dhaka and other large centres. Even during the dry season when navigation is difficult, traffic volume is significant, as indicated in Table 2.8. Data in Table 2.8 has been derived from limited sampling at landing sites and is considered only approximate. The method of collecting data involves counting all landings and all departures and gives great scope for misunderstandings. The number of trips could be half of that indicated. Small boats ferrying local people and goods across the river (e.g ferry service at Jaria to cross Kangsha River) account for about half the total traffic volume.

Table 2.8: Estimated Annual River Landings and Departures

Item	Dry Season	Monsoon Season	Calendar Year
Cargo (Tons):			
Inbound	43,000	54,000	96,000
Outbound	36,000	50,000	86,000
Total	79,000	104,000	182,000
Passengers:			
Inbound	2,460,000	3,027,000	5,487,000
Outbound	1,607,000	3,069,000	4,676,000
Total	4,067,000	6,096,000	10,163,000

The river system of the area is seasonally navigable as a result of rainfall and runoff from the Meghalaya Hills. At present a seasonal water transport system is available for 4 to 5 monsoon months in the upper areas and 6 to 10 months in the lower areas.

During the dry season, river flow decreases substantially and the upstream reaches become too shallow for boat traffic. This problem is aggravated by use of surface water for irrigation, which depletes most or all of the residual flow in many of the border rivers. Siltation is also occurring in the lower Kangsha and Someswari Rivers which restricts their use to smaller boats for transport during the dry season. Embankments have closed connections between the main rivers and the interior floodplains in some locations, principally in the Kangsha River Improvement project downstream of Jaria.

Country boats have traditionally been used as the principal means of transporting inputs to the farmer and produce to the market, particularly to the Dhaka area and Narayanganj markets. Smaller boats are used in the dry season and this is possible only in the lower reaches of the Kangsha River and in the Someswari River.

Industry

The project area has a small manufacturing base that is dominated by medium and large scale rice mills. Other activities include hand looming, biri factories, wood processing plants, and brick fields. In total the industrial sector employs approximately eight thousand workers of which approximately 80% are in food related industries and 16% in the brick fields.

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Employment
There are more than one million people in the potential labour force of the project area including 85% of the females and 23% of the males who are 'unpaid family workers'.

The major source of employment for both men and women is agriculture. Transplanting and harvesting are the main activities. Men earn Tk 30 to 45 and two meals daily during peak agricultural periods and Tk 20 to 30 daily during the off periods. During lean times labourers migrate to Sunamganj and Sylhet Districts for the *boro* rice harvest, or elsewhere for a variety of urban jobs. Employment opportunities for women are limited in the area and only a few are employed as seasonal labourers and in the rice husking mills. A few of the poorest women are employed by the Rural Maintenance Program of CARE and some women migrate to the cities in the area to work as domestics.

Fishing is an important economic activity. Thirteen thousand people and their families depend on it for their sole source of employment, directly supporting some 70,000 people or 5% of the population. In addition large numbers of people are engaged part-time in fishing or depend on it for subsistence.

Water Management Projects
There are a number of water management projects in the Basin. These include larger projects constructed by the BWDB, smaller embankment projects constructed by NGOs in the Someswari area, and small cross-dams for water retention in small border streams.

Generally it is found that the projects which are constructed under local initiatives are more successful at meeting the needs of the people but these are limited in scope and do not always work successfully. Many of the larger projects also do not operate as designed; embankments frequently breach, water retention structures are damaged, and regulators do not function or are not operated properly. These conditions are not limited to the Kangsha Basin but are common throughout the region. Further details of the existing projects are provided in Annex A.

3. WATER MANAGEMENT ISSUES IN THE KANGSHA BASIN

Broadly speaking, the Kangsha Basin suffers from two water problems - excess of water during the monsoon season and shortage of water during the dry season. Thus both problems need to be addressed. A further problem is the morphological instability of the border rivers, especially the Someswari River. Other environmental constraints are important and need to be considered.

This chapter provides a review of the water management issues in the Basin. Issues are described in terms of problems, priorities, constraints, and possible solutions based on information provided by the local people, direct observations, and analysis in this study.

3.1 Flood Damage to Crops and Homesteads

More than 60 per cent of the area of the Basin is flooded once, twice, or more times annually. Flooding is flashy, especially in the Piedmont tributaries. It occurs quickly and with little warning, and inundates extensive areas. The flood conditions are serious and difficult to control.

Flooding has an important hydrologic role in moderating the downstream flows. Peak flows in the Kangsha River would be doubled if the upstream flooding were to be eliminated. As shown in the flood hazard map (Figure 12) the nature and extent of flooding varies throughout the Basin.

Flooding results in direct damage and decreased yields of monsoon season rice crops. T. *aman* crops are re-transplanted after flooding, sometimes two or more times, which results in extra costs and lower yields. Flooding also causes direct damage to homesteads, roads, and embankments. The risk and uncertainty discourages farmers from planting higher-yielding varieties of t. *aman* and from making other investments in their future, thus limiting the potential for economic growth in the Basin.

Thus stabilizing flood regimes and installing a measure of predictability are a pre-requisite for economic and social development within the Basin.

3.2 Existing Water Management Works Do Not Function As Planned

Many of the existing water management projects in the Basin do not function as planned. This failure occurs for a number of reasons including breaching of embankments, deposition of sediments, and failure of regulators during floods.

Some projects are inappropriate for their application. Some examples in the Basin:

- Embankments along the Piedmont rivers cause aggradation by cutting off the overbank spills of sediment, leading to breaching of the embankments such as presently occurs in the Chillakhali River.
- Manually operated regulators are not appropriate in water retention structures in the border rivers where flashy peaks occur before the regulators can be opened. Overflow weirs could be used instead to provide a fail-safe outlet.
- Embankments are prone to breaching or public cuts if they do not address the drainage problems and the needs of people living outside the protected area.

A common problem is one of the embankments obstructing drainage from the protected area. This can be solved by providing an adequate number of drainage regulators at the required locations.

Inadequate maintenance of embankments and regulators also contributes to project failure. Many of the embankments and their regulators are maintained poorly or not at all which contributes to their early failure and ultimately to their abandonment. Some regulators are not operated correctly.

These problems suggest that better coordination between local bodies, BWDB, and NGOs is required. There is no effective organization for planning and managing water resources on a Basin scale. Problems can be reduced through greater participation of the local people in planning and operation of the project. Many of the processes and constraints are regional in scale and cannot be solved by projects that have a local focus.

3.3 Depletion of Fisheries Resource

Fisheries are important as the primary source of livelihood for large numbers of people and for subsistence for a large number of poor and landless people. Fish are the primary source of animal protein.

The productivity of the floodplain fishery is low compared with other parts of the Northeast Region. Although some 60 per cent of the Basin area is flooded during the monsoon season less than 0.1 per cent of it retains water throughout the dry season. The available habitat for overwintering fish is limited and is further deteriorating due to siltation of the *beels*, channels, and floodplain areas especially in the Malijhee lowlands upstream of Sarchapur. Migration routes from the Sylhet Basin are long and difficult (Figure 15). There is considerable scope for improvement by creating even a small number of sanctuaries and overwintering areas in the upstream areas.

The development of a sustainable fishery requires coordinated management of the floodplain fishery and enforcement of existing regulations. Short-term leasing provides little incentive for conservation. The present situation leads to overfishing and depletion of fish brood stock and the means for annual regeneration.

A large number of ponds are used for fish culture in the Basin but a high percentage of them are derelict and need to be rehabilitated. There is considerable scope for increased productivity through better management. Protection against flooding is required.

3.4 Use of Surface Water for Irrigation

Surface water is in short supply during the dry season and most of it is withdrawn in the upper reaches where it is used for irrigation. Irrigation is mainly practised for *boro* rice cultivation. About fifty percent of the net cultivated area in the Kangsha Basin is irrigated in the dry season; about 26% of this comes from surface water. There is little scope for further development for irrigation by surface water.

Dry season crops can be grown only under irrigation. Groundwater tables are deep in the Piedmont areas and do not permit extensive development of groundwater resources. Meanwhile, surface water which is sustained primarily by groundwater discharge in the Indian portion of the

catchment is in short supply during the dry season. Consequently agricultural development in such areas depends largely on the efficient management of the limited surface water that exists in the rivers.

The available surface water is used to its capacity during the dry season and there is little capacity for expansion. There is potential for better management through more efficient use, particularly for intensive cultivation of high-value, low-water use crops.

Conflicts over the use of this water will increase when an upstream user deprives a downstream user. There are several examples of such conflicts occurring in the Piedmont streams where cross-dams are built to retain water for irrigation. Upstream users release water when it is surplus to their needs but resist doing so during times of shortage. Sometimes the various parties come to agreement by themselves but sometimes they turn to legal remedies or to intervention by local authorities. A system of licensing should be considered in which the proponent would be responsible to demonstrate that sufficient water is available for the intended use and to determine what impacts to downstream users would occur.

As a matter of policy the surface water resources should be used only where alternative supplies from groundwater are not available. Priority should be given to using surface water for high-value crops which use less water such as vegetables, and for the use of surface water in upstream areas where groundwater is not available.

There may be some potential for further development along the Someswari and lower Kangsha Rivers where dry season flows are highest. However the morphological changes which are occurring in the Someswari River will substantially reduce the available flow.

There is little water available during the dry season for other uses such as fisheries, conservation, bathing, and water transport. There seems to be little scope to improve this situation. One possible solution is to divert flow from the Brahmaputra River into the upper reaches of the Malijhee River, which would augment the winter discharge throughout the downstream river system.

These issues will become more critical considering that increasing deforestation of the upstream catchment is likely to decrease the dry season river flow.

3.5 Development of Groundwater for Irrigation

In general the Basin area has abundant groundwater resources. The available resource is sufficient to supply twice as much land area as is presently irrigated.

Groundwater is generally available in the lower parts of the Basin toward the south, where it is widely used for irrigation. The available groundwater resource is sufficient to support the foreseeable irrigation use. However, full development of this resource will require adoption of deeper wells and deeper pumps and will lower the dry season groundwater levels. In some areas the capacity of shallow tube wells (STWs) has been reached and deep tube wells (DTWs) will be required to support further expansion. Many domestic wells are shallow and may run dry.

Less groundwater is available on the Piedmont plain which lies on the north side of the Kangsha Basin. Ground elevations are higher, water tables are lower, and soils are sandy and have little capacity for retaining soil moisture. There, the available resource could be used more efficiently

by irrigating non-rice crops which require less water. Vegetable crops are more profitable and will become more attractive with improved roadway access to local markets and the Dhaka urban area.

Groundwater irrigation has expanded at a rate of 8 to 10 per cent per year in recent years. The future rate of growth is difficult to predict but will likely be lower since groundwater development has been privatized and the most favourable areas have probably already been developed.

In those areas that are presently irrigated from groundwater, further expansion will put additional strains on the aquifer and may result in lower water level. The spatial distribution of the irrigation wells plays a crucial role - where the command area for a given well is small there is a tendency toward over-use of water. Each well should be allowed to irrigate the maximum area possible for its yield, thus reducing the overall rate of groundwater abstraction.

Since privatizing the drilling industry, the government has taken a hands-off approach to groundwater development. There is no official regulatory or enforcement mechanism to prevent over-use of the available resource (this approach is supported by NMIDP). The potential for overuse is, to an extent, self-limiting provided that one type of pumping technology is used in a region; extraction will stabilize when groundwater levels fall to the lift capacity of the technology. Impacts are generally localized and fairly immediate. However there is potential for conflict where STWs and DTWs are used in the same area.

More data on groundwater levels and the distribution of soil conditions within the major aquifers of the Basin are needed. The groundwater analysis contained within this report was made with a lumped conceptual model that represents the average conditions within a *thana*. Thus the model does not necessarily represent local conditions. In addition there is limited field data with which to calibrate the model. Therefore the appraisal is on a regional scale and does not substitute for specific investigation and local experience.

Professional well drillers who rely on local experience would benefit from better data on regional groundwater levels and aquifer conditions. In turn the drillers should be required to provide soils logs and results of pumping tests for each well.

3.6 Inadequate Domestic Water Supply and Sanitation Facilities

Urban Water Supply and Sanitation

Though most of the urban population use safe water for drinking purpose, few of them use it for all other domestic purposes. To ensure use of safe water for all domestic purposes, running water is essential. Piped water supply is available only in Netrokona and Sherpur towns and its coverage is also very limited. It is essential not only to expand the piped water supply network in Netrokona and Sherpur towns but also its introduction in all nine *thana* centres.

Despite concerted efforts, sanitation coverage remains as low as 40% even in Netrokona and Sherpur Town and only 18% in the *thana* centres of the area. So, there is much scope to expand such facilities to the remaining vast population. As the urban population continues to expand, the need for improved sanitation facilities will become ever more pressing.

Rural Water Supply and Sanitation

Present indications show that the No. 6 hand pumps that are used for domestic wells are slowly being replaced by Tara pumps within the Kangsha Basin. The No. 6 hand pump can only abstract water from a depth of 6 metres below the village mound whereas the modified hand tube well (Tara pump) can withdraw water from depth of 15 metres or more. Shallow wells run dry during the winter months in parts of the Basin and are more vulnerable to contamination. The rate of replacement will need to be accelerated in the future with increased drawdown of the groundwater level.

Table 3.1 indicates the required types of pumps for replacing hand tube wells (HTWs) in the Basin over the next 20 years. DPHE has a program for improving domestic wells that should be encouraged and supported.

According to the 1991 BBS data, less than 3% of the rural population of the Kangsha Basin use sanitary latrines. The remaining population either use surface (water) latrines or have no facilities at all. The main reason is the general apathy of people towards hygienic practices and also poverty to some extent. So, the urgent task is to educate users of the traditional latrines to change to hygienic units and motivate those who are not using latrines now.

Groundwater Quality

The quality of groundwater is not routinely monitored for bacterial contamination when it is used for domestic purpose or toxic contamination when it is used for both domestic purpose and irrigation.

Table 3.1: Future Tube Well Requirements for Rural Potable Water Supply

Thana	Recommended Technology for Rural water supply	
	Upper Aquifer	Lower Aquifer
Sribordi	Tara	Tara
Jhenaigati	Marginal Super Tara	Tara
Sherpur	Marginal Tara	Marginal Tara
Nalitabari	Tara	Tara
Nakla	No. 6	No. 6
Haluaghat	Tara	Super Tara
Phulpur	Tara	Tara
Durgapur	Tara	Super Tara
Dhubarra	Tara	Marginal Super Tara
Kalmakanda	Tara	Tara
Purbadhala	Tara	Tara
Netrakona	Tara	Tara
Barhatta	Super Tara	Super Tara

Note: Suction lift for Marginal Tara, Tara and Super Tara are respectively 8.0 m, 15.0 m and 30.0 m

3.7 Threats to Wetlands and other Natural Areas

Permanent wetlands have become virtually extinct in the Basin, making up less than 0.1 per cent of the Basin area. These areas have been decreasing over time due to siltation by flood spills and due to increasing use of the wetlands area for agriculture.

Future expansion of agriculture will place additional demands on the wetlands areas. Wetlands are threatened by encroachment of crops and by drainage of *beel*s and channels for agricultural use. In many places the surface water is used for irrigation until it is exhausted before farmers turn to groundwater. This leaves no water for conservation and preservation of wetlands. Even the drainage channels themselves are used for cropping except for a narrow strip in the centre of the channel to carry the base flows.

Flood control embankments affect the monsoon season water levels and therefore affect the seasonal wetlands. Deepening and re-excavation of drainage channels pose a greater threat to the permanent wetlands.

Wetland products are important to many poor and disadvantaged people for food, fuel, and building materials. *Beel*s are also critical overwintering areas for fish. Wetlands are also important for diversity of plants and animals including some rare and endangered species.

Specific steps will be required to ensure preservation of the few remaining wetlands areas and their development as a resource.

3.8 Agricultural Production

Agriculture is the dominant sector of the Basin's economy and provides the greatest potential for development.

Increasing population requires that food production be increased at least 35 per cent over the next 20 years. Meanwhile the cultivable land area is decreasing as more land is lost to homesteads, urban areas, and infrastructure. Therefore greater productivity is required.

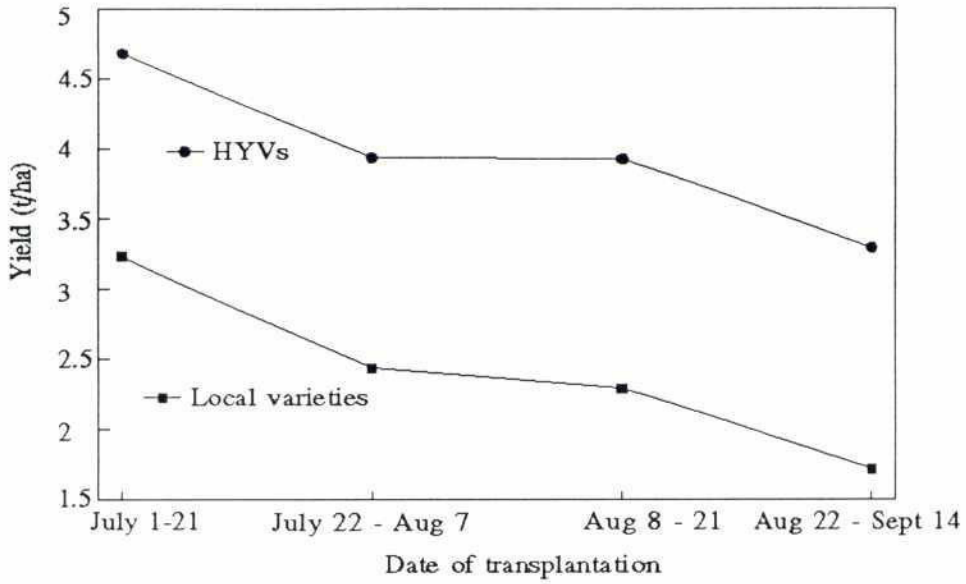
Seasonal Flooding

Flooding is the major constraint to rice production in the monsoon season. About 60 per cent of the cultivable area is flooded to a depth exceeding 2 m in places. The risk of flooding causes farmers to delay transplantation of *aman* crops and discourages farmers from adopting HYVs. Flooding during transplantation and early growth period causes delays, crop damage, and reduced yields. Sometimes the farmers are forced to re-transplant their crops.

Delays in transplantation result in lower crop yields. The relationship between yield (paddy) and date of transplantation is shown in Graph 3.1.

Water Supply for Irrigation:
Boro rice crops are grown in the dry season with irrigation. Surface water is in short supply in the dry season and most of the available water is already used in the upper basin. However groundwater is available in sufficient quantity to supply most of the agricultural needs except on the Piedmont plain and alluvial fans.

Graph 3.1: Effect of Transplantation Timing on Yield of T. *Aman*



Piedmont Plain and Alluvial Fans:
Soils have little moisture-holding capacity and are difficult to irrigate in the winter when groundwater levels are low and surface water is in short supply. These areas are generally not suitable for winter rice cultivation except in the lower portions.

3.9 Transportation Needs

Water transport remains important to many people of the Basin although improvements to roadways have reduced the dependency of people on the water transport system. Modernization and mechanization of county boats has occurred and will enable them to provide improved, speedier, and more efficient service especially in the transportation of heavy, bulky cargo.

However, waterways of the Kangsha Basin are mostly only seasonally navigable. Discharges are too low during the dry season to provide adequate draft in most places. There are few constraints during the monsoon season.

Jaria, Thakurakona, and Kalmakanda are important water transport hubs in the region. Improved dry season navigation links are required between these centres and the rest of the region and Dhaka. Streamflows are higher in the lower Kangsha Basin due to inflows from the Someswari River, but the river channels are shallow and go dry in places. The original Kangsha channel has silted in and the Ghulamkhali channel goes dry near Madhyanagar during the winter season. The Dhonaikhali is shallow in the winter season. Winter draught conditions will worsen as more of the Someswari flow is diverted away by the on-going avulsion toward the Atrakhali River.

4. PAST AND FUTURE TRENDS

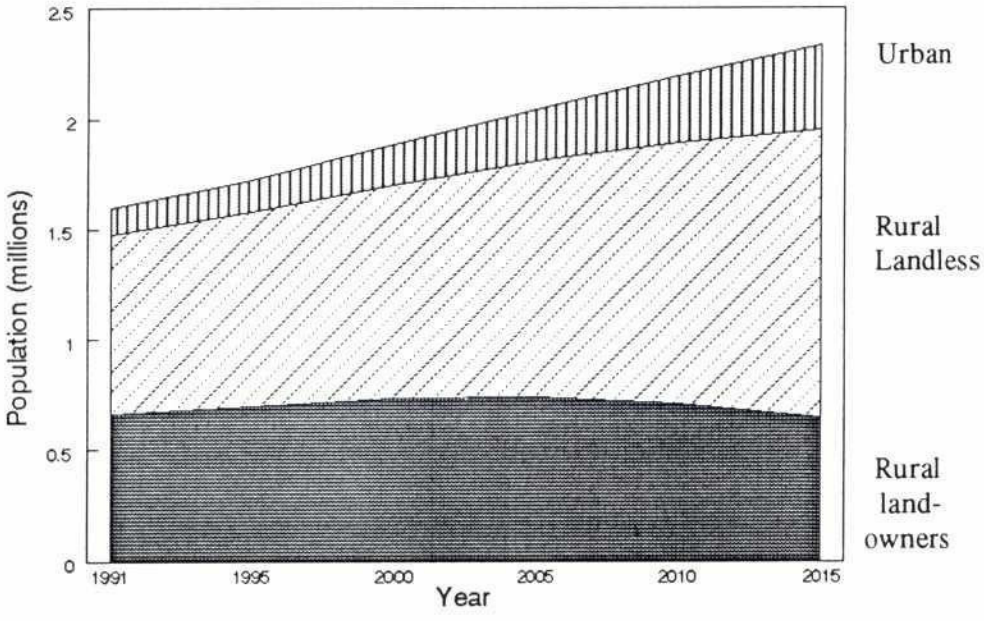
4.1 Socio-economic Trends

4.1.1 Population

It is estimated that the population of the study Basin will increase to between 2.3 million and 2.4 million people by the year 2015[1], an increase of about 35% from today's (1995) population. This increase will place additional demands on the resources of the Basin.

Graph 4.1 shows the projected population trends to Year 2015.

Graph 4.1: Population Forecast for the Kangsha Basin



4.1.2 Urban/Rural Population

Urban population has been increasing at a faster rate that the rural population because of better facilities for health care, education, and employment. Landless people are particularly attracted by opportunities for non - farm employment. This trend is expected to continue and possibly

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[1] Based on data provided in Bangladesh Population Census 1991, National Series, Volume 1, BBS, Dhaka, 1994 and World Population Projections, The World Bank, The John Hopkins University Press, Baltimore, 1994. All projections have been made by 'age-sex cohort component'.

accelerate. Assuming an annual growth rate of 5% it is estimated that the urban population will increase to over 380,000, more than double today's, by the year 2015[1].

Notwithstanding this increase the rural population will continue to make up the vast majority (80 to 85%) of the Basin's population. The rural population will increase by about 25% to 2 million people in year 2015.

4.1.3 Land Ownership

About 55% of the rural population is currently defined as landless[2]. This proportion is expected to increase to 67% by the year 2015. Increase in population is the main factor as the existing land base is divided among an ever-increasing number of people. Contributing factors are loss of land to urban areas, concentration of landholding among a small number of more affluent land-owners, and increase in salaried employment. During the period from 1960 to 1990 the landless population increased at an annual rate of 2.9 per cent which is higher than the population growth rate.

This implies that employment opportunities will need to increase or there will be an increase in poverty in the Basin.

4.1.4 Labour Force

Infant mortality rates are expected to decline and life expectancy will likely increase. As a result of these changes the civilian labour force (CLF) will increase from 0.75 million in 1991 to 1.20 million in 2015[3]. This means that as many as 455,000 new jobs will need to be created during this period to maintain the current level of labour absorption.

4.2 River System

Someswari/Shibganjdhala/Atrakhali Rivers
The Someswari River will continue to experience substantial morphological activity and to undergo large changes in channel form and location, flow distribution, and water levels. Since 1963 the Shibganjdhala channel has been developing to become the main course of the Someswari River. Deposition has been occurring in Sitli *beel* to the point where it has substantially filled in. As this process continues the locus of deposition has been shifting further

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1 Annual rate of 5% was assumed for urban population growth. Urban population grew at an annual rate of 7.33 percent in Bangladesh from 1974 to 1991. Much of this increase was concentrated in the major metropolitan areas of Dhaka, Chittagong, Khulna and a few district headquarters.

2 1991 landless figure has been extrapolated from the 1988/89 Household Expenditure Survey of the BBS. Forecasts assume an annual growth rate in the landless population of 2.0 percent. Data correspond to the whole country but there is little variation in different districts. A landless household is defined as one which owns less than 0.5 acre of land.

3 CLF (civilian labour force) is defined as the population aged 10 years and above who are available for employment. Estimates are based on national data but it has been observed that there is little variation in life expectancy in different areas of the country.

upstream to near Durgapur. Deposition and rising water levels are leading to an increased tendency to form avulsions, which are channels formed by overbank spills, as has occurred in 1988 and 1995.

The active channel and floodplain zone has extended over a width of about 3000 m. This zone will be subject to high-velocity overbank spills, bank erosion, and sand deposition.

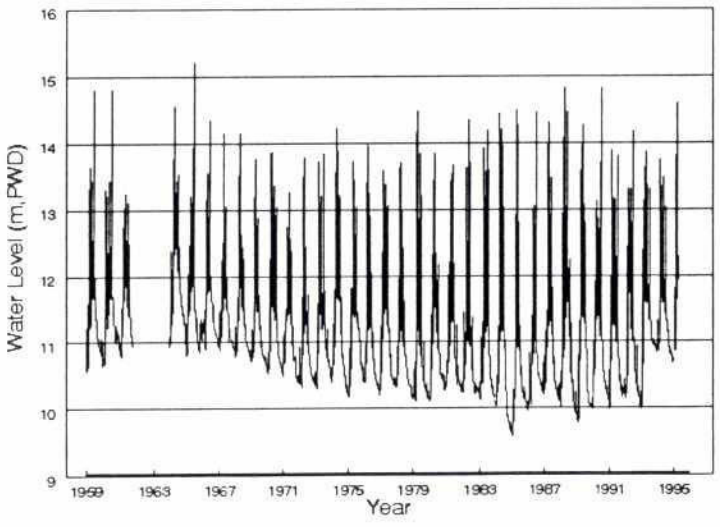
These historic changes are a model of those which will likely occur in the Atrakhali Khal. This channel formed as an avulsion in 1988 and will likely continue to grow until it becomes the dominant channel in the system. Deposition and channel formation will occur in the Atrakhali and lower Someswari River (downstream of Kalmakanda). Initially the locus of deposition will be in the upper reaches and the floodplain of the Atrakhali but as these areas fill in the bed material will be carried further downstream. Ultimately the channel will aggrade upstream which will cause water levels to rise and start the process of avulsion again.

As this process continues the flow in the Shibganjdhala will be reduced and the rate of sediment deposition will increase near Durgapur. This will initially lead to increased channel instability near Durgapur but may reduce the rate of siltation on the lower end of the fan, in Sitli *beel*, and in the lower Kangsha.

These processes are inherently unstable, depending on the occurrence and sequence of large floods and intervening dry years, and are difficult to predict with any certainty. They will threaten infrastructure, villages, crop lands, and fisheries habitat. If a complete avulsion down the Atrakhali channel occurs it would affect roughly 38 km^2 of land on the fan. It is likely that this increased instability will persist for at least 20 to 30 years. These changes will further contribute to the risk and uncertainty of the people of the area.

Graph 4.2 shows the past changes in water levels at Durgapur. Water levels fell by as much as 1 m from 1963 to the mid-70s as the newly-formed Shibganjdhala channel eroded and became entrenched. Flood levels subsequently rose between 1975 and 1988 to a level near those which

Graph 4.2: Water Levels in the Shibganjdhala River at Durgapur



occurred in the early 1960s, possibly due to infilling of the Old Someswari channel. It is likely that this cycle of water level changes will repeat over the medium future as the Atrakhali channel continues to develop and the Shibganjdhala channel fills in.

Discharges in the Shibganjdhala River will be reduced as the channel fills in and the Atrakhali channel develops. Initially the change in flood discharges may be small as a spill channel will continue to exist. Dry season flows will be more seriously affected as the Shibganjdhala will likely be blocked off entirely at lower stages and the entire lean-season flow may be carried by the Atrakhali channel.

Kangsha River
Sediment inflows into the Kangsha River have been increasing as the Shibganjdhala has developed and Sitli *beel* has filled in. These changes have increased the lateral activity and formation of bed forms and point bars throughout the reach from Jaria to the trifurcation. Downstream of the trifurcation the original Kangsha channel has largely filled in and a new channel, the Dhonaikhali, has developed to become the main channel. These processes will continue at least in the near term. As the Someswari stabilizes in its new regime with Atrakhali channel as the main branch the amount of sediment being carried into the Kangsha will decrease and the Kangsha will stabilize somewhat.

Winter discharges in the lower Kangsha River which originate almost entirely from the upper Someswari River will be seriously reduced. Winter water levels will decline which will aggravate the problems of winter navigation in the Kangsha River. Flood discharges in the Kangsha River will likely not change initially but may decline somewhat over time as the Atrakhali channel develops and the Shibganjdhala channel fills in.

The upper Kangsha River, from Sarchapur to Jaria, is relatively stable and no significant changes are expected. Bank erosion will continue at the outside of meander bends as part of the normal meandering process.

Malijhee River
The Malijhee River appears to be relatively stable in the upper reaches although it has local erosion and siltation problems. Flooding and siltation will continue to occur in the Malijhee depression as presently is the case.

Chillakhali River
The Chillakhali River will continue to aggrade in the embanked reach until it attains a more stable profile (steeper longitudinal slope) that is capable of transporting the bed material load. Lateral instability, erosion, and breaching of the embankments, especially where they are located adjacent to the river, will be more frequent. Deposition of the sand and silt bedload in the Malijhee depression will continue and will possibly increase as the inflow of sediment increases.

Bhogai River
The Bhogai is relatively stable in its upper reaches but bank erosion and breeching of the embankments will continue to occur from time to time. Direct impacts to homesteads and agricultural lands will be localized and of short duration. Flood damages will be more serious further downstream where the topography is flatter and flooding is more prolonged.

Southeast of Nalitabari the channel bifurcates into two branches. The south or Malijhee channel has developed to become the main channel while the north or Bhogai channel has been filling in with bed material. This trend will continue.

Flooding will continue to occur in the lowland floodplain of the lower Bhogai/Malijhee River, much as happens today. Flood levels may be modified over time by the processes of erosion and deposition that are occurring in this area but it is unlikely that these changes will be dramatic or rapid. Development of the Malijhee channel is retarded somewhat by the presence of cohesive clay deposits in the river bed and banks.

Nitai River
The Nitai River is stable in its upper reaches but is shifting about in the lower reaches where deposition is actively occurring. This will continue and may accelerate in the future especially as it is affected by deposition from the Someswari.

4.3 Siltation

The future sediment loads supplied to the area will depend primarily on future climatic conditions and the extent of land use in the catchments. There is evidence from satellite photos that deforestation and sediment runoff from the Meghalaya Hills has increased substantially in the last few decades. It is likely that this trend will continue.

The main impacts from increased sediment yields would be increased instability of river courses, reduction of land area suitable for agriculture, increased hazards to infrastructure, reduction of fish habitat such as *duars* and *beels*, and reduced navigability of the Basin's rivers. Areas along the Shibganjdhala River, Atrakhali channel, and Malijhee floodplain will likely be most affected.

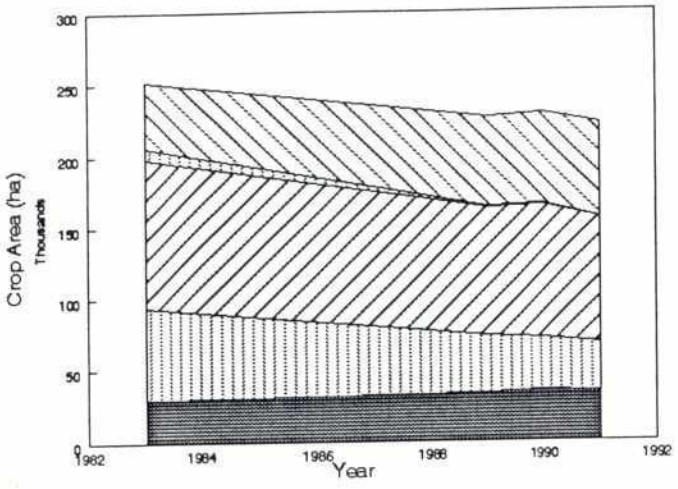
4.4 Agriculture

4.4.1 Recent Trends

Cropped Area
The net cropped area has decreased by 8% over the last decade, implying that the area under homesteads, roads, and markets has increased. The total crop area has declined by about 12%, primarily due to declines in the double-crop area.

Graph 4.3 shows the trends in crop areas from 1983 to 1991/92.

Graph 4.3: Trends in Crop Area



Boro

Broadcast *Aman*

T. Aman

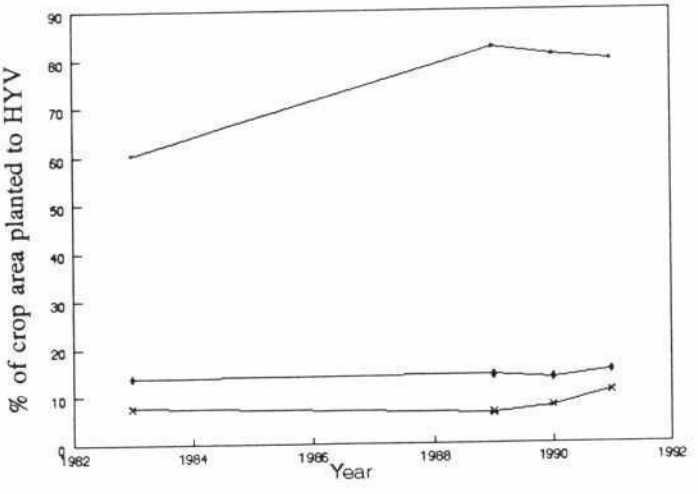
Aus

Non-rice

Rice Crop Area

The area of rice crop has declined by about 15%, primarily due to significant decreases in the *aus* and t. *aman* crop areas. B. *aman* (deepwater rice) cultivation has virtually disappeared. There has been a significant (40%) increase in HYV *boro* rice which indicates that areas which have traditionally been cropped in local *aus* and broadcast *aman* varieties are being converted to *boro* cultivation. HYVs have become more common and represent the majority (80%) of the *boro* crop area as shown in Graph 4.4.

Graph 4.4: Trends in High-Yielding Varieties of Rice



Boro

Aman

Aus

Non-rice Crop Areas
There has been a significant increase in the area of non-rice crops in the past decade:

wheat	67%
vegetables	48%
pulses	21%
oilseeds	67% (rape, mustard, and groundnut)

Vegetables and water melon are now grown commercially in some areas. The area dedicated to fruit trees has also increased.

The area of jute has declined by 23% due to global decrease in the market for this product.

Input Use
GOB distributes seed to promote alternative crops, especially wheat. Distribution of seed by GOB has almost doubled since in the past decade but still represents less than 10% of the total amount of seed used. Most seeds remain privately purchased.

Use of fertilizers, primarily urea, has doubled since 1983. The fertilizers have helped in the gradual increase of rice production, particularly in *boro* season.

Use of pesticides has increased by about 80% in the same period.

Crop Production
In the past decade, rice production increased by 10% from 289,200 tonnes/yr to 318,100 tonnes/yr, mainly due to the expansion of the area under HYV *boro* crop. Contributing factors included increased use of irrigation and chemical fertilizers. The average HYV *boro* rice (paddy) yield increased from 2.4 ton/ha to 2.7 ton/ha.

From 1983 to 1991/92 wheat production has increased by 25% from 4,250 tonnes/yr to 5,300 tonnes/yr. However, the average yield has actually declined, from 2.3 ton/ha to 1.6 ton/ha, because a lower proportion of the wheat area is irrigated.

Jute production has declined by 30% from 111,000 bales/yr to 77,400 bales/yr, reflecting decreasing crop areas.

The production of vegetables has increased significantly, from 21,000 tons/yr to 35,000 tons in 1991/92. Improved road transportation to markets may be a factor.

Prices and Consumption
Rice production has increased in recent years. Bumper crops occurred in 1991 and 1992 and resulted in lower prices. Meanwhile there has been increased consumption of wheat, fruit, meat, and milk which has resulted in higher prices for these products.

4.4.2 Future Trends

Monsoon crops, especially t. *aman*, will continue to suffer from flooding particularly in the Malijhee Depression, between the Kangsha and the Mogra River, on the Kangsha north floodplain, and on both sides of the Atrakhali and Shibganjdhala channels.

Siltation will reduce the land available for agriculture and the productivity of land. The most vulnerable area is the floodplain of the Atrakhali channel but parts of the Malijhee depression and the Bhogai-Malijhee floodplain will also be affected. Local areas will also be affected along the Chillakhali and Bhogai Rivers due to embankment breaches.

There will be a slight increase in crop areas and yields in the dry season due to expansion of irrigation from groundwater and due to increased use of fertilizers and pesticides. Cropping intensity will increase slightly due to the increased cultivation of non-rice crops. These increases are not expected to match the increase in population.

Table 4.1: Changes in Irrigated Area

Crop	Irrigated Area (ha)	
	1983-84	1990-91
Rice:		
Aus	2,679	1,019
Aman	2,426	1,406
Boro	50,688	63,655
Wheat	2,269	2,340
Potato	319	694
Vegetables	179	835
Other	982	5,254
Total Irrigated Area	**59,542**	**75,203**

Source: Yearbook of Agricultural Statistics, BBS 1987 and 1992.

Rice will remain the dominant crop. Crop areas are expected to increase slowly and most of this increase will be in high-yielding varieties. Non-rice crops will continue to represent a small but increasingly important component of the total crop production. Improved road transportation to urban and regional markets will further encourage cultivation of these high value crops.

4.5 Irrigation

Irrigation Use

The total irrigated area increased from 60,000 ha in 1983-84 to 75,000 ha in 1990-91 (a 25% increase). HYV *boro* rice remains the major irrigated crop, accounting for 85% of the total area under irrigation (Table 4.1). The use of irrigation for wheat, potato, vegetables, and sugarcane has also increased.

Recent trends in surface water and groundwater use for irrigation are shown in Graph 4.5.

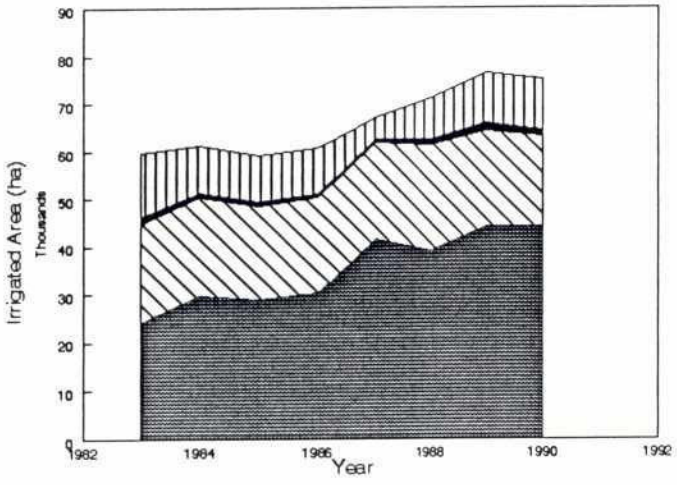
Surface Water

Irrigation from surface water has more-or-less reached its potential and there will be only small increases. There will continue to be irrigation from cross-dams in the upper tributaries to grow winter rice crops, and depletion of the available flow downstream of these dams will continue to occur. The Kangsha River will continue to go dry in the winter and this trend may increase as more water is used upstream. Supplemental irrigation from surface water in the t. *aman* season and early *boro* season may increase.

Groundwater

Substantial expansion of groundwater irrigation has taken place during the last 20 years, especially in the use of STWs. Recent years have seen an increase in irrigated area in Bangladesh of about 10% per year. The trend is still strong but future increases will probably be lower.

Graph 4.5: Trends in Irrigated Area



If expansion within existing irrigated areas continues the additional strain on the upper aquifer may result in water shortages for the STWs. STW pumping technology cannot be used where the depth to groundwater is greater than 7 m.

Development of DTWs has declined since the Government's stopped its DTW program. The cost and the technical knowledge required to operate this technology are substantially higher than for STWs. A contributing factor is the difficulty in assembling a sufficiently large block of land to warrant the installation of a DTW, which serve a larger area than do STWs. However if STWs begin to experience water shortages then DTWs may become more in demand.

Continuing development of irrigation, especially using DTWs, will put further stress on the hand tube wells that are used for domestic water supply. It is expected that conversion to HTWs will be required in a number of *thanas* in the study area.

4.6 Fisheries

Floodplain Fishery

The open water capture fishery will decrease substantially because of sedimentation of *beels* and *duars*, deterioration of water quality, and overfishing. These changes will impact both professional fishermen and subsistence fishermen. The landless and disadvantaged segment of the society will be particularly affected.

Many *beels* will become less productive. Siltation will affect most of the *beels* in the Malijhee depression. Overwintering grounds will be reduced due to siltation, expansion of agricultural lands, and closing of migratory routes due to road and embankment construction.

Changes in fishery production will be materially affected by the morphological changes that are in progress in the Someswari River. The Shibganjdhala River will continue to deposit silt and sand in the Kangsha River. If the Someswari continues to shift into the Atrakhali channel the

Kangsha flows will be virtually eliminated during a large portion of the winter months. These changes will further impede the winter and early pre-monsoon migration from the Sylhet Basin.

Increased use of pesticides and other toxic chemicals in agriculture will cause further threats to fish eggs and juveniles which are especially sensitive.

Over-fishing and depletion of the brood stock are the most important causes of decline in the fisheries resource. They are related to increased population which creates more demand for fish, especially by subsistence fishermen. This situation will continue unless the existing laws are better enforced.

Change in fish species diversity will occur. Some species which are abundant now may become rare. Such a trend has already been observed for some species like Veda, Mahasoal, and others.

Department of Fisheries statistics would indicate that fish production has increased; however our field investigation and interviews with the local fishermen revealed that there has been at least a 30% decrease over the last 10 years.

Culture Fishery
Culture (pond) fishery production has increased significantly over the last 10 years. There has also been an increase in the number of hatcheries and nurseries. These trends will continue in the future and will primarily benefit the people who own land and can afford the input costs. Development of this industry will create employment opportunities for professional fishermen who will be displaced from their traditional profession by decline in the floodplain fishery.

Fish Consumption
Fish consumption in 1991 is estimated by NERP's fish consumption survey to be 5,300 T/yr. It is expected that per-capita fish consumption will decrease slightly due to declining availability but that the total consumption of fish will increase due to the increasing population. It is estimated that the total fish consumption will be 7,500 tons in year 2015. Fish will remain the primary source of animal protein for most people.

4.7 Transportation

Although still important the water transportation sector has experienced a substantial decline in recent years, largely due to improvements to the roadway network. Siltation in the rivers has also made water transport more difficult. Currently, river transport and roadways each carry almost 50% of the paddy and long distance transport while the share of the railway system has declined to 1.35 percent of the total.

Road transportation will increase substantially with LGED's programme to connect all the growth centres with the national highways, including construction of three bridges across the Kangsha at Goatala, Jaria, and Thakurakona (now in progress). This will become the most important mode of transporting high value agricultural products that require speedy transport to urban markets including poultry, dairy products, and fish. The movement of people to and from Dhaka and other urban centres will also increase over this mode of transportation.

The rail system will lose its importance as the road networks are improved.

Water transportation will decrease due to the expansion and improvement of road communication in the area and continuing siltation and closing of waterways. However, it will continue to provide long-distance transport of bulk cargo. Transport of paddy to rice mills near Dhaka is mostly done by boat (70%). Passengers in the deeply flooded area will continue to use this mode of transportation, especially for local transportation during the monsoon season.

The fate of water transportation will depend on how effectively this mode of transport can compete with road transport. The speed and efficiency of country boats have recently been improved through modernization and use of engines. Improvement to conditions in the Kangsha such as are proposed in BIWTA's dredging programme for this river will also be a factor.

GOB has traditionally followed a 'laissez-faire' policy towards river transport in the country, especially with respect to the needs of country boats and launches. No maintenance or development work has been carried out in the Kangsha Basin and consequently there are shallow areas that impede the efficient use of the waterway system in the dry season.

In 1989 GOB appointed a foreign firm, DHV of The Netherlands, to carry out a feasibility study for the Waterways Master Plan for the country[1]. The Master Plan stated that the Kangsha River needs to be improved from its present seasonal status to the Class-II and Class-III standard. The Kangsha River is an important navigation channel because it connects to the country's network of Class-I and Class-II routes.

In accordance with the recommendation of the Master Plan and BIWTA's 5th Five-Year Plan (1995-2000), BIWTA has started dredging in the Kangsha downstream of Mohanganj. A total of 3.9 million cubic metres of material will be removed in the first year (1995-96) to provide Class-II and Class-III standards. Additional field work and studies are planned by BIWTA for deepening the Kangsha River up to Jaria-Janjail.

Generally, BIWTA, if requested by the local authority raises market places and growth centres. In absence of such scope, the drege spoil is placed in the river waters assuming that a large portion will be carried down to the sea.

4.8 Social Conflicts and Issues

With the need for more production to satisfy the demand of the growing population, conflict will increase over the use of dry season irrigation water and the provision of flood protection to monsoon crops.

Local authorities will continue to construct flood control schemes. Some of these will be unplanned and uncoordinated and will be constructed without proper study, which may give people a false sense of security, and which also may be detrimental elsewhere.

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[1] Bangladesh Inland Water Transport Master Plan (BIWTMAS), Final Volume No.1, 1989.

5. WATER RESOURCE DEVELOPMENT OBJECTIVES and PRINCIPLES

5.1 Goal

The fundamental purpose of the Water Management Plan is to indicate possibilities for sustainable development of water and related natural resources in the Kangsha Basin.

5.2 Objectives

1. Provide food security
   - protect agricultural land and crops from flooding
   - increase crop production:
     - improve farm management practices
     - sustainable irrigation
     - crop diversification
     - drainage
   - increase open-water (capture) and culture fisheries production
   - protect and manage natural areas used for food and other materials

2. Protect people and property against flooding
   - protect homesteads against flooding
   - protect infrastructure (roads, power, rail, water transport)
   - protect agricultural lands and crops
   - re-settle people on a voluntary basis from flood-prone areas

3. Facilitate economic and social development
   - reduce distress levels in the Basin through reducing risk and uncertainty
   - increase economic food production (beyond subsistence level)
   - protect and enhance water transport
   - provide adequate quantity and quality of domestic water supply for all
   - enhance local management of resources and projects
   - help alleviate poverty through generation of employment opportunities
   - improve the condition of the poor and disadvantaged, especially destitute women
     - ensure that project benefits accrue to the ultimate target group, the poor and disadvantaged
     - minimize direct impacts of flood control, drainage and irrigation (FCDI) projects on the poor and disadvantaged
     - ensure that benefits of resource development are passed as directly as possible to those who are most needy
   - create sustainable management of natural areas

4. Conserve and enhance the environment
   - protect important natural areas
   - improve management of wastelands
     - establish shrubs and trees for fuel and other purposes (roadside, wasteland, homesteads)

5.3 Water Development Principles

5.3.1 Social and Gender Equity

Whenever possible, resource development should target the poor and disadvantaged.

Development programs tend to benefit the higher-income strata of society more than the poor and disadvantaged. For example, FCDI projects, by improving agriculture and enabling crops to be grown in areas that were formerly at risk, result in higher crop yields and direct economic benefits to the landowners. These landowners may not even be the farmers. Unless these landowners and/or farmers employ the poor and landless[1] people as farm workers, the benefits are not passed down to the most needy. Meanwhile wetlands and other natural areas are reduced, which adversely impacts poor people who rely on these natural areas for subsistence. Benefits of economic development will eventually accrue, however a more effective strategy is needed to bring more immediate and more direct benefits to the poor and disadvantaged who are the ultimate target group for development. Protecting homesteads from flooding, by contrast, benefits all levels of society and probably preferentially benefits the poorer people who are more likely to have their home in marginal or at-risk locations.

Delivery of benefits to the poor and disadvantaged people can be improved through:

- preferentially hiring poor and disadvantaged people, especially destitute women, in employment in project construction and operation
- preserving and enhancing wetlands and other natural areas wherever possible
- developing programs and projects which target the poor and disadvantaged (for example, enhancement of capture fishery)
- providing direct subsidy programs for employment of farm workers

5.3.2 Good Governance

Good governance promotes law and order, stability, and discipline in the population. It also provides the opportunity for individuals to succeed.

Many water related projects involve conflicts in that while one group may benefit greatly others may be disadvantaged to a greater or lesser degree. However, unless there is a mechanism for resolving conflicts, including a way for the "winners" from a project to compensate "the losers", the project is not likely to be viable. It is quite common for farmers to cut a dike during the flood period if they perceive that the dike is doing them more harm than good, despite the fact that cutting the dike may cause great damage and hardship to others. There have been some successes (community based O&M Program) but apparently these are at quite a small scale. These skills need to be extended to larger projects, where the groups affected may live at long distances from one another.

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1 People are conventionally considered landless if they own no land other than a homestead. Thus the Landless people, by definition, include those who own no land or less than 0.2 ha.

5.3.3 Integration of Resource Development and Environmental Protection

It is explicitly recognized that environmental conservation is an integral part of natural resource management and both are necessary and interdependent. Conservation cannot ignore the needs of human beings, while development that ignores the environmental limits is doomed. Resource management can only be sustainable if it is conducted within the constraints of the capacity of the natural systems.

If natural resources are to be managed and their use moved toward sustainability for the benefit of national economies and local needs, then those charged with their management must address many issues. These issues are as wide-ranging as international treaties, domestic policy and legislation, rural community empowerment to manage natural resources, law enforcement as well as research and monitoring. Such a holistic approach is difficult but necessary.

5.3.4 Maintenance

Maintenance is essential with most modern facilities, otherwise they cease to function as intended. There apparently is a tradition of relying on government agencies for maintenance. But government forces are stretched thin and cannot hope to maintain all the hundreds of small structures and embankments nominally under their care. Getting communities organized to take responsibility and look after public facilities in their area will be essential. It is worth noting that farmers seem to have no difficulty in maintaining their tube well pumps and motors in good working order. Organizing groups to extend the same care to communal facilities should be possible.

5.3.5 Sustainability

Development should be sustainable. It is no use doing something that benefits people in the short term, if it makes them worse off in the longer term. This means ensuring its ability to continue providing the people in the Basin with an adequate living. The population will eventually have to stabilize for long-term sustainability to be achieved although it will continue to grow in the short-term.

To help ensure social sustainability and reduce the likelihood of societal breakdown the average standard of living (as measured in the crude way by GDP/capita) will have to continue increasing, or at least not begin to decline. From the water management point of view, this means promoting projects that have a favourable economic rate of return.

Almost everyone would agree that sustainability should be an important goal of any development initiative.

6. WATER MANAGEMENT STRATEGY

This chapter proposes a strategy for the management of the water and related natural resources in the Kangsha Basin. The strategy is composed of nine thrusts, each of which contributes to the achievement of objectives defined previously in this report and addresses the key water management issues. Each strategic thrust contains one or more specific initiatives (projects) totalling 29 initiatives, each initiative standing alone but meeting the overall objectives and supporting the strategy for development.

The nine strategic thrusts are described in sections 6.1 to 6.9. A summary of the 29 initiatives is given in section 10 and their details are further described in Chapter 8.

6.1 Protect Homestead and Agricultural Land Against Flooding

Issue:
Seasonal and flash flooding causes extensive damage to crops and homesteads in the Basin. It contributes to risk and uncertainty and generally discourages people from making investments that are important for economic development of the region. These pressures will increase as the population of the Basin and the country continue to grow.

Remedial Measures:
The proposed remedy consists of a number of projects designed to provide flood protection to different areas of the Basin. They include several initiatives that were included in the Pre-Feasibility study: Dampara flood control embankments, Malijhee River improvement, extension of Konapara embankment, and the Someswari Project. A number of new initiatives are included for further consideration.

Malijhee Floodplain:
Flooding in the Malijhee lowlands is extensive and difficult to control. No simple solutions exist. Embankments along the river are not feasible because the river is the sole drainage outlet and furthermore the flood discharge and water level in the river would increase substantially. Drainage improvements were proposed in the pre-feasibility study but have raised concerns regarding possible erosion of the excavated channel.

Three alternatives are identified for further consideration including the drainage improvements which were originally proposed in the earlier study. Two new alternatives involve diversion of flood peaks away from the flood-affected area. One involves diversion from the Malijhee River to the Mrigi River and one involves a flood bypass from the upper Bhogai via the north floodplain to return to the Kangsha River near Jaria. The Mrigi River would be re-excavated and the excavated section would be made large enough to accommodate the increased flow. The Bhogai diversion would involve re-excavation of an ancient channel of the Bhogai River which once flowed in this direction. Both alternatives would significantly improve flooding conditions in the Malijhee floodplain, but are large and ambitious undertakings and have serious technical and environmental questions that need to addressed in detail. They are recommended for further consideration in pre-feasibility studies.

Someswari Fan:
River shifting is the dominant process in the Someswari River. The Someswari has been forming an avulsion into Atrakhali channel which threatens to become the dominant channel and to partially or completely close off the Shibganjdhala and Old Someswari channels. While this change will benefit the area on the west side of the fan it will create problems of deposition, flooding, and channel shifting on the east side.

River shifting contributes to uncertainty and affects fisheries, settlements, and land use.

The pre-feasibility study proposed closing or regulating Atrakhali channel to prevent further development of the avulsion path. This is no longer possible due to construction of embankments along the Shibganjdhala River and recent changes in the river. At best this would be a short-to-medium term solution. The Shibganjdhala River will eventually aggrade and will need to shift, and Atrakhali channel remains the likely path of avulsion.

The strategy proposes an integrated approach to floodplain management on the Someswari fan. Phase 1 includes some priority projects that are required to protect existing infrastructure and the town of Durgapur. Phase 2 calls for the formation of a floodplain management committee composed of local representatives, government authorities, and NGOs that would be responsible for land use and water management planning, for relocating people out of high-risk areas, for monitoring changing conditions, and for implementation of local channel maintenance works to minimize impacts from the Atrakhali channel widening. Phase 3 consists of longer-term monitoring and engineering works to provide a wide floodway for the developing Atrakhali channels and a number of embankments to provide flood protection when conditions on the fan stabilize.

The general approach is to permit the river to continue to shift into Atrakhali and to help residents to adapt to the changing situation. A floodway zone would be designated in both the Atrakhali and Shibganjdhala floodplains based on the probable limits of active river shifting. No development would be permitted in this zone and no embankments would be allowed to encroach within this zone.

This proposal provides the best prospect for a long-term solution but like all others is not a permanent cure. Eventually the Atrakhali floodway will fill up with sediment in the upstream areas and the process of avulsion will occur again, this time possibly toward the west. Therefore an adaptive approach is suggested that will respond to future changes.

Local river engineering works would be constructed at the edge of the active floodway to control the extent of the floodway development and to encourage deposition of transported bed material so as to eventually form useful settlement areas. Flood-control embankments would be set back further on the floodplain to provide protection of land outside the active floodway and to save the embankments from the most severe attack from the river.

People presently living within the designated floodway would be relocated at their option to safe ground. River engineering works (armoured spurs and bank revetment) would be constructed to protect key areas near Durgapur against shifting of the Atrakhali and Shibganjdhala Rivers. Embankments would be provided at locations which are not completely exposed to river attack to provide whatever flood protection is reasonable.

A management structure would be set up to implement the management plan, composed of representatives from the local people and the BWDB. In addition to implementing specific works the management committee would continually monitor the changing conditions on the fan and modify the plan as required. Specialist input would be provided annually to review the plan and experience gained in its implementation and to develop an annual program of activities.

Non-Structural Interventions:
The needs of people living outside the embankment need to be considered. Intense conflicts often occur between beneficiaries and people living outside the embankment, especially if they perceive that the embankment is causing higher flood levels. This often leads to cutting of the embankment. Wherever possible these conflicts should be addressed through the following measures:

- embankments should be located as closely as possible to the river bank so as to minimize the number of homesteads and the area of crop lying outside the flood-protected zone,

- homesteads which are located outside the embankment should be raised and protected to ensure that they are above the potential flood level. In some cases secondary embankments will also be considered to provide as much security against flooding as possible, but it has to be recognized that these secondary embankments are vulnerable and cannot be guaranteed. Experience has shown that breaching of the secondary embankments can lead to further cutting of the main embankment if the homesteads are flooded. Therefore the homesteads lying within the secondary embankment should also be raised to be made floodproof.

- people who live between the embankment and the river and cannot be reasonably protected by the embankment should be given the option of being relocated to more secure areas,

- active involvement of local people in planning, design, construction, and operation of the project should be encouraged to ensure that their needs are addressed and that the project has their support.

People living within the project areas should also be given the opportunity to raise or relocate their homesteads to more flood secure areas. Embankments are often justified by increased agricultural production in "normal" years and are designed to provide relatively modest protection, typically against a 1:20 or 1:25 year flood. Experience has shown that embankments often fail and do not guarantee protection against even the relatively modest events for which they are designed. Therefore the homesteads should be raised and floodproofed as though the embankment was not in place. Design and construction standards for embankments should be raised and maintenance efforts should be increased.

It would be better if homestead raising and erosion protection could be included as part of a flood-protection (embankment) project, but as pointed out in the Flood- and Erosion-affected Protected Villages Project (FEAVDEP) pre-feasibility report the scale and time frame of homestead protection is different from that of other construction activities. Therefore a separate program of homestead raising and erosion protection is identified specifically to improve the security of homesteads against flooding.

Rationale:
Protection against flooding is a pre-requisite for economic development and to restore a measure of stability to the social environment. There is also significant potential for increased food production by providing protection of crop areas against flooding, principally by increasing the area and yields of t. aman rice crops. These changes will encourage people to adopt more intensive agricultural management practices including use of HYVs and fertilizer and to invest in other sectors of the economy and in their future.

Flood protection will facilitate increased area and yields of rice crops. Protection against flooding during the transplantation and tillering stage of t. aman crops is especially important as this period is when the plants are especially vulnerable.

Economic benefits of flood embankments, provided that they are appropriate for local conditions, can be substantial. Examples in the Kangsha Basin include the Kangsha River Improvement Project and the Thakurakona sub-project, which have lead to social, agricultural, and economic benefits even though these projects are not fully functional. Completion of the Dampara Project embankments will enable these projects to reach their full potential.

Areas of Uncertainty:
Notwithstanding the efforts to resolve conflicts through appropriate planning, design, and involvement of the people, it is likely that some people's needs will not be met. People may continue to cut the embankments to reduce their flood damages or to exert political pressure. It is also difficult to predict how widely and how quickly the farmers will adopt HYVs and intensive management practices which are required for increased rice production, and in part measure this depends on how much confidence they have in the embankments.

Specific Initiatives:
Identified projects include the following:

Embankments:
- Dampara Water Management Project
- Konapara Embankment
- Someswari River Hazard Management
- Chillakhali River Project

Diversions:
- Bhogai River Bypass
- Malijhee River Diversion

Channel improvements:
- Malijhee/Bhogai/Kangsha River Channel Improvements

Non-structural:
- Homestead Raising and Erosion Protection

6.2 Institutional Strengthening and Development

Issue

Many of the existing projects do not function as planned. The reasons are complex but are largely related to the fact that project implementation and operation are the responsibility of a remote institution; they do not adequately respond to local conditions or to the needs of the people. It is hoped that the present Water Management Plan will help by defining the constraints in the Basin and by outlining a development strategy and a number of specific projects. However it is only a first step and a number of steps will be required before the projects can be implemented. Changes to the development concepts may be required along the way.

The chapter on institutional perspective has examined the institutional environment in which the Upper Kangsha Water Management Plan has to be developed. It finds that there is a need for a mechanism to coordinate the implementation of the plan because:

- it requires coordination among several departments, agencies, and NGOs, each of which may be involved in individual projects in its own area of expertise,
- it spans thirteen *thanas* and three districts and there is no existing institutional arrangement to coordinate activities over such a large geographic area,
- many of the projects are interdependent and require an understanding of the regional constraints.

Among the present institutional structures there is no "natural" agency which can provide direction and coordinate efforts on a basin plan scale. Local administrative structures are focussed on the districts as the principal administrative divisions. While there are individual variations, line ministries are centralized and coordination at the district level is weak. It would be difficult for any ministry to undertake the floodplain Water Management Plan described in this report.

Similar difficulties occur in regional political structures which are focussed either above the level that is needed (they are focussed at the level of the *Jatiya Sangsad*) or below it (at the level of the union).

NGOs cannot be assumed to take on the role of regional water management coordinator. They may take a role in various projects if these projects are compatible with NGO priorities.

Local organizations are usually ad hoc and too small to play much of a role in regional water management. If locally-based management of projects is to be achieved within the plan, enough time must be factored into the project to allow for this. Alternatively the projects must be small enough that the time required to organize the communities is not a limiting factor.

Possible Strategies

Three strategies are suggested that would assist in the implementation of elements of the Water Management Plan. The first is a project-based strategy in which the integrating mechanism is the Water Management Plan itself. For this to be successful it is suggested that the plan needs to be

reorganized so that it can be presented in discrete parcels suitable for implementation. Two presentations need to be arranged, one for line ministries and one for donors. The purpose of the presentations would be to place forward a number of discrete project proposals.

This approach was followed to some extent with the Regional Plan. The Regional Plan carried the project proposal to the pre-feasibility stage. NERP organized a workshop to explain the elements of the plan to GOB officials who were at that time engaged in assembling the medium-term plan. The goal was to have aspects of the Regional Plan incorporated into the GOB medium-term plan.

The second strategy is to set up a regional development project that would have implementation of the plan as its specific mandate. That would allow the donor to undertake the necessary coordination among ministries. Projects such as this have been successfully implemented in Bangladesh, such as the Char Development Project which is being conducted under Dutch funding.

In the absence of any development agency, however, such a project would have a hard time finding a home. It would probably end up being located in one of the existing ministries with all the difficulties attendant upon that commitment. The most popular home for such projects at the present time is LGED. However LGED, for all its strengths, is becoming overloaded; it may not have the capacity to absorb any more projects at the present time.

Nevertheless a donor agency could propose such a project and explore with the Planning Ministry how it might be located. Perhaps the Ministry itself might to be prepared to act as a nominal sponsor. Even if it represented a departure from present practice, it would seem to be an appropriate activity.

A third possible approach, which is an extension of the second, would create a Kangsha Basin Water Management Authority which would be responsible for coordinating the activities of the various line ministries in implementing the Water Management Plan, for advanced planning, for organizing public participation, and for implementing the projects. It would consist of:

- a policy-making board consisting of locally-elected officials plus the three District Commissioners,
- a core staff of professionals led by an executive director, plus other staff assigned from line ministries as required,
- local committees that would mobilize community participation and guide the development process.

Such an institution could be funded by a foreign donor and would be given a specified time horizon. Such development authorities exist successfully in other parts of the world but to our knowledge have never been tried in Bangladesh and for this reason the concept might be difficult to implement. Finding a suitable home for the authority would involve a number of challenges and negotiations among the various ministries - on one hand its work could be better coordinated by the agency which has most involvement, the BWDB, but on the other hand it would be more readily accepted by other agencies if a neutral body without a vested interest were responsible.

It is critical that it have ties to and be accountable to the local people who are to be served by development. Perhaps WARPO could be the lead agency.

Suggested Strategy
The second option, that of a foreign donor-sponsored Kangsha Basin development project, is preferred. It would be responsible for coordinating the implementation of all water management projects in the Basin. It would coordinate the activities of all donors and line ministries and would set up Project Coordination Committees (PCCs) at the intermediate (basin) level and a number of project-level PCCs as recommended in the FPCO guidelines. It would also coordinate the preparation of pre-feasibility studies as required for specific projects that are proposed under this Plan.

Involvement of the BWDB, Department of Fisheries, Ministry of Agriculture, and others is vital for the successful implementation of this project.

Benefits
It is hoped that such a project would provide the required direction and coordination of efforts in the Basin. It would help to achieve effective public participation and would be more responsive to local needs. It would also help to avoid problems in project conception, design, and implementation by recognizing the unique conditions within the Basin.

Specific Initiatives
The primary initiative is the formation of a Kangsha Basin Water Management Project which is included in the project descriptions for completeness. It would ideally be implemented in association with a specific project such as the Someswari Project which includes the formation of an intermediate-level PCC. Other PCCs would be formed for individual projects such as the Dampara Project.

6.3 Protect and Enhance Fisheries

Issue:
Productivity of the floodplain fishery is low due to a number of factors:

- siltation of *beels* and channels, especially in the Malijhee floodplain, and lack of overwintering areas;
- long and difficult migration routes from the Sylhet Basin for spawning fish;
- overfishing and depletion of brood stock, compounded by poor enforcement of existing regulations;
- drainage of *beels* and channels for agricultural purposes;
- use of *beel* water for irrigation;
- cutting of floodplain spills by flood-control embankments.

These trends are likely to continue with expansion of flood control, on-going siltation, and expansion of agriculture.

Productivity of culture fishery is also low due to flooding and siltation of ponds and lack of intensive pond management for increased production.

Both areas show significant scope for improvement.

Remedial Measures:
The plan identifies the opportunity to develop a sustainable floodplain fisheries resource by protecting and creating new overwintering areas for fish. Selected *beels* will be excavated and managed as fish sanctuaries to preserve overwintering brood stock, especially in the Malijhee floodplain.

The plan recognizes that pressures on the floodplain fishery will increase as demand for fish continues to increase. Therefore culture fisheries will play an increasingly important role in the total fisheries production. Several initiatives are targeted to increase culture fishery production and diversification. A number of additional fish hatcheries will be needed, as is expansion of the existing programs of the Department of Fisheries (DOF) to release fish fry. Alternative fish crops such as freshwater pearl and freshwater prawn will be promoted and developed through demonstration projects that will prove the feasibility and make the technology available to the local people. Demonstration projects will also develop and make available better management practices for culture ponds.

Rationale:
Enhanced fisheries production is needed to raise the nutrition level of the people, as the fish is the main source of animal protein to the people of this country. The professional fishermen and landless people depend on the open water fisheries for their subsistence. Enhancement of the floodplain fishery and the pond (culture) fishery will contribute to economic and social growth.

Specific Initiatives:

- Fish Sanctuaries and *beel* Improvement, to development and protect overwintering grounds;
- Open Water Fry Release, to strengthen and expand existing programs of DOF;
- Support to Diversified Fisheries, consisting of several demonstration projects to diversify fisheries and to develop alternative fish crops;
- Fishpass Structure in the Kangsha River Improvement Project, to improve migration of spawning fish;
- Kharia River Fisheries Enhancement, a project to develop the Kharia floodplain as a large captive fishery;
- Shallow Floodplain Aquaculture, a project to apply aquaculture management practices to selected floodplain areas which will enable these to be developed for commercial fish culture;
- Rehabilitation of Malijhee Water Retention Structure for fisheries purposes.

6.4 Improve Management of Surface Water Use

Issue:
Winter flows in the rivers are low and are largely depleted by irrigation use. This leaves little flow for downstream users, fisheries, and conservation. Conflicts occur between upstream users and downstream users who are deprived of water by cross-dams. *Beel*s are used for irrigation and winter cropping and are mostly drained dry. Wetlands are mostly depleted.

Remedial Measures:
Better management and use of surface water should be promoted which does not require specific initiatives.

The present practice of using surface water in the upper reaches, where groundwater is not available in large quantities, is sensible and should be encouraged. However, better and more efficient use should be made of the available (limited) resource. Irrigation of rice crops in the piedmont areas is wasteful and is not practical in many places. The soil has low moisture-holding capacity. Instead, high-value vegetable crops that can be sustained with relatively limited water should be promoted. Groundwater should be used for irrigation wherever possible, especially in downstream areas where there is enough to supply irrigation demands.

Expansion of roadways into the project area should be promoted as a means to improve transport to regional markets and the Dhaka urban markets and thus encourage production of non-rice crops.

It may be possible to reduce conflicts in surface water use by means of regulation. A system of permits could be established in which a proponent would be required to demonstrate that there was enough water available for his intended purpose and to determine what impacts would occur to existing downstream users.

The Malijhee Water Retention Structure could be rehabilitated for fisheries use. It is no longer used for irrigation as it has been damaged in previous floods. Irrigation in this area is presently supplied from groundwater and from small-scale cross dams further upstream. The project would be provided with an improved outlet that would be less vulnerable to flash floods that destroyed the previous structure.

Three alternatives to increase base flows within the Kangsha River system might be considered:

- diversion of water into the Basin during the dry season, from the Brahmaputra River into the Malijhee River and the Kangsha River, by means of a gravity diversion or pump station;

- a weir-cum-lock in the Kangsha River at Jaria that would create a backwater pool as far upstream as Sarchapur, and would permit Someswari flows to be used in upper Kangsha River;

- a bypass in the Someswari River to sustain Kangsha base flows after the avulsion of the Someswari into the Atrakhali cuts off the winter flows in the Shibganjdhala River. The bypass channel would carry flows from the upper Someswari River, past the Atrakhali offtake, into the Nitai River or Shibganjdhala River.

These projects are large and expensive and may not be justified by the potential benefits.

Specific Initiatives:

- Rubber Dam for Irrigation, a pilot project to replace an existing earthen cross-dam with an automatic inflatable rubber dam designed to allow flash floods to pass,

- Improved Management of Surface Water Irrigation, a project to improve irrigation practices.

6.5 Improve Management of Groundwater Use

Issue:
Abundant groundwater is available in most of the Basin, but full development of this resource will require conversion to deep-well technologies that will result in lowering of winter water levels. In some places the resulting water levels will be below the limits of shallow tube wells used for irrigation and shallow hand tube pumps used for domestic water supply.

Remedial Measures:
Since GOB has privatized irrigation development, control over well development has passed into the hands of individuals or groups of farmers. In practice this means that there is no longer any specific management system in place to govern the development and use of groundwater resources. Developmental zoning which would restrict a specific type of abstraction technology to certain areas would seem plausible for tracts of land not yet developed for groundwater irrigation, but is impractical in zones which are already developed. Educating the users in proper irrigation techniques and water conservation practices may prove to be the best strategy for intervention.

In the meantime, careful monitoring by GOB of the developing groundwater irrigation situation and continued observation of groundwater levels should be undertaken. Effects of extraction for irrigation use should be monitored and periodic assessment of the groundwater status and prospects for further development should be made. Results should be freely available to potential users and professional well drillers in the Basin in order that they can make sound and informed decisions regarding further development of the resource.

Efforts should also be made to improve management of the available groundwater resource to prevent wastage. Cultivation of low-water use crops such as vegetables instead of rice should be encouraged. Surface water can be used for irrigation in highland areas where groundwater is not available in sufficient quantities.

Groundwater extraction should be limited to a maximum depth of 14 metres which is the lift capacity of the Tara pumps which are used for domestic water supplies. The alternative is to develop a HTW technology which is capable of pumping from greater depths.

Existing shallow wells that use the No. 6 hand pump for domestic water supply should be replaced with deeper wells and Tara pumps. Shallow wells are vulnerable to contamination and many of them already go dry during the winter months. The situation will worsen as groundwater extraction for irrigation is expanded. Existing programs of DPHE should be encouraged and supported.

Rationale:
The socio-economic conditions and land ownership pattern in the Kangsha Basin are complex and there are no simple means to ensure better management of groundwater resources. Cooperatives are often formed among small land holders who combine their resources to finance drilling of a well, purchasing the necessary pumping equipment, and sharing the operational cost.

This situation may be sustainable in the long run since extraction of groundwater is to a large extent self-limiting; that is to say the impacts are relatively immediate and localized such that extraction will reach an equilibrium governed by the resource availability. However, for the system to work the people who are involved in developing groundwater wells need to have reliable and up-to-date information on the resource availability.

Specific Initiatives:

- Expansion of the Kangsha Basin groundwater observation network,
- Rural Water Supply in the Kangsha Basin Area, to improve domestic water supply through upgrading of hand tube wells

6.6 Expand Domestic Water Supply and Sanitation Facilities

6.6.1 Urban Water Supply

Issue

Almost hundred percent of the Kangsha Basin urban population use safe water for drinking purpose but a large percentage of them use surface water for other domestic purposes. Surface water becomes polluted due to increasing urban population, and its use for any domestic purpose is detrimental to health. One of the reasons for use of surface water for domestic purposes is the short supply of piped water.

Strategy

To increase population coverage of safe water users for all domestic purposes in the urban areas, it is required to arrange running water through expansion of existing piped water supply networks and introduction of the same in the Kangsha Basin's urban centres where it is not available now. The GOB's target is to bring 50% of the population living in district towns and 10% of the population in the *thana* centres under piped water supply by year 2000.

Remedial Measures

To increase the use of safe water for all domestic purposes, it is required to increase running water supply. This may be achieved through expansion of existing piped water supply system in Netrokona and Sherpur towns by sinking of more production wells, construction of overhead tanks and expansion of water supply network. It is also required to arrange running water in the nine *thana* centres of the study area through introduction of piped water supply.

Rationale

Safe water and sanitation are vital for the improvement of health, productivity, efficiency and quality of human environment. Use of safe water for all domestic purposes is a pre-requisite for good health. Though almost hundred percent of the area people are using safe water for drinking purpose but its use is very low for other domestic purposes. To increase the use of safe water for all domestic purposes, it is required to expand the existing piped water supply in Netrokona and Sherpur towns and also to introduce the system in the *thana* centres.

6.6.2 Urban Sanitation

Issue

Of the area's 11 urban centres, the hygienic sanitation coverage in Netrokona and Sherpur towns (two district towns of the area) is as low as 40% as of 1991. In the nine *thana* centres, it is only 18%. The full health benefit of improved access to safe water will not be realized without improved hygienic sanitation coverage. With the rapid growth of urban population, the need for improved sanitation facilities will become ever more pressing.

Strategy

The national target of Government of Bangladesh for sanitation is to bring 80% of the population under safe sanitary facilities in district towns (10% under sewerage system, 40% under septic tanks and 30% under sanitary pit latrines) and 70% in *thana* centres (30% under septic tanks and 40% under sanitary pit latrines) by year 2000.

Remedial Measures
Improved sanitation coverage may be achieved through construction of piped sewer lines in Netrokona and Sherpur towns, and supply of low cost sanitary pit latrines in all urban centres. This has to be backed by a strong social mobilization to create an awareness in the minds of the public about the importance of sanitation.

Rationale
Use of safe water for all domestic purposes without hygienic sanitation will not improve the health conditions. Morbidity and mortality from water and excreta related diseases will persist at a high level.

6.6.3 Rural Water Supply

Issue
Upgrading of shallow domestic wells is required as they are vulnerable to contamination and many of them already go dry during the winter months. The situation will worsen as groundwater extraction for irrigation in expanded.

The DPHE has been monitoring the fluctuations of the groundwater table using a measuring network of tube wells, one in each union of the country. In 1986 about 12% of the wells were unable to supply water during the driest portion of the year. By 1990 about 20% of the wells were affected. It is forecast that as many as 50% of the wells will be affected by the year 2000.

Every year more than 7 per cent of the installed tube wells get choked up and need re-sinking. Also, many tube wells remain out of order as spare parts are not available locally or there are no funds for maintenance.

Strategy:
The Fourth Five Year Plan (1990-95) envisaged a national coverage of 106 persons per tube well. A DPHE proposal based on a UNICEF strategy paper aims at a national average coverage of 120 persons per tube well (this target ranges from 84 to 157 persons per tube well in different areas). Viewed in this context it is reasonable to aim for one public hand tube well to serve a maximum of 120 people by year 2000 and 100 people in 2015.

It has been estimated that a tube well fitted with the No. 6 suction pump can serve a population of 100 persons based on consumption of 50 l/person/day. A force-lift Tara pump can serve a population of up to 200 persons.

Remedial Measures:
The current aim is to change the No.6 HTW's to Tara types which are capable of pumping from depth of over 15 metres in most of the *thanas*. Existing programs of DPHE and UNICEF would be supported and strengthened.

Piped water supplies for the urban centres will require DTW technology which abstracts groundwater from the lower aquifer.

The domestic water supply will come under increased pressure as groundwater irrigation expands. In order to protect the supply for the growing population, some 50Mm^3 has been set aside up to year 2015, as shown in Table 6.1. The percent of the population that will be served by either

urban piped supplies or HTWs and the estimated consumption in litres per capita per day is shown in Table 6.2.

Table 6.1:
Domestic and Industrial Groundwater
Reserved for Future Use (Mm^3)

Thana	Year			
	1995	2000	2010	2015
Sribordi	0.23	0.28	0.42	0.46
Jhenaighati	1.83	2.24	3.39	3.71
Sherpur	1.49	1.87	2.92	3.23
Nalitabari	3.45	4.29	6.61	7.30
Nakla	0.94	1.16	1.76	1.93
Haluaghat	3.69	4.53	6.85	7.52
Phulpur	1.93	2.36	3.56	3.90
Durgapur	2.58	3.18	4.87	5.35
Dhubaura	2.39	2.92	4.40	4.82
Kalmakanda	1.15	1.42	2.15	2.36
Purbadhala	2.97	3.66	5.58	6.13
Netrokona	1.68	2.12	3.31	3.67
Barhatta	0.11	0.14	0.21	0.23
Total	24.43	30.16	46.01	50.60

Table 6.2:
Consumption Rate for the Population Groups

Population	Percent of Population			
	Year 1995	Year 2000	Year 2010	Year 2015
Pipe supply for Urban	25	35	45	45
HTW for Rural	61	67	87	87
Under-served	Remaining			
Population	Consumptive use in l.p.c.d			
	Year 1995	Year 2000	Year 2010	Year 2015
Pipe supply for Urban	105	110	130	130
Rural supply	53	56	60	60
Under-served	18	19	20	20

Note : l.p.c.d = Litres per capita per day

Rationale

In the country side, existing shallow wells are under threat of contamination and many of them go dry in the winter months. The situation will worsen with expansion of groundwater use for irrigation. Protection of the domestic water supply is essential because development and abstraction of groundwater for irrigation is presently unregulated. Further expansion of irrigation will occur into new areas using DTW technologies in many cases.

Women especially will benefit from improved access to tube wells as the responsibility for fetching water lies almost entirely with women. Fetching of water by women from outside the boundary of the *bari* is constrained by the norms of *purdah*.

6.6.4 Rural Sanitation

Issue

As of 1991, only 8,300 out of 291,000 households (less than 3%) of the Kangsha Basin's rural areas have sanitary latrines. Safe water without sanitation and good hygiene habits cannot be expected to reduce the incidence of diarrhoeal diseases or the resulting mortality.

Strategy
The GOB's goal by the year 2000 is "a latrine in every household". Emphasis has been placed on homemade bamboo/timber latrines, low cost 'one slab one ring' concrete pit latrines, and intensive social motivation programme to achieve the goal.

Remedial Measures
To achieve GOB's goal of providing "a latrine in every household", it is required to emphasize the construction and use of homemade low cost hygienic bamboo/timber latrines which is acceptable and affordable even to the poorest sectors of the community. In addition, supply of concrete pit latrines at a subsidized rate has to be made to the users who can afford the cost. Above all, it is very much required to educate users of the traditional latrines to change to hygienic units and motivate those who are not using latrine now through social mobilisation employing multi-sectoral channels such as different NGOs, Ansar-VDP, health and family planning workers, women's groups, religious leaders, teachers, students, etc..

Rationale
Safe water without sanitation and good hygiene habits cannot be expected to reduce the incidence of diarrhoeal diseases or the resulting mortality. An ICDDRB/UNDP/World Bank study in Bangladesh shows that a 25% reduction in incidence of diarrhoea in children under 5 is possible where there is one hand pump available for 50 users and every family has a sanitary latrine.

6.6.5 Water Quality

Issue
Groundwater quality monitoring in the area has been rather sporadic and few samples are available. In the area, groundwater is the main source for drinking and irrigation purposes. Recently, arsentic contamination in the groundwater has been detected in the country's western areas. People of this area also live in arsenic contamination panic. There is also possibility of toxic contamination in the groundwater used for irrigation.

Strategy
It is proposed to monitor groundwater quality to detect any bacterial and toxic contamination.

Remedial Measures
It is proposed to take necessary treatment measures, if any contamination is detected.

Rationale
Virtually all the population of the basin use groundwater for their drinking. Groundwater is also intensively used for irrigation. The presently available analytical data is insufficient to produce a comprehensive and meaningful picture of the groundwater quality for drinking and irrigation purposes in the basin.

There are two major concerns as regards quality of drinking water. These are:

- bacterial contamination (E-Coli); and,
- arsenic level

Except in limited areas in Sherpur and Netrokona towns, people of the area use hand tube wells to withdraw groundwater for drinking purpose. Most of the hand tubewells are situated in the

water table in the vadose zone (surface aquilude). Due to poor sanitary conditions, the water table in the vadose zone is subject to bacterial contamination (E-Coli) and may present serious health hazards.

Moreover, groundwater is being constantly contaminated by the use of fertilisers, biocydes and industrial affluent. Area's groundwater may also contain heavy metals that harm soil fertility and impact negatively on environment.

6.6.6 Specific Initiatives:

- Piped Water Supply in Kangsha Basin Urban Areas
- Rural Water Supply in Kangsha Basin Areas
- Kangsha Basin Urban Sanitation
- Kangsha Basin Rural Sanitation
- Baseline Groundwater Quality Survey

6.7 Protect and Enhance Natural Areas

Issues

The natural environment of the Kangsha Basin has been experiencing serious environmental degradation due to increasing pressures of human use. With increasing population, continuous fragmentation of homestead platforms, rapid urbanization, changing pattern of land use, and demand for fuel wood and house construction materials, tree cover in the area has sharply declined. New plants are not generated to meet the growing need of the increasing population. Thus an ecological imbalance is happening and people are not aware of the situation.

Wetlands are virtually extinct due to agricultural expansion and FCD project development, and a large number of wetland dependent plant and animal species are seriously threatened.

The project area supports 265 species of wildlife representing amphibians, reptiles, birds, and mammals. There has been wide-spread alteration of habitat, loss of wetland area, lack of vegetated area, and lack of perching/roosting areas for colonial birds and large raptors. There is a general lack of public awareness of the values and needs of these animals in the ecosystem. All these obstacles make the task of wildlife management difficult.

Remedial Measures

The proposed remedy consists of organising people for tree plantation, mobilize technical and financial resources for the programme, protection and management of areas of high biodiversity values, identification of degraded area and taking of measure to either restore them or take measures to arrest further degradation. An education programme will help to create and increase public awareness on issues related to conservation and enhancement of biodiversity and to move towards sustainable utilization of natural resources.

Rationale

With increasing population and increased demand for bio-mass, tree plantation has become a necessity. Homestead forest has been the largest source of fuel, timber and house construction materials for the people which meets as much as 70% of the demand for domestic use.

In the Basin, there are hundreds of kilometres of roads and embankments lying fallow. Afforestation of these roads and embankment will increase the national income and also improve the state of the environment. Moreover, a significant income can be provided to the landless and destitute women by associating them with the programme.

Many wetland plant and animal species are used by destitute people for subsistence. Several wildlife species are economically important too, for example, bull frog, varanus lizard, and common otter; hence increasing their population may be directly beneficial to certain sections of the community.

Several wildlife species act as biological pest controllers. For example the decrease in the population of frogs accelerates the increase in crop pests. Snakes and owls are important to control the rodent population.

The Basin supports some representative habitat types which if not cared now will be irreversibly transformed. Several internationally threatened wildlife species, such as Pallas's Fish Eagle and Bengal Fox have become locally restricted because of large scale alteration to their habitat resulting from increased human activities.

Resource development must recognize that conservation and development are both necessary and interdependent. Conservation cannot ignore the needs of human beings, while development that ignores the environmental limits is non-viable. So, protection and enhancement of natural areas, and conservation of biodiversity are vital for the benefit of the human species.

Specific Initiatives
Identified initiatives include the following:

- Social Forestry
- Conservation of Biodiversity

6.8 Expand Agricultural Production

Issue:
The population in the Basin is forecast to grow by 35% over the next 20 years. Meanwhile the area of cultivable land is ever decreasing at a rate approaching 1% per year as more areas are converted to homesteads and infrastructure. Thus, greater crop intensity and higher crop yields will be required to meet the ever-increasing demands for food.

As the dominant sector of the local economy, agriculture shows the greatest potential to generate employment and economic development. Only about 26% of the civil labour force is employed in non-agricultural occupations such as manufacturing, construction, trade, and transport services.

At the present stage the main policy objective of water development is towards increased foodgrain production and increased self-sufficiency in food. The objective is to increase agricultural production by optimizing the use of natural resources in a sustainable and environmentally sound way.

Remedial Measures:
The following will be required in order to diversify and expand agricultural production:

- control of flooding
- supply of water for irrigation
- providing reliable and adaptable technical guidance on farming practices and crop management for higher yields
- assistance and information regarding the marketing of farm products.

Suggested strategies in these areas are discussed below.

Flood Protection:
Agriculture suffers heavily due to floods. Between May and October more than 60% of the cultivated land is flooded to depths exceeding 2 m. There is substantial scope for increasing production of t. *aman* rice by preventing flooding of rice fields in the monsoon season.

Protection against flooding prevents damage to crops in the field. It also enables crops to be transplanted earlier which results in higher yields. As shown in Graph 3.1 in Chapter 3, advancing the transplantation date by two weeks, from August 1 to mid-July, would increase t. *aman* yields by about 50%. It also encourages farmers to switch to HYVs which require more inputs but generate higher yields. Presently only about 14 percent of the t. *aman* crop is in high-yielding varieties - thus there is potential for a substantial increase.

An increase in total rice production in the order of 10-20% is considered possible if the identified flood control projects are implemented.

Irrigation
A substantial increase in area and yield of *boro* crops is possible with expanded irrigation from groundwater. Presently almost one-half of the total rice production is with *boro* crops and most of the *boro* crops are grown under irrigation. Surface water is in short supply but there is sufficient groundwater available to substantially increase the *boro* rice area. Even allowing that

parts of the area could not be economically irrigated according to the land capability mapping which is presented in Annex A, a 50% increase in *boro* crop area is considered possible, and a 20-25% increase in total rice production.

Diversification of Agriculture:
Diversification of agriculture includes high value non-rice crop production, intensive livestock production including the introduction of medium-scale cattle farming, improvement of rice-fish culture, improvement of agro-forestry, and introduction of small-scale mixed farming.

Land capability mapping suggests that there is significant potential for increasing the non-rice crops, especially in the highland areas where soils conditions are not suitable for rice cultivation.

More than 100 crops, including 85 field crops, are grown in the Basin. These crops can be broadly classified as cereals, fibre crops, pulses, oilseeds, root and tuber crops, spices and condiments, vegetables, fruits, and narcotics. Non-rice crops presently account for 15% of the total crop area and 25% of the total crop production. They are suited to local conditions as they require less water than rice. For example, a wheat crop requires 300 to 450 mm of water whereas rice requires 800 to 1600 mm. Non-rice crops require small investment and low management.

Diversification in cropping can be expected to occur in the winter season - the agro-climatic condition will continue to favour rice production in the wet season. Non-rice crops can also be grown in the post-monsoon season between the t. *aman* and *boro* rice crops. The agricultural strategy should insure sufficient flexibility to allow for non-rice crops in the winter season if the farmers find such crops more profitable.

Development of Improved Farming Systems:
Improved farming systems should be developed to integrate other components of agriculture into farming practices by means of:

- intensive non-rice production
- integration of fish culture and livestock production into farming systems
- increased use of fertilizers and HYV rice
- research, extension, and demonstration projects
- more funding and training for extension programs to improve farming practices
- helping farmers adapt to the changes in flood and drainage regimes that are introduced by flood-control projects.

A research and demonstration project is suggested to develop and apply appropriate technologies and methods on pilot farms. Results would be made available to the people who would be encouraged and assisted in applying them to their farms.

Farmers should be encouraged to use technologies that increase productivity while conserving soil and maintaining land productivity. Farming systems which integrate crops, fisheries, livestock, and forestry should be encouraged to optimize resources.

Strategic Zones:
Crops should be diversified in those areas which are best suited. Land capability varies throughout the Basin. The recommended agricultural strategy for each of the agro-ecological zones defined in Annex A and Figure 10 is provided below:

Zone A - Lowland Floodplain:
Slow drainage and risk of monsoon-season flooding cause people to delay transplantation *aman* crops in this zone. Improved yields and increased area of t. *aman* crops can be achieved by ensuring protection against flooding. There is some possibility for non-rice crops between the monsoon and winter rice crops.

Zone B - Medium Floodplain:
Periodic seasonal flooding combined with rapid rise of flood levels cause damage to t. *aman* crops. Flood control and drainage improvements are required to increase t. *aman* crop areas and yields. Irrigation is possible in the dry season to as much as one-half of this area, to facilitate cultivation of *boro* rice crops.

Zone C - Piedmont Plain:
This area is generally well-drained and flooding problems are localized. Drought conditions occur in the winter season. A portion of this area has three crops - pre-monsoon, monsoon, and dry season - supported by irrigation from surface water and groundwater. There is potential for some DTW irrigation, but available water would be put to better use by expanding the area of non-rice crops.

Zone D - Upper Basin:
Sandy soil with little moisture holding capacity experiences drought conditions in winter. This area is generally well-drained but is affected by flash floods during the monsoon season. Drainage improvements would help prevent monsoon damage to rice crops. Better management of surface water and use of irrigation to support non-rice crops are suggested.

Zone E - Lowlands:
These areas are extensively and frequently flooded by flash floods during the monsoon season. *boro* is the primary crop; *aus* and *aman* are grown in higher areas. Improved monsoon-season flood protection would allow the area of t. *aman* crops to be increased.

Zone F - Uplands:
Well drained highlands experience drought problems during the dry season. Soil conditions are too dry; water supply for irrigation is limited to *boro* rice cultivation. Irrigation should be used to grow vegetable crops in the dry season.

Zone G - Susang Hills:
Small in extent, these hilly areas are suitable for tea plantations.

Rationale:
Self-sufficiency in food production has long been the aim of GOB. However, Bangladesh imports foods and beverages are worth almost one billion dollars per year. Major items include wheat, dairy products, bird eggs, honey, root and tuber vegetables, oil seeds, fruits, cotton, tobacco, wool, and silk.

GOB has initiated a shift in its approach towards more scientific and sustainable agricultural production. This includes improved availability of inputs, long- and short-term credits, and irrigation equipment. In view of these steps, the prospects are now encouraging for rapid agricultural diversification through appropriate water control and management. Increasing yields of crops are largely dependent on three major components: the use of improved production technology, modern varieties, and water management.

The introduction of new varieties of crops has opened up the possibility of increasing the agricultural production through use of chemical fertilizers and pesticides. A shift in high-value-added and labour intensive farming practices can be expected in the wake of this advance. Diversification of agriculture will contribute to increased crop production and general economic development. Increased stability through protection against flooding is required to protect and encourage such investments.

Specific Initiatives:
Two specific opportunities are identified for development of agriculture in the Basin:

- Pilot Studies for Buried Land, to rehabilitate lands in the piedmont plain which are degraded by the deposition of sandy alluvium,
- Farming Systems Development to assist farmers to adopt modern methods and to adapt to changing hydrologic regimes.

Agricultural production will also be increased by a number of initiatives provided under other strategic thrusts:

- protect homesteads and agricultural land against flooding,
- more efficient management and use of surface water,
- better management of groundwater use,
- Baseline Groundwater Quality Survey.

6.9 Improve Water Transport

Issue:
Water transport is important for movement of passengers and heavy, bulky cargo to and from local, district, and regional destinations. Yet most of the waterways in the Basin are not navigable during the dry season. Better dry season connections are required between the transport hubs of the Basin and the rest of the region.

The main outlet from the Basin suffers from shallow draught conditions in several places. The Kangsha River channel has silted downstream of its trifurcation near Thakurakona and is becoming a dead channel. The main monsoon-season channel, the Ghulamkhali, goes dry near Madhynagar during the winter months. The third channel, the Dhonaikhali, has several shallow sections that limits the available draught.

A shallow section also exists in the Someswari (Updakhali) River between Kalmakanda and Madhynagar and needs to be deepened to provide a winter link to Kalmakanda.

BIWTA has embarked on a program of dredging the lower Kangsha River downstream of Mohanganj and is considering extending the program upstream of Mohanganj. The upstream extension is not recommended as the dredged reach would almost certainly fill in again quickly as has been occurring in recent years. It will not be possible to maintain all three branches of the lower Kangsha and it would be better to focus efforts on the Dhonaikhali or Ghulamkhali channels which are becoming the main outlets of the Kangsha.

Remedial Measures:
A limited dredging program is proposed to improve the dry season water transportation link between key locations in the Kangsha Basin and the rest of the country. It involves dredging in the downstream reaches of the Ghulamkhali and Updakhali Rivers near Madhynagar.

Water levels in the proposed dredging reaches are maintained by backwater conditions from the Baulai River. Upland flows are not required to support adequate draught conditions and thus adequate draught can be provided even if flow conditions change as a result of the morphological changes in the Someswari River.

Details of the dredging program are provided in Chapter 9.

Water Transport from Sarchapur to Jaria:
It does not appear to be feasible to materially improve navigation conditions upstream of Jaria where the winter flows are too low to provide adequate draught in the dry season. One possible solution is to divert flow from the Brahmaputra River into the upper reaches of the Malijhee River. Another possible solution is to construct a weir and navigation lock at Jaria, which would create a backwater pool upstream as far as Sarchapur and would provide water for winter fish habitat and conservation. However these alternatives are large and ambitious undertakings that cannot be justified.

Further development of the roadway transport system is encouraged to improve the road connections to Dhaka and other areas in the Northeast Region and to provide better transportation in the dry season when water transport is difficult or impossible in many areas.

Rationale:
Thakurakona, Jaria, and Kalmakanda are important hubs in the water transportation network and can be provided with a reliable dry season navigation outlet by means of a limited dredging program. Many people rely on the water transport system for movement of passengers and cargo. Water transport retains a cost advantage for movement of heavy, bulky cargo even with extension of roads in the Basin.

GOB has shown a renewed interest and commitment to the water transport sector. Since modernization, the fleet of country boats is better able to compete with road transport and to offer efficient, low-cost service. This service can be provided with little additional public support other than limited dredging programs to provide a winter transportation link.

Specific Initiative:
Further details of the intervention are provided under an initiative for dredging in Lower Kangsha Basin. It proposes dredging to provide a winter navigation channel in the Someswari River (known locally as Updakhali River) and in the Ghulamkhali River near Madhynagar.

6.10 Summary of Specific Water Management Initiatives

Table 6.3 presents a short description of each specific water management initiative.

Table 6.3: Summary of Specific Water Management Initiatives	
Initiative	**Purpose**
Malijhee River Diversion	Reduction of flooding downstream by diverting flood waters into the Brahmaputra River via the Katakhali and Mrigi Rivers.
Bhogai Bypass Channel	Reduction of flood levels in the Bhogai, Malijhee, and Upper Kangsha Rivers and protection of homesteads and crops from damage.
Malijhee/Bhogai/Kangsha River Channel Improvements	Improvement of drainage and lowering of the flood levels in the Bhogai-Malijhee floodplain.
Konapara Embankment	Protection of crops, homesteads and roads in the area between the Bhogai River and the Gudaria River from flood damage.
Dampara Water Management Project	Protection against flooding as well as enhancement of drainage capacity. The project includes the construction of a 29.7 km full flood embankment along the Kangsha River right bank from Jaria to Meda, the re-sectioning of 2.01 km of CARITAS Road by Netrokona, and the re-excavation of 9.6 km of Dhalai drainage channel. The water management programme will take advantage of existing regulators.
Chillakhali River Project	Rehabilitation of the Chillakhali River Embankment.
Someswari River Hazard Management	Reduction of downstream flooding of the Shibganjdhala River and the affects of the avulsion of the Someswari to the Atrakhali River.
Homestead Raising and Erosion Protection	Reduction of flood impacts on homesteads, construction of new homesteads using channel spoil, and protection of homesteads.
Kangsha Basin Water Management Project	Coordination of the planning and implementation of the water management projects in the Kangsha Basin using an integrated basin approach. Its primary responsibilities would be to coordinate the efforts of various line ministries in preparing pre-feasibility and feasibility studies, and to organize and mobilize community participation in project planning and implementation.

Table 6.3: Summary of Specific Water Management Initiatives (continued)	
Initiative	**Purpose**
Fish Sanctuaries and *beel* Improvement (Development and Protection of Overwintering Grounds)	Enhancement of fisheries production in the Upper Kangsha River floodplain by protecting the existing overwintering grounds and developing selected *beels* as overwintering grounds through re-excavation and declaration as sanctuaries.
Fishpass Structure in Kangsha River Improvement Project (KRIP)	Enhancement of fish migration and natural recruitment into the existing Kangsha River Project.
Kharia River Fisheries Enhancement	Enhancement of fisheries resources in the Kharia River through intensive aquaculture with full participation of professional fishermen.
Shallow Floodplain Aquaculture	Enhancement of fish production through culture fisheries in the shallow floodplain utilizing available natural foods.
Open Water Fry Release	Enhancement of already depleted open water fishery resources.
Support to Diversified Fisheries	Diversification of fishery activities to reduce dependency on capture fisheries.
Rehabilitation of Malijhee Water Retention Structure	Enhancement of fisheries resources in the Malijhee Basin.
Rubber Dam for Irrigation	Replacement of existing practice (construction of earthen dams) for conserving water for irrigation allowing flash flood waters to pass without damage.
Groundwater Monitoring Programme	Provision for a much needed expansion of the present groundwater observation well network. It will facilitate development and improve management of groundwater for domestic, industrial, and agricultural use in a sustainable manner.
Improved Management of Surface Water Irrigation	Increase of total irrigated land, promotion of crop diversification, adaptation of new technologies for intensive cropping, and increase of labour absorption per unit area of land by using available water more efficiently. It will contribute to better and more efficient use of the available surface water resources.
Support to Domestic Water Supply Programs	Improvement of rural water supplies.

Table 6.3: Summary of Specific Water Management Initiatives (continued)	
Initiative	**Purpose**
Piped Water Supply in Urban Areas of Kangsha Basin	Expansion of the piped water supply system in Netrokona and Sherpur Towns as well as implementation in the nine *thana* centres.
Kangsha Basin Urban Sanitation	The project intends to bring 90% of the population of Netrokona and Sherpur and 80% of the population of nine *thana* centres under hygienic sanitation by year 2015.
Kangsha Basin Rural Sanitation	The project intends to provide one sanitary latrine for each homestead in the rural areas of the Kangsha Basin by year 2015.
Baseline Groundwater Quality Survey	Implementation of a water quality monitoring program of the area's groundwater used for drinking and irrigation.
Social Forestry	Improvement of environment and enhancement of income opportunities for poor women
Conservation of Biodiversity	Protection and enhancement of biodiversity of the Upper Kangsha River Basin area.
Pilot Studies for Buried Land	Development of strategies for crop production and revegetation in the piedmont land buried under sand.
Farming Systems Development	Improvement of farming systems in seasonally flooded areas.
Dredging in the Lower Kangsha Basin River	Improvement of navigation on the Updakhali and Ghulamkhali Rivers to provide Kalmakanda and Jaria with year round access to centres downstream.

7. INITIAL ENVIRONMENTAL EXAMINATION

7.1 Introduction

The intention of this Initial Environmental Examination (IEE) is to review the concept plan in general terms and to examine the individual conceptual initiatives in terms of their probability of creating significant impacts. Just as the plan concerns itself with diagnosis and identification of remedies to be examined in greater depth later, the present IEE is only indicative of the potential broad impacts and consequences that could result from further development of the plan.

This IEE overview does not remove the need for more comprehensive environmental evaluation studies. Once the plan and its initiatives have been taken to the pre-feasibility and feasibility stages they will require more in depth IEEs and full Environmental Impact Assessments (EIAs), respectively.

7.2 Methodology

Information used for this examination includes the description of the plan itself and the individual descriptions of the 28 initiatives outlined in the plan. The concept plan - its philosophy, general intent, objectives and stated strategies, have been examined and a general environmental statement has been prepared. A multi-team approach was used to examine the plan's initiatives. Each initiative has been examined to determine: i) whether or not the initiative would warrant further examination at successive stages of project development (in essence, a preliminary screening) and, ii) for those screened for further examination, the likely positive and negative environmental impacts to be expected from each project if it went through to implementation.

Through scoping, the Important Environmental Components (IECs) have been identified for the whole management plan. Each initiative has been examined in terms of the potential impacts and consequences to be expected from the different activities of each IEC.

A set of tables (presented in chapter 8) provides a summary analysis for each of the initiatives, including a short description and a qualitative significance rating of each potential impact. Feasible mitigative measures are also presented for each negative impact.

Section 7.7 presents an overview of the potential environmental impacts related with the present conceptual Water Management Plan.

7.3 Screening

The plan and the initiatives contained within the plan, are included in the assessment. The plan itself, as described through its intent, objectives and strategies, would, if taken to further stages of development, have a significant effect on the lives of the people within its boundaries, and would have an impact on the natural resources of the area. Although the overall effect of an implemented plan would be positive, there would be negative impacts. These are described in Section 7.7.

Many of the initiatives are engineering-oriented, which by their nature would require an environmental evaluation. Other initiatives relate to the management of natural resources,

specifically agriculture and fisheries, and they also must be subjected to an environmental evaluation.

7.4 Scoping

Twelve IECs have been identified for the whole Water Management Plan. IECs have been selected given the general level of detail and the large scale of resolution of the present preliminary study. IECs have been identified through discussions and working sessions carried out by the NERP environmental team. Information gathered from local communities about their concerns and needs has also been taken into account. In order to simplify the analysis as well as the presentation of the tables and to avoid repetitions, some environmental components have been grouped together.

- Erosion and sedimentation processes
- Surface water quality
- Groundwater quantity
- Agricultural land and production (and associated food production, job opportunity and income)
- Fish habitat and production (and associated food production, job opportunity and income)
- Biodiversity
- Property ownership
- Public health and welfare
- Employment and economic activity
- Social harmony
- Homesteads and public infrastructures
- Navigation

Annex A presents the IECs background description and their present status.

7.5 Bounding

The spatial bounds of the assessment include the geographical area covered by the Water Management Plan, and beyond where it is felt that any of the initiatives would be extending their influence. For instance, water diversion flows to the Mrigi River would enhance the fisheries of the Brahmaputra River to the south of the plan area. The assessment covers the general effects of the initiatives over a period of twenty years.

7.6 Significance rating

The significance of each impact is rated as either positive (+), or as negative (-) on a scale of high (H), moderate (M), or low (L). This basic scale is qualitative and is based on the charts presented in Table 7.1. It takes into account the magnitude and scale of the change, the value of the IECs and the duration of the impact. Positive impacts or benefits have been identified as well as negative, but no attempt has been made to rate or score the benefits.

Table 7.1 Impact Significance Rating Charts

A. Importance of the Change (function of magnitude and scale)

Magnitude	Scale of the Change		
	Site-Specific	Local	Regional
Small	Little importance	Little importance	Medium importance
Medium	Little importance	Medium importance	Very important
High	Medium importance	Very important	Very important

B. Value of IECs in terms of Rarity, Economic Value and Cultural Importance

Value	IEC
Low	Erosion and sedimentation processes
Medium	- Surface water quality - Groundwater quantity - Biodiversity - Employment and economic activity - Homesteads and public infrastructures - Navigation
High	- Agricultural land and production (and associated food production, job opportunity and income) - Fish habitat and production (and associated food production, job opportunity and income) - Property ownership - Public Health and welfare - Social harmony

C. Global Scoring

Value of the IEC	Short Term			Long Term		
	Importance of the Change as per Table 7.1.A			Importance of the Change as per Table 7.1.A		
	Little Import.	Much Import.	Very Import.	Little Import	Much Import.	Very Import.
Low Value	L	L	L	L	M	M
Medium Value	L	M	M	M	M	H
High Value	L	M	H	M	H	H

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7.7 Potential Environmental Impacts

7.7.1 Water Management Plan

The purpose of the plan is to stimulate the sustainable development of water and related natural resources in the Kangsha Basin. This implies that current development of the Basin's resources is carried out in an ad hoc manner and without any framework of sustainability. If such is the case, then it can be said that the overall effect of the plan would be one that would contribute to the protection and enhancement of environmental values. This is further supported by the plan objectives which relate to the achievement of food security, flood protection and the conservation and enhancement of the environment. As well, the plan is to be developed and implemented within a framework of several principles which are environmentally supportive. These include social and gender equality and the integration of resource development and environmental protection.

Clearly with these objectives and principles the plan's intention is to ensure that the environment is to be well protected, and in some cases enhanced.

Even though the plan's purpose, objectives, and framework may support the environment, the potential impacts of such a plan can only be known through the examination of its component parts - the development recommendations that are put forth for implementation. The following section analyzes, to the extent possible for a conceptual plan, the individual initiatives that are to contribute to the achievement of the plan objectives.

7.7.2 Development Initiatives

There are 28 development initiatives described in the management plan. Each of these has been analyzed for its impacts, both positive and negative, on aspects of the environment. The analysis for each is provided in the tables presented in chapter 8. The following sections summarizes the major categories of the most significant potential impacts and the probable feasible mitigative measures that have to be considered in order to minimize the effects of these impacts.

It should be noted that the proposed Water Management Plan has not been analyzed since each specific project or initiative which presumably would be constructed under this Water Management Plan is analyzed individually.

7.7.3 Potential Positive Impacts

The Upper Kangsha River Water Management Plan would provide a number of social and economic benefits to the people of the Basin. At the same time, it is intended to ensure that aspects of the environment would be protected and in some cases enhanced.

Crop and Property Protection
The most important benefit, or positive environmental impact, would be the protection of agricultural crops and personal property from flooding. It is certain that crop production would increase as a result of the various engineering activities described in the above section. In addition to the protection of crops, several of the plan's initiatives include farming systems improvement, surface water management, and sediment land management which would all lead to increased crop production throughout the Basin.

Fisheries Production
In spite of the loss of open water fisheries production, several of the plan's initiatives focus on increasing fish production in the Basin through open water fisheries management and the introduction and management of aquaculture.

Job and Income Opportunities
Job and income opportunities would be provided through general increased resource production (crop, fisheries and tree), construction and maintenance activities related to the various engineering activities, and through the general economic development of the Basin. Further detailed analysis at the pre-feasibility and feasibility levels would indicate whether or not these additional jobs and incomes would offset job and income losses as a result of the potential negative impacts indicated in the above section.

Biodiversity Conservation
One initiative addresses the need for the conservation of biodiversity through protected area management activities. This would protect important habitats and individual species. The management of different systems could also contribute to the protection and production of important economic species that could be harvested on a sustainable basis, thus providing potential additional sources of jobs and income to the area.

Poverty Alleviation
One initiative under 'Social Forestry' will improve the ecological balance with more tree cover and provide income to the landless people especially destitute women.

Health and Welfare
Safe water and sanitation are vital for the improvement of health, productivity, efficiency and quality of human environment. The proposed four initiatives will meet the need for safe water for all domestic purposes and sanitary latrines in the Kangsha Basin's urban and rural areas.

Advantages to Women
There are three major benefits that could accrue to women as a result of the plan. Flood control would ease the additional household burdens that women generally bear during flooding. These include cooking under difficult conditions, and the care of livestock. Secondly, with increased crop protection/production, job opportunities, and general economic improvement, women would have the opportunity of gaining their own income and improving their independence and self-esteem. Finally, through the expansion and protection of the domestic water supply, women's work load would be reduced.

Conflict Resolution
The rehabilitation of the Bhogai left bank embankment and construction of Dampara Project would resolve long standing conflicts between two opposing groups in the respective areas.

7.7.4 Potential Significant Negative Impacts and Mitigative Measures

Agricultural Lands and Crop Production
The plan contains a number of engineering activities required to control water flows, specifically floods. Excavating, spoil deposition, loop cutting and river diversion - all require land to be taken from other uses. In the Kangsha Basin approximately 85% of the total area is under agricultural production. The area, or the country for that matter, can ill afford the loss of crop

production land when there is a constant struggle to maintain grain self-sufficiency. As projects succeed to pre-feasibility and feasibility level of study it will be necessary to ensure that land resources required to implement these initiatives are analyzed for their current and potential productive capacity. Lands chosen to be taken out of production should be those that are the least important for crop production, notwithstanding those lands that have other significant environmental values.

Fishery Habitats and Production

Much of the open water capture fishery, which is an important economic activity of the people of the area, is dependent upon floodwater for the maintenance of habitat and high production. A number of the project concepts focus on flood control and activities such as embankment rehabilitation, river diversion, and to some extent dredging and damming. These activities would have an impact on floodplain water levels and the quality of fish habitat. The balance between crop and property protection and the loss of floodplain habitat and fish production would be a difficult one to achieve. Succeeding studies would have to carefully measure the benefits to be gained and lost to the various communities relying on the different resources. From the viewpoint of food production, a loss of open water capture fishery production could be offset to some degree by an increase in pond fish culture.

Biodiversity Losses

Channel development, channel improvements, and dredging could have potential impacts on the biodiversity of the area. Any development that controls floods could also have an effect on biodiversity, particularly that of the seasonal floodplains and *beels*. Fisheries programs including the Kharia initiative, open water fry release, and aquaculture could all have an adverse effect on the area's biodiversity; particularly if exotic species are introduced. At succeeding stages of project development it would be necessary to examine carefully the Basin's biodiversity and to identify the significant elements that could be threatened by the implementation of various activities. It would also be necessary to ensure that further project planning and design take into account the need to protect these elements, and indeed the biological systems that are necessary for their support.

Soil and Water Quality

The conceptual plan contains few activities that could contribute to the degradation of soil and water quality conditions. However, dredging could promote turbidity; which in turn could have an impact on fisheries. The deposition of dredging spoil could also contribute to soil and groundwater pollution as well as polluted runoff into the river. This would result from dredged material releasing a variety of toxins that were harmlessly tied up in the river bed sediments. The possibility of soil and water pollution will have to be examined and containment procedures would have to be designed and implemented. Dredging and other activities that involve mechanical procedures, which include the use of petrochemicals, could be a source of pollution. Such materials will have to be contained and disposed in a proper and safe manner.

Social Conflicts

The concept presents a number of potential moderate social conflicts as a result of modification to the resource base. This is particularly true where flood protection measures would lower flood waters. This would provide benefits to farmers in terms of crop protection, but would reduce the normal water catch fishery production expected by fishers. Pre-feasibility and feasibility level studies on individual initiatives would have to take into account the impacts and the conflicts that could arise as a result. Mitigative solutions would have to be introduced. These could range from

monetary compensation and the provision of job opportunities for those who would lose income and jobs, to innovative compromise solutions that would protect fisher opportunities.

Loss of Jobs and Income
This potential impact is related primarily to the loss of agricultural and fisheries resources. In the case of flood protection, the decrease in fish production and the consequent loss of incomes and jobs would be offset by the increase in agricultural production and the provision of jobs and increased income. Further detailed studies would be able to quantify the net results of these trade-offs. Other lost jobs and income relate to lost agricultural land as a result of various structures and engineering activities. In both cases where jobs and incomes are lost, mitigative solutions could include compensation and job opportunities provided through construction and maintenance of the various engineering activities. As the area's economy develops through Basin management activities, additional job opportunities in support services would likely be created.

Other Social Impacts
Another potential significant social impact would be the loss of access to fields, water resources, and community through the channelling activities. Channels should be located where disruption of access would be minimal. Bridge access should be provided where required.

Resettlement would be necessary in cases where engineering activities such as spoil deposition, channelling, and embankment construction require a land-base. Normally, sites occupied by homesteads would be avoided, and prime agricultural land should be avoided where possible. It is inevitable, however, that some lands under occupation either for homesteads or farming would be required and compensation would likely include the resettlement of affected people. Resettlement can be very upsetting, particularly if the individuals affected are forced to move a great distance from their social, economic, and cultural ties. Mitigation would include the minimization of resettlement or resettlement to sites nearby to minimize disruption and hardship. The further development of each of the relevant initiatives would require detailed analysis and the preparation of optimum resettlement programs.

River Morphology
A number of the concept initiatives infer changes to river morphology including scouring, sedimentation and erosion. The environmental consequences of these actions would have to be considered in more detail at the pre-feasibility and feasibility stages.

7.8 Beyond Basin Impacts

It is envisioned that there would be three significant positive impacts outside of the Basin as a result of the initiatives that have been put forward. These would include, i) the improved fishery in the Brahmaputra as a result of excavation of the Mrigi River; ii) increased food production to contribute to the country's requirement to maintain grain self-sufficiency; and, iii) the contribution made to the country's protection of biodiversity through the specific initiative to conserve Basin biodiversity.

No negative impacts outside of the Basin, as a result of plan implementation, are envisioned.

7.9 Cumulative Impacts

The cumulative impacts, including three possible flood control interventions (Bhogai Bypass Channel, Konapara Embankment, Dampara Project) and the anticipated future changes in the Atrakhali and Shibganjdhala Rivers, will be to lower the flood levels at all locations, typically

by 0.30 m in a 2-yr flood and 0.5 m in a 20-yr flood (see Table 7.2). Peak discharges at Jaria would be reduced by about 25% in a 2-yr flood and 40% in a 20-yr flood, largely as a result of the avulsion into Atrakhali.

The Malijhee diversion via the Mrigi River was not included in the cumulative impact analysis as it is unlikely that it and the Bhogai Bypass would both be constructed, and the Bhogai Bypass has the prospect for making greater changes.

The reduced flood depth will increase the crop production and increase job opportunity significantly through protection of crops from flood damage and promotion of increased HYV crop cultivation.

Table 7.2: Cumulative Impacts of Flood Control Interventions

Location[1]	Change from Existing Conditions	
	20-yr Flood	2-yr Flood
Water Levels (m, PWD)		
Urfa	-0.45	-0.30
Sarchapur	-0.65	-0.35
Jaria	-0.40	-0.55
Discharge (m^3/sec)		
Jaria	-600 m^3/sect (-40%)	-350 m^3/sec (-25%)

[1] see Figure 2

Reduced flood depth will reduce groundwater recharge and during dry period impact on domestic and irrigation water supply from groundwater source.

Notwithstanding the mitigation measures and the specific remedial initiatives that are proposed within the plan, the cumulative impacts on the open water fishery may be significant. There could be a serious depletion of open water fishery habitat, production, and job opportunities. The Kangsha and Thakurakona Project areas once had larger open water fisheries. The implementation of Bhogai Bypass Channel, Konapara Embankment and Dampara Project will further reduce the region's open water fish habitat and production. In addition, the wetland biodiversity will be weakened through implementation of these flood control projects. Such an overall impact could negate any gains that would be made through the biodiversity conservation initiative.

In summary, the cumulative impacts of implementation of all the proposed projects will be reduced floodplain fisheries and fishing income, reduced groundwater recharge and increased depletion of HTWs used for domestic water supply, and deterioration of water quality due to increased use of biocides ; but increased cereal and non-cereal production, increased economic returns to landowners, increased employment and wages, improved domestic water supply and sanitation, improved water transportation, reduced dependency on borrowing at high rates of interest and progressive impact on gender equity.

7.10 Residual and Net Impacts

If mitigation of the various impacts is carried out successfully, the probable significant residual impacts would include the reductions in open water fish habitat, fish production, fisher jobs and income; and, the related loss of biodiversity. This would have to be weighed against gains to be made in flood protection of crops and property and the probable long-term benefits of improved socio-economic conditions.

7.11 Towards an Environmental Management Plan

At this level of assessment an environmental management plan is neither required nor possible to prepare with any degree of soundness or utility. Not until the initiatives described within the plan are further developed to the pre-feasibility and feasibility stages would an environmental management plan be required.

7.12 Summary and Conclusion

The preparation and implementation of a water basin management plan that promotes sustainable development appears to be environmentally positive. In general, if all of the initiatives are implemented the resulting scenario would be one of flood protection and improved prosperity for the people of the area. However, the area's open water capture fishery habitat would be reduced and open water fish production would decrease. This would have an effect on those who depend upon the fishery for at least part of their livelihood, and possibly, a negative effect on the area's biodiversity. Only further detailed analysis at the pre-feasibility and feasibility levels will indicate conclusively whether or not all the projects which are proposed under the management plan will be environmentally sound.

These conclusions reinforce the need to do a detailed environmental assessment in succeeding stages of each project, which should include a re-examination of the question of cumulative impacts based on the most detailed planning information that is available. This implies an IEE at the pre-feasibility study stage and an EIA at the feasibility stage.

8. SPECIFIC WATER MANAGEMENT INITIATIVES

This chapter contains a brief description of each of the initiatives that are included under the Water Management Plan. Each initiative relates to a strategy outlined in Chapter 6. The purpose and concept of each initiative are provided along with an estimate of the project costs, benefits, and significant impacts. Details of the potential impacts and their mitigation are provided, based on the methodology presented in chapter 7. Where areas of uncertainty have been identified these are also described. The projects are described at a conceptual level although some of them have been analyzed in other pre-feasibility or feasibility studies; where more detailed studies exist they are identified herein under "History".

Structural initiatives are shown in Figure 16.

Thrust: **Protect homesteads and agricultural land against flooding**

Project Name: **Malijhee River Diversion**

Purpose: The project would reduce flooding in the Malijhee lowlands by diverting flood peaks from the flood-affected area into the Mrigi River and the Old Brahmaputra River.

The purpose of the project is to lower flood levels and improve drainage in the Malijhee lowlands in order to enhance monsoon-season crop production and to protect a large number of homesteads. The project also aims to protect the Sherpur-to-Jhenaigati road and the Sherpur-to-Nalitabari road from flood damage.

History: This is a new alternative for flood protection in the Malijhee floodplain. Other options include channel improvements in the Bhogai, Malijhee, and Kangsha River channels, and a flood bypass from the upper Bhogai River to the lower Kangsha River.

Description: The project consists of a diversion channel that would carry flood peaks to the Mrigi River and from there to the Old Brahmaputra River near Sutia offtake.

The project involves re-excavating 45.5 km of the Katakhal-Mrigi River from Surihara to Char Betmari. A plan view of the required work is provided in Figure 17 and a conceptual design profile is provided in Figure 18. Two road bridges are required to be rebuilt on the Sherpur-to-Sribardi road and on the Sherpur-to-Bhotpur road to accommodate the wider channel. The channel would be designed to carry about 200 m^3/s of flow from the Malijhee floodplain in a 5-yr flood.

Rationale: The low-lying floodplain of the Malijhee area is affected by periodic flash floods. Floods damage monsoon-season crops, homesteads, and roads over a large area. Even emergency food and medical supplies cannot be brought into the area during floods.

Diversion is the most promising way to reduce flood levels in the area. Embankments are not feasible as the Malijhee River is the sole drainage outlet from the area. Re-excavating or dredging the river may improve drainage conditions but will not significantly affect flood levels.

Diversion to the Mrigi River seems to be technically feasible. It was also observed during field reconnaissance that relatively few homesteads are located on the bank of this channel. Local people will be willing to accept diversion if it occurs via an existing channel.

There are plans to re-excavate the Mrigi River to remove sediment that has accumulated over the years. The re-excavated channel would be made larger to accommodate the diversion from the Malijhee River.

Environmental evaluation:

Table 8.1 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits:

Benefits would be primarily in the reach of the Malijhee River upstream of its confluence with the Bhogai. Modelling indicates that the diversion would reduce peak flood levels by 0.7 m at Barakanda (near the point of diversion), 0.15 m at Baluaghata, and a negligible amount at Urpha (at the confluence with the Bhogai River).

Flood control would reduce flood damage to crops, homesteads, and infrastructure and would promote HYV crop production (and associated food production, job opportunity and income) in the lower Malijhee River.

Temporary job opportunities are associated with the construction phase.

Disbenefits:

It is likely that some homesteads along the diversion route would need to be re-located.

Reducing the flows in the Malijhee River would reduce the flooded area and, as a result, the fish habitat and fish production (and associated food production, job opportunity and income) in Malijhee depression. Siltation or erosion may be induced in the diversion route and in the Mrigi River unless the excavated channels are designed carefully taking into account the increased discharges and sediment loads.

Loss of agricultural land (and associated food production, job opportunity and income) along the diversion route.

Social disruption may occur since people along the Mrigi River associate projects with transferring of flooding problems to their area.

Areas of Uncertainty:

Resistance can be expected to come from people living along the diversion route.

The sustainability and feasibility of the scheme cannot be predicted without a pre-feasibility level of analysis. Drainage improvements in the Malijhee floodplain may prove to be a better solution.

Cost:

Based on a conceptual design analysis the cost estimate of the scheme is estimated to be US $ 11.0 million.

Implementing Agency:

Bangladesh Water Development Board

Implementation Plan:

This is one of three alternatives which have been defined to help reduce flooding in the Malijhee lowlands. All require further analysis in a pre-feasibility study before an alternative can be adopted.

Better hydrological data are required at critical locations in the upper Malijhee and Mrigi Rivers. The available data are not adequate to support any definite solution. Data collection should cover at least one hydrological year and preferably three to five years. The discharge gauge at Barakanda should be continued for two or three more years and a new discharge gauge should be installed near the mouth of the Mrigi River. A water level gauge should be installed at the point where the diversion channel would connect to the Mrigi River.

Reduced fish habitat and production should be mitigated through increased culture fishery and increased fish population through beel management.

With respect to the project design, the following is recommended:

- widespread distribution of dredged spoil in lowland cultivation areas, and using spoil to raise low-lying areas for homesteads, where practical;
- enlarge the channel to provide sufficient capacity;
- design of regime channel to minimize erosion and siltation;
- in order to avoid social disruption, public awareness and public participation should be implemented in planning and design phases; and
- select poorest agricultural land and avoid areas of biophysical importance; rehabilitate site for vegetable production.

Table 8.1: Malijhee River Diversion
This initiative is intended to reduce flooding downstream by diverting flood waters into the Brahmaputra River via the Katakhali and Mrigi rivers.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Diversion from the upper Malijhee River	Agricultural land and production	. Increased crop production (and associated food production, job opportunity and income) in the lower Malijhee River	+	
	Fish habitat and production	. Reduced fish habitat and fish production (and associated food production, job opportunity and income) in Malijhee depression	M	. Increase culture fishery . Offset by increased fishery in the Mrigi River . Increase fish population through beel management
	Homesteads and public infrastructure	. Reduced loss of infrastructure	+	
	Employment and economic activity	. Reduced loss of home-based economic activities	+	
Re-excavation of Katakhali River	Employment and economic activity	. Job opportunities . Socio-economic gains	+	
Deposition of spoil from Katakhali River	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income)	M	. Spread material over a wide area in lowland cultivation area
Increasing water volumes in Mrigi River	Erosion and sedimentation processes	. Bank erosion and sedimentation	M	. Enlarge channel to provide sufficient capacity . Design of regime channel to minimize erosion and siltation
	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income)	M	
	Fish habitat and production	. Increased fish habitat and production (and associated food production, job opportunity and income)	+	

Table 8.1: Malijhee River Diversion (continued)

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Increasing water volume in Mrigi River	Social harmony	. Social disruption (people along the Mrigi River regard project as transfer of flooding problems to their area)	H	. Public awareness and public participation in planning and design phases
Excavation of Mrigi River	Employment and economic activity	. Socio-economic gains . Job opportunities	+	
Deposition of spoil materials	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income)	M	. Disposal site acquisition - select poorest agricultural land and avoid areas of biophysical importance; rehabilitate site for vegetable production; use spoil to raise low-lying areas for homesteads, where practical
Diversion to Old Brahmaputra River	Increased discharge	. Increase Old Brahmaputra River level	L	. Heighten the existing river dyke

Thrust: **Protect homesteads and agricultural land against flooding**

Project Name: **Bhogai Bypass Channel**

Purpose: The project would reduce flooding in the Malijhee lowlands by diverting a large portion of the flood flow around the affected area.

History: This is a new alternative for flood protection in the Malijhee floodplain. Other options include channel improvements in the Bhogai, Malijhee, and Kangsha River channels and flood diversion from the Malijhee River to the Mrigi River.

Description: The project consists of 25 km of floodway channel which would carry flood water from the Bhogai River near Nakuagaon, southeast toward a low depression near Haluaghat, and back to the Kangsha River near Jaria. Details of the concept are provided in Figure 19 (location map), Figure 20 (profile) and Figure 21 (cross-section).

The diversion route would follow existing river channels and an old course of the Bhogai River (Mara Bhogai) wherever possible. Two structures would be provided at the floodway inlet to regulate the diversion flows; a gated control structure in the Bhogai River and a fixed-weir structure in the floodway inlet. A de-silting basin would be provided near the inlet to the diversion channel to allow the coarser sediments (sands) to be trapped, and thus to reduce the deposition of this material in the main floodway.

The floodway would have capacity for the 1:10 year flood discharge in the Bhogai River (approximately 1,000 m^3/s) plus local drainage. The diversion would operate only during flood conditions. The channel would be designed to contain the flood discharges and to provide drainage of adjacent land. Spoil from the floodway construction would be used to construct new homestead platforms and containment dikes in low-lying areas.

The floodway would empty into a low depression near Haluaghat. This depression and the area downstream are presently flooded by backwater from the lower Kangsha River; thus there would be little increase in flood levels. Some improvements may be required in the river channel which connects this depression with the Kangsha River.

Rationale: The project would provide stability in flood regimes and protection against severe flood conditions. Such conditions are required for economic and social development.

Diversion is the only option which is likely to make a significant improvement in the flood conditions in the low-lying areas of the Malijhee-Bhogai floodplain. The project would make a substantial improvement in flood conditions. It would also be more reliable than embankments which often fail even in modest flood

conditions. Embankments provide no benefit when their design event is exceeded and actually cause more damage than would otherwise occur in severe floods.

By following and re-excavating an old course of the Bhogai River the impacts on the environment and local people would be minimized. The Kangsha River is the existing outlet for flood waters from the area and thus the impacts on flood levels in the lower Kangsha River would be minimal.

Environmental evaluation:

Table 8.2 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits:

Flooding would be reduced and water levels would be more stable in the Malijhee, Bhogai, and Kangsha River floodplains increasing infrastructure and homestead protection. Flood damage to crops and homesteads would be reduced and the production of HYV crops would increase in the lower Malijhee River. Modelling indicates that flood levels could be reduced by as much as 0.5 m at Urpha (the Bhogai-Malijhee confluence) and 0.4 to 0.8 m at Sarchapur. The depth of flooding would be reduced on 40,000 ha of land; 3,000 would be made essentially flood-free. There is significant potential for increased agricultural production on the flood-protected land.

Flooding would be prevented or eliminated along the upper Bhogai River. Peak water levels would be reduced by as much as 5 m near Nakuagaon. The height and extent of the any Konapara embankments could be reduced.

A large number of employment opportunities would be created in construction, operation, and maintenance of the floodway infrastructure.

Disbenefits:

A large number of homesteads lie within the floodway right-of-way that would be required for this project. They would need to be re-located.

Loss of access and loss of agricultural land and homesteads (and associated food production, job opportunity and income) due to construction of channel.

According to model results, flood discharges would rise by about 0.1 m at Jaria because of reduced flood storage in the Malijhee floodplain. The impact may be offset by changes that are expected to occur within the Someswari River.

Declining biodiversity.

Long-term reduction of floodplain fishery habitat in Malijhee lowlands.

Areas of Uncertainty:

People living in the diversion path and along the lower Kangsha River will rightly be concerned about the potential impacts on flooding and sedimentation in their area. These aspects need to be resolved through detailed analysis - the magnitude of the potential impacts needs to be clearly demonstrated.

Avulsion of the Someswari River may reduce the flood levels in the Kangsha River which would serve as the outlet from the floodway. This would generally benefit the project but the time scale of these changes is uncertain. The potential effects on the floodway outlet channel need to be considered.

Cost: US $20 million (planning-level estimate only).

Implementing Agency:

Implementation Plan:

The potential implications of such a large-scale change in river configuration, along with the potential flood-control benefits, need to be carefully considered before a recommendation to proceed can be made. A pre-feasibility study is recommended to consider the available alternatives and to secure more input from local residents and policy makers. The project raised some serious concerns and may not prove to be sustainable.

The pre-feasibility study would include a careful analysis of the cost, benefits, and impacts. It should include a detailed morphological assessment and a flood routing analysis to confirm the sustainability of the project, design capacity, operating rules, and the resulting water levels in the Malijhee floodplain and along the Kangsha River. The potential impact on homesteads and people along the diversion route should also be investigated in detail. In this regard, the use of the old course of the Bhogai River, which avoids homestead areas, should be considered. Crop studies will be required to quantify the agricultural benefits.

Sensitive natural habitats should be avoided while areas of low agricultural value should be preferred.

In order to compensate for the reduction of floodplain fisheries, the project should include provisions for increased culture fishery.

Table 8.2: Bhogai Bypass Channel
This initiative is intended to reduce flood levels in the Bhogai, Malijhee, and Upper Kangsha Rivers and protect homesteads and crops from damage.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Excavation of bypass channel	Agricultural land and production	. Loss of agricultural land and homesteads (and associated food production, job opportunity and income) due to construction of channel . Increased crop production in the lower Malijhee River	M +	. Follow the old course of the Bhogai River; avoid homestead areas
	Biodiversity	. Contribution to declining biodiversity due to construction of channel	M	. Compensation . Avoid sensitive natural habitats
	Homesteads and public infrastructures	. Loss of access due to construction of channel . Infrastructure protection	M +	. Provision of access
	Fish habitat and production	. Long-term reduction of floodplain fishery habitat in Malijhee lowlands. . Loss of fish production (and associated food production, job opportunity and income)	H	. Compensation . Increase culture fishery
Development of desilting basin	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income)	M	. Select area of low agricultural values . Compensation
	Biodiversity	. Contribution to declining biodiversity	M	. Avoid sensitive natural habitats
Disposal of accumulated materials from desilting basin	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income)	M	. Site selected to be of low agricultural value
	Biodiversity	. Contribution to declining biodiversity	M	. Avoid sensitive natural habitats

Thrust: **Protect homesteads and agricultural land against flooding**

Project Name: **Malijhee/Bhogai/Kangsha River Channel Improvements**

Purpose: The project consists of channel improvements to improve drainage and to reduce the flood conditions in the Bhogai-Malijhee floodplain. The purpose of the project is to enhance rice crop production.

History: The project was studied during the Upper Kangsha River Pre-feasibility Study (September 1994) and was put forward as the Malijhee River Improvement Project. The proposal called for channel improvements (loopcuts) in the Malijhee and Bhogai Rivers upstream of Sarchapur and in the Kangsha River downstream of Sarchapur.

This is one of three alternatives for flood protection in the Malijhee floodplain. Other options include a flood bypass from the upper Bhogai River to the lower Kangsha River, and flood diversion from the Malijhee River to the Mrigi River.

Description: The 1994 pre-feasibility report proposed about 16.6 km loopcuts in the Malijhee, Bhogai, and Kangsha Rivers to improve drainage of the area. Channel re-excavation in the floodplain upstream of the Bhogai-Malijhee confluence should also be considered.

Rationale: This alternative will provide drainage benefits to the area and may increase rice production. It will also help to prevent pre-monsoon flood damage to boro crops in the flood-affected area.

Environmental evaluation:
Table 8.3 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: Modelling during the earlier study indicated that the peak flood levels would not be significantly reduced. The main benefit accrues from improved drainage which allows the water levels to fall more quickly between floods and after the monsoon season is finished, and provides greater protection against flash floods in the winter and pre-monsoon seasons. This ensures increased crop production (and associated food production, job opportunity and income), and protection of infrastructure in Malijhee Basin. The benefitting area is in the order of 20,000 to 40,000 ha.

Temporary job opportunities are associated with the construction phase.

Disbenefits: Straightening the Malijhee, Bhogai, and Kangsha Rivers could have a serious impact on the stability of these rivers. The river will undoubtedly try to re-establish a meandering pattern which could threaten villages and farmland.

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Extensive maintenance efforts could be required as a result. Such problems have been experienced elsewhere in Bangladesh and other places.

Loop cuts would create nonviable farm units and isolated pockets of habitation occupying the high ground adjacent to the original meander loops, and would induce loss of agricultural land (and associated food production, job opportunity and income). Loop cuts would also contribute to declining biodiversity.

Reducing the water levels in the Malijhee River would reduce the flooded area available to fish for grazing during the monsoon season and for overwintering during the dry season. As a result, floodplain fishery activities (and associated food production, job opportunity and income) would be reduced.

Areas of Uncertainty:

Previous work has already taken place in the vicinity of the Bhogai-Malijhee confluence and in the Malijhee offtake. The effects of these previous works are not well understood. The area is morphologically active (sand and silt are being deposited in this area). It will be difficult to separate the effects of the man-made changes from the naturally-occurring ones, which will increase the uncertainty of predicting future channel changes in response to the channel improvements described in this project.

Cohesive clay deposits appear to be retarding channel development in the area; their effects on loop-cut development and channel erosion will be difficult to predict.

Cost: Based on a conceptual design analysis the cost estimate of the scheme is estimated to be US $ 4 million.

Implementing Agency:

Bangladesh Water Development Board

Implementation Plan:

The project needs to be thoroughly evaluated by a detailed morphological study of the area during the pre-feasibility level of investigation. It would review the concept and should consider other alternatives for flood control and drainage improvements in the area. The feasibility of re-excavating the Malijhee River upstream of the Bhogai River confluence should also be investigated.

Loop-cuts should be sited through land of low agricultural value, avoiding sensitive natural habitats. Land compensation should be provided and overland access reestablished. Spoil piles should be used to improve agricultural production and build homestead platforms.

In order to compensate for the reduction of floodplain fisheries, the project should include provisions for increased culture fishery.

Table 8.3: Malijhee/Bhogai/Kangsha River Channel Improvements
This initiative is intended to improve drainage and lower the flood levels in the Bhogai-Malijhee floodplain.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Excavation for loop-cuts	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income) due to construction of loop-cuts	H	. Site loop-cuts through land of low agricultural value
		. Increased crop production (and associated food production, job opportunity and income) in Malijhee Basin	+	
	Biodiversity	. Contribution to declining biodiversity due to construction of loop-cuts	M	. Avoid sensitive natural habitats
	Homesteads and public infrastructures	. Formation of isolated parcels of habitation	M	. Compensation . Improve access
		. Creation of nonviable farm units (and associated job opportunity and income)	M	. Resettlement
		. Protection of infrastructure	+	
	Fish habitat and production	. Reduction of floodplain fishery habitat (and associated food production, job opportunity and income)	H	. Compensation . Increase culture fishery
	Employment and economic activity	. Job opportunities	+	
Deposition of spoil	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income)	H	. Acquire at market value sites of low agricultural value . Rehabilitate spoil piles for agricultural production and homestead platforms
	Biodiversity	. Contribution to declining biodiversity	M	. Avoid sensitive natural habitats

Thrust: Protect homesteads and agricultural land against flooding

Project Name: Konapara Embankment

Purpose: The purpose of the project is to protect the area between the Bhogai River and the Gudaria River from flood damage. Overbank spills come from the Bhogai River, overland, and through Kodalia Khal. This causes damage to crops, homesteads, and roads. Ponds which are used for fish culture are flooded, and this discourages the pond owners from intensive aquaculture.

There is also a social issue over the existing closure of Kodalia Khal. The existing closure is located about 3 km downstream of the offtake from the Bhogai River such that homesteads and crops between the river and the closure are flooded. People living upstream of the closure cut it to attempt to relieve their flood problem, thus causing people living on the downstream side to be flooded. Resolution of conflict over the closure of Kodalai Khal is one of the prime motives for this project.

History: The area was studied during the pre-feasibility study of the Upper Kangsha River Basin Development (September 1994) which proposed that the existing Konapara Embankment should be extended further upstream to cut off the overbank spills. That recommendation has been adopted for the present Kangsha Basin Water Management Plan except that, in the present version, the embankment is extended all the way upstream to the border.

Description: The existing Konapara embankment which ends at Bahirshimul would be extended upstream along the left bank of the Bhogai River all the way to the international border near Kalyankura. The Kalyankura-to-Urpha road-cum-embankment, along the left bank of the Bhogai River, was constructed on the river bank with no setback. Design and maintenance of the work is very poor. Consequently the embankment is breached at different locations by floods every year. Existing local embankments will be strengthened to proper design sections and elevations will be retired where necessary to provide adequate setback.

As mentioned above the present closure of Kodalia Khal at Amtail is at an inappropriate location. The new embankment will close the Kodalia Khal nearer to the river and thus will solve the prevailing conflict between protected and upstream landowners.

Rationale: The monsoon season crop must be protected from flood damage. Agriculture is the main economic activity in the area - more than eighty-five percent of the people of the area depend on agriculture for their livelihood. The area is heavily dependent on rainfed monsoon crops; much of it cannot be brought under winter cropping because very little surface water or groundwater is available for irrigation.

Protection of the road link is vital. Roads are the only mode of transportation for the area since the river channels are too shallow for all-season navigation.

Flooding also damages homesteads and fish ponds. Thus flood protection is a pre-requisite for the improvement of the socio-economic condition of the people of the area.

The project would also solve the problem of conflict between people living upstream and downstream of the existing closure of Kodalai Khal.

Environmental evaluation:

Table 8.4 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits:

Protection from Bhogai flash floods will reduce the monsoon-season crop damage, promote cultivation of high-yielding and high-value crops (and associated food production, job opportunity and income) in the area between the Bhogai River and the Gudaria River and in the northern areas as well. It will also reduce damage to homesteads and roads. Reducing the risk of flooding will enable farmers to delay planting the boro crop and as a result the farmers will have sufficient time to grow a third (non-rice) crop between the aman and boro crops. Late plantation will increase the availability of rainfall for the crops and reduce irrigation water requirement. This will be saving for the farmers.

Modelling results indicate that about 700 ha of land to the north of the embankment would be made flood-free. Flood levels on a much larger area, perhaps as large as 5,000 ha, would be reduced.

Temporary job opportunities are associated with the construction phase.

The project would contribute to resolve a long standing social conflict.

Disbenefits:

Discharges and water levels will increase in the Bhogai and Malijhee Rivers as a result of cutting off the overbank spills. The Kodalia Khal discharge is estimated to be about 200 m^3 /sec in the 1988 flood condition (considered to be a 20-yr event in the area). Preliminary modelling results show that flood levels in the Bhogai River near the embankment will rise by about 0.2 to 0.3 m and that an additional 200 ha of land in the Bhogai floodplain would be flooded. As there is no discharge data with which to confirm these estimates, there is a wide range of uncertainty.

The embankment would reduce the floodplain fishery slightly in the project area (there are not much fish in the project area presently because the flooding is intermittent) but would increase fish production slightly in the Bhogai/Malijhee floodplain due to increased flood levels. The magnitude of these changes is not considered to be significant.

Loss of agricultural land (and associated food production, job opportunity and income) would occur due to excavation.

Crop reduction is likely to occur outside the embankment, creating new social conflict and tension.

The project would also cause flooding of homesteads inside of the embankment.

Areas of Uncertainty:

The conflicts which presently exist are not consistent with the actual effects of the present closure and suggest that other, more personal issues, are involved. The death of two people over the conflict supports this view and might explain why emotions over the issue run so deeply. Therefore it cannot be certain that solving the flooding problem will completely resolve the conflict, but at least it should become apparent what the true issues really are.

New conflicts may arise if the people living within the Bhogai floodplain perceive that the embankment is causing them more flooding. They may cut the embankment out of spite or because they think that doing so will relieve their flooding. To an extent this possibility can be minimized by locating the embankment as close to the river bank as possible, subject however to providing sufficient setback to protect the embankment against the river.

Cost: US $ 1.49 million (planning level estimate only).

Implementing Agency:

Bangladesh Water Development Board

Implementation Plan:

As the project concept and solution are clear, it is recommended to study the project directly at the feasibility level.

The scope of the project is somewhat dependent on whether the Bhogai By-pass channel is adopted. It would be prudent to develop the embankment in two stages with the downstream section (Sarchapur to Urpha) to proceed first. This portion of the work is largely independent of any reduction in flood levels due to the diversion. The upstream section can and should be deferred until a decision is made whether to proceed with pre-feasibility studies of the diversion options. If diversion is deemed unsuitable then the upstream portion of the embankment could be implemented.

In order to minimize the effects of excavation on agricultural land, topsoil should be stripped and saved while 50 cm maximum of soil is taken for embankment material. Topsoil should be returned and cropping continued.

In specific sites, excavation should be carried out to a depth suitable for fish ponds and culture fishery should be promoted in ponds excavated for borrow.

Flood-proofing activities should be conducted to mitigate negative impacts on homesteads and property.

Families residing on the river side of the embankment should have the first opportunity for embankment jobs.

Table 8.4: Konapara Embankment
This initiative is intended to protect crops, homesteads and roads in the area between the Bhogai River and the Gudaria River from flood damage.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Excavation of material for embankment	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income) due to excavation	L	. Topsoil stripped and saved; 50 cm maximum of soil taken for embankment material; topsoil returned and cropping continued . Excavate to a depth suitable for fish ponds
Construction of embankment	Employment and economic activity	. Socio-economic gains . Job opportunities	+	
General location of embankment	Agricultural land and production	. Crop reductions outside embankment (and associated food production, job opportunity and income) . Increased crop production (and associated food production, job opportunity and income) in the area between the Bhogai River and the Gudaria River and in the northern areas as well	M +	. Compensation (flood proofing activities) . Families residing on river side of embankment have first opportunity for embankment jobs
	Social harmony	. Long standing social conflict resolved . Creation of new social conflicts, unrest and tension	+ H	. Compensation (flood proofing activities)
	Fish habitat and production	. Decreased fishery in northern areas (and associated food production, job opportunity and income)	L	. Promote culture fishery in ponds excavated for borrow
	Homesteads and public infrastructures	. Flooding of homesteads inside of embankment . Loss of property	L	. Raise homesteads

Thrust: **Protect homesteads and agricultural land against flooding**

Project Name: **Dampara Water Management Project**

Purpose: The purpose of this project is to protect crops, homesteads, and roads within the Dampara Project area from flooding resulting from overbank spills from the Kangsha River. It will:

- increase crop production through flood protection, drainage improvement, and sustainable irrigation development;
- increase capture and culture fisheries and productivity of wetlands inside the project area;
- provide protection to people and homesteads;
- rehabilitate the Kangsha Project;
- ensure domestic water supply, and
- generate employment opportunities.

Problem: The project covers an area of 15,000 ha between the Kangsha and Mogra Rivers. About seventy-six percent of the area goes under water annually due to floodwater that spills overbank from the Kangsha River and through Kalihar Khal. The floods damage crops, homesteads, and roads.

The existing BWDB Kangsha Project cannot function due to the public cutting of its western embankment which is the border between the two projects. Prior to its development the Kangsha Project area served as floodway for the Kangsha River. After project construction the floodway has been blocked; this causes more flooding in the Dampara Project area. This situation leads the people of Dampara Project to cut the common embankment when they are flooded by the Kangsha spill.

History: This is one of four projects for which pre-feasibility studies have been carried out in the study of Upper Kangsha River Basin Development (September 1994). The project was subsequently selected for feasibility study in Phase II of the Northeast Regional Project. The details of the feasibility study will be given in a separate report.

Description: In this project, as is illustrated in Figure 22, embankments on the right bank of the Kangsha River are extended 30 km, roughly from Meda to Jaria. The embankments tie into the existing Kangsha River Improvement Project embankment near Jaria to provide complete flood protection on the right bank of the Kangsha River. Dhalai drainage channel also needs to be re-excavated.

The existing 10-vent regulator on the Balia outfall and 5-vent regulator on the Kalihar outfall are adequate to drain the project area runoff. However, four small drainage outlets are needed at key locations to provide for local drainage.

To enhance production of fisheries the project proposes to re-excavate five beels to serve as overwintering grounds and fish sanctuaries. The project also proposes to introduce culture fisheries on the floodplain, instead of the conventional ponds, as a pilot project. Existing village roads would form a compartment around a beel and a drainage outlet would be provided from each compartment. Fish hatcheries will also be developed in the private sector jointly with DANIDA's ongoing fishery programmes.

Initially an NGO will look after the fisheries development programme and ensure participation of professional fishermen in the project.

Rationale: Increased food production is necessary to meet the demand of the growing population of the country and the Kangsha Basin. Flooding is one of the major obstacles to increased crop production. There is considerable scope to increase the productivity of monsoon-season crops (especially t. aman) by providing protection against flooding. The 1995 land use survey conducted by NERP reveals that t. aman is heavily damaged on about 8,000 ha of land almost annually.

T. aman is a rainfed crop - its input is minimum, its yield is high - and for that reason farmers prefer to cultivate this crop instead of winter-season boro. In any case there is little scope for increasing the production of boro as the irrigable area is almost fully developed in this project area.

Fish are the major source of animal protein for the people. The project aims to increase fish production by protecting the ponds from flooding and providing overwintering grounds.

Floods in the area disrupt road communication with two thana centres and many growth centres and villages. Roads provide the main mode of transportation within the project area.

Environmental evaluation:

Table 8.5 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: The project will increase cereal production and will protect homesteads and roads. The project will generate employment directly and through improved socio-economic conditions brought about by the reduced flooding and improved agricultural conditions. Full quantification of these benefits will be made in the feasibility study report.

As stated earlier the Kangsha Project's embankment is cut by the Dampara Project people when they are flooded. The flood protection to Dampara area will solve that problem.

The project's positive impacts include:

- increased access to pumps during monsoon;
- large increase in crop productivity (and associated food production, job opportunity and income);
- increased sanitation and access to potable water during the monsoon season;
- increased opportunities for women;
- homestead and infrastructure protection;
- enhancement of home based economic activities; and
- socio-economic gains.

Disbenefits: Model results for this project give numbers that suggest that after the construction of the embankment, flood levels in the north floodplain will rise by about 5 cm in a 2-yr flood and 10 cm in a 20-yr flood. These numbers are smaller than the sensitivity of the model and the change is not considered significant.

The project's negative impacts include:

- loss of agricultural land (and associated food production, job opportunity and income) due to embankment construction;
- decrease in groundwater recharge;
- deterioration of water quality inside the embankment due to standing water;
- contribution to declining biodiversity through loss of wetland;
- decreases in fish production (and associated food production, job opportunity and income) due to reduced migration, recruitment and habitat (open-water and wetland) loss;
- potential conflicts with those outside the embankment;
- potential conflicts between fishers and farmers over flooding and flushing programmes, and
- loss of navigability on Khalihar Khal.

Areas of Uncertainty:

No uncertainty is foreseen at this level of study as the project is rather straight-forward.

Costs: US $ 2.0 million (subject to confirmation pending results of the feasibility study)

Implementing Agency:
Bangladesh Water Development Board

Implementation Plan:
The project is presently under feasibility study and a report is expected shortly. Once a source of funding is identified the following works will need to be completed to implement the project:

- design of structures and preparation of construction drawings, bill of quantities and tender document;
- cadastral survey and land acquisition;
- formation of a project-level committee;
- construction of embankment and other related structures;
- formation of a community organization to take over operation and maintenance of the project;
- monitoring of the project.

The implementation plan should include the following mitigative measures:

- monitoring flushing, control flooding and crop diversification in order to mitigate the negative effects of groundwater recharge decrease;
- adequate training for monitoring and use of drainage regulators to avoid deterioration of surface water quality due to standing water;
- non-formal education programmes to protect and enhance remaining wetlands;
- controlled flooding during monsoon to allow some migration:
  - re-excavation of some internal channels,
  - sanctuary designation,
  - intensify culture fishery;
- improve schools outside the embankment to use them as flood shelters; and;
- prevent potential conflicts between fishers and farmers by forming a committee with representatives from both communities to operate the regulators.

Table 8.5: Dampara Water Management Project

The purpose of this initiative is to provide protection against flooding as well as to enhance drainage capacity. The project includes the construction of a 29.7 km full flood embankment along the Kangsha River right bank from Jaria to Meda, the re-sectioning of 2.01 km of Caritas Road by Netrokona, and the re-excavation of 9.6 km of Dhalai drainage channel. The water management programme will take advantage of existing regulators.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Construction activities	Agricultural land and production	. Loss of agricultural land due to embankment construction	L	. Long term objective will compensate for this loss
	Employment and economic activity	. Temporary job opportunities	+	
Water management	Groundwater quantity	. Decrease in groundwater recharge . Increased access to pumps during monsoon	L +	. Monitoring flushing, control flooding and crop diversification
	Surface water quality	. Deterioration of water quality inside the embankment due to standing water	M	. Adequate training for monitoring and use of drainage regulators
	Biodiversity	. Contribution to declining biodiversity through loss of wetland	M	. Non-formal education programmes to protect and enhance remaining wetlands . Monitoring and enhanced conservation methods
	Fish habitat and production	. Decreases in production (and associated food production, job opportunity and income) due to reduced migration, recruitment and habitat (open-water and wetland) loss . Increased culture fisheries	M +	. Controlled flooding during monsoon to allow some migration. . Re-excavation of some internal channels . Sanctuary designation . Intensify culture fishery
	Agricultural land and production	. Large increase in crop productivity (and associated food production, job opportunity and income)	+	
	Health and welfare	. Increased sanitation and access to potable water during monsoon season . Increased opportunities for women	+	

Table 8.5: Dampara Water Management Project (continued)

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Water management (continued)	Social harmony	. Potential conflicts with those outside the embankment . Potential conflicts between fishers and farmers over flooding and flushing programmes . Existing conflict between the Dampara and the Kangsha residents alleviated	M M +	. Improve schools outside the embankment to use them as flood shelters . Diversify sources of income . Committee with representatives from both communities to operate the regulators
	Homesteads and public infrastructures	. Homestead and infrastructure protection	+	
	Employment and economic activity	. Enhancement of home based economic activities	+	
	Navigation	. Loss of navigability on Khalihar Khal	M	. Road improvement programme
Re-excavation of Dhalai Channel	Agricultural land and production	. Increase in crop productivity (and associated food production, job opportunity and income)	+	
	Fish habitat and production	. Increase in fish production	+	
	Employment and economic activity	. Socio-economic gains . Job opportunities	+	
Deposition of spoil materials	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income)	H	. Spread spoil materials over a large area in thin layers

Thrust:	**Protect homesteads and agricultural land against flooding**
Project Name:	**Chillakhali River Project**

Purpose: The purpose of the project is to rehabilitate the Chillakhali River flood control embankment.

History: BWDB constructed 42 kilometres of embankment on both banks of the Chelakhali River from the international border to the Malijhee confluence to try to contain the overbank spills. As no funds were provided under the Food for Works Programme for land acquisition the embankment was constructed without providing any setback distance. As a result the embankment is breached due to toe scour at several places every year. The ensuing flood causes damage to a number of homesteads and a large area of crop, and causes sand to deposit over the agricultural land at the breach.

Deposition is occurring in the embanked reach because some of the overbank spills have been cut off. As a result the channel elevations are higher than the surrounding floodplain. This situation contributes to lateral instability and breaching of the embankments.

The alternatives for the project are to abandon it completely, to strengthen and retire portions of the embankment and continue an active maintenance program, or to rebuild the embankments further back from the river and raise them higher to contain the deposition of sediment.

The 23-vent Chelakhali Water Retention Structure is difficult to operate because it has a large number of bays, the stoplogs are difficult to remove, and there is no operating deck (the deck may have been left off to prevent the structure jamming with debris). It was damaged in its first year of operation and has since been expanded. It remains vulnerable if a flash flood should occur while the stoplogs are in place.

Description: The existing embankments would be re-built with adequate setback from the river to prevent erosion of the embankments and to provide a buffer area for deposition of sediment. The embankments would be raised in anticipation of the ultimate rise in bed levels which would occur with the new sediment and discharge regimes.

The project also aims to protect the water retention structure and the adjacent embankments against overtopping during flash floods. The most feasible approach appears to be to modify the structure so that it could withstand overtopping. An armoured plunge pool and stilling basin could be provided downstream. Embankments would be raised and armoured at the structure and for some distance upstream and downstream.

The existing wooden stop logs would be replaced with steel fall boards. Raising the structure or providing it with an operating deck would probably not be feasible as this would make it more vulnerable to debris problems and overtopping in the event of a sudden pre-monsoon flood.

Rationale: The existing embankments are vulnerable to breaching. This results in damage to crops and farmland. The only option short of abandoning the project is to strengthen the existing embankments or set them further back so that they are more capable of withstanding the flood discharges and sediment deposition.

The water retention structure will be damaged and ultimately destroyed if it is not protected.

Environmental evaluation:

Table 8.6 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: Rehabilitation would protect the embankments and the water retention structure, would help to protect the areas outside the embankment from overbank spills and sand deposition, would increase crop production (and associated food production, job opportunity and income) in the protected area, and would protect homesteads from flood damage. More reliable supply of water for irrigation would increase crop production.

Temporary job opportunities are associated with the construction phase.

The project would contribute to solve a long standing social conflict.

Disbenefits: More sediment would be transported downstream into the Malijhee floodplain where it infills beels and drainage channels and reduces fishery habitat. Areas between the river and the new embankment would be severely impacted by flooding and deposition and a number of homesteads would need to be displaced, likely resulting in creation of new social conflicts.

Other negative impacts include:

- loss of agricultural land (and associated food production, job opportunity and income) due to excavation, and
- crop reductions inside embankment.

Areas of Uncertainty:

The main area of uncertainty concerns the deposition of bed material within the embanked reach. Strengthening or rebuilding the embankments to prevent the breaching and overbank spills will accelerate the process of aggradation. It is unknown if a stable regime channel can be contained within embankments and consequently what the required embankment height will be - only a detailed morphological investigation can tell.

Theft of steel fallboards could occur. One way to reduce the possibility of theft is to ensure that the project has local public support and is operated by a local organization.

It is unclear at this time whether the project has local public support.

At the moment the feasibility and sustainability of the project seem unlikely.

Cost: US $ 2.5 million

Implementing Agency:
Bangladesh Water Development Board

Implementation Plan:

Before going to implementation a detailed morphological study is required to evaluate the sediment transport/deposition characteristics of the river through this reach and to evaluate the technical feasibility of containing the deposited sediment within the embankments. It would be part of a pre-feasibility study which should also consider the options of doing nothing (letting the embankments erode until the project is abandoned), planned abandonment of the project, or continuing a program of local armouring, retiring of revetments, and maintenance.

The pre-feasibility study should also establish a preliminary design of modifications to the water retention structure including bank protection and scour protection to protect the structure against inadvertent overtopping during a pre-monsoon flood. It should determine the economic benefits of the different options and confirm the local views regarding the project.

Prediction of future changes to the river and the ultimate configuration rely on good data on discharges and sediment loads. The existing data is thoroughly inadequate for a sensible evaluation and therefore additional hydrometric and sediment monitoring is required on a priority basis if the project is to be considered further.

In order to minimize the effects of excavation on agricultural land, topsoil should be stripped and saved while 50 cm maximum of soil is taken for embankment material. Topsoil should be returned and cropping continued.

In specific sites, excavation should be carried out to a depth suitable for fish ponds, and culture fishery should be promoted in ponds excavated for borrow.

Families residing on river side of embankment should have first opportunity for construction and maintenance jobs on embankment.

Table 8.6: Chillakhali River Project
The intention of this initiative is to rehabilitate the Chelakhali River Embankment.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Excavation of material for embankment	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income) due to excavation	H	. Topsoil stripped and saved; 50 cm maximum of soil taken for embankment material; topsoil returned and cropping continued . Excavate to a depth suitable for fish ponds
Construction of embankment	Employment and economic activity	. Socio-economic gains . Job opportunities	+	
General location of embankment	Agricultural land and production	. Crop reductions inside embankment (and associated food production, job opportunity and income) . Increased crop production (and associated food production, job opportunity and income) in the protected area	M +	. Compensation . Families residing on river side of embankment have first opportunity for construction and maintenance jobs on embankment
	Social harmony	. Long standing social conflict resolved . Creation of new social conflicts, unrest and tension	+ M	. Compensation
	Homesteads and public infrastructures	. Protection of homesteads inside protected area . Flooding of homesteads inside of embankment . Loss of property	+ M M	. Raise homesteads . Compensation/relocation
	Erosion and sedimentation processes	. Increase silt load in downstream areas . Flooding . Navigation and drainage difficulties	M	. Dredging

Thrust:	**Protect homesteads and agricultural land against flooding**
Project Name:	**Someswari River Hazard Management**

Purpose: To reduce damages caused by flooding and channel shifting on the Someswari River alluvial fan.

History: The Someswari fan is plagued by a history of avulsion; the main channel shifts abruptly from time to time. Problems include deposition along the Shibganjdhala channel and flooding and erosion of agricultural land and homesteads. The recent formation of the Atrakhali channel has directed more flow eastward and is likely to cause problems in that area as the channel continues to grow and become established. Meanwhile the Shibganjdhala channel has been rising and flood problems have been increasing.

The problem and an approach to managing it are more fully described in Annex D of this report entitled "Someswari River Stabilization Project."

Description: The project proposes a comprehensive program of river hazard management which contains the following components:

Phase 1 - Priority Works (immediate):

- Upgrade existing roads and local embankments on both banks of the Upper Someswari River upstream of Durgapur to reduce the risk of the river developing new avulsion paths across the fan;
- Construct a stone spur dike to protect the town of Durgapur from future erosion by the Atrakhali River;
- Construct a 2 km long stone revetment river training structure at the north end of the Durgapur - Janjail Road to prevent further eastward shifting and spills from the Shibganjdhala River.

Phase 2 - land use and water management planning (three years):

- Develop a water management committee to plan and coordinate future work on the fan, to implement land-use planning and promotion of future development in the designated "low hazard" area, and to coordinate and implement river maintenance work;
- Monitor conditions on the Atrakhali River and assist local people to re-locate from high risk areas in the floodway that will experience future

erosion and flooding. Where warranted carry out local channel maintenance work to minimize adverse impacts from future widening and sedimentation.

Phase 3 - long term:

- upgrade the local embankment on the left bank of the Shibganjdhala River after conditions on the Shibganjdhala River have stabilized;
- initiate river training work to provide a wide floodway for the Atrakhali channel;
- construct embankments along the Kangsha River and Old Someswari River to protect the adjacent lands against overbank spills.

Rationale: The proposed work includes several measures to reduce the risk and uncertainty while recognizing the practical limitations of controlling channel processes on an alluvial fan. It proposes several priority projects that should be constructed immediately to protect existing infrastructure and settlements as well as a long-term strategy that will cope with future conditions as well as possible.

The people living in the avulsion path have developed remarkable strategies to cope with flooding and channel shifting. However, they will require help to adapt to changes that will occur.

Environmental evaluation:

Table 8.7 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: The main benefits from this work include:

- increased security from flood spills and future avulsion on the Upper Someswari River;
- protection of Durgapur town against further erosion of the Atrakhali channel, and reduction of flood damage;
- reduced damage to agriculture on the east side of the fan between the Shibganjdhala River and Old Someswari River;
- reduced flooding and sediment deposition in the lower Kangsha River;
- land use planning that identifies and avoids the high-risk areas;
- an effective strategy for anticipating future changes and responding to them as they occur, before it is too late;
- reduced damages resulting from flooding and sedimentation along Atrakhali channel, and

- creation of temporary jobs associated with the construction phase.

Disbenefits: The construction of the stone spur dike would cause loss of homesteads.

Areas of Uncertainty:

Cost: Approximate cost of the priority work (Phase 1) is 32.8 million taka (USD 0.8 million). Cost of Phase 2, planning, including three fulltime national professionals, one-quarter time of an expatriate advisor, four Community organizers, and office/support staff is estimated to be USD 1.0 million which includes provision of USD 500,000 for relocating homesteads. Cost of potential future works (Phase 3) have not been determined at this time.

Implementing Agency:

Implementation Plan:

The priority components of the project could proceed directly to feasibility study and implementation once a source of funding is identified. Formation of the local management committee should also initiated as soon as possible.

The dike should be located to avoid homesteads as much as possible.

Table 8.7: Someswari River Hazard Management
This initiative is intended to relieve the downstream flooding of the Shibganjdhala River and to relieve the effects of the avulsion of the Someswari to the Atrakhali River.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Upgrading of existing roads and local embankments	Homesteads and public infrastructures	. Improve flood protection . Minimize loss of property and crops . Improve local communications	+	
	Employment and economic activity	. Socio-economic gains . Jobs opportunities	+	
Construction of stone spur dike at Durgapur	Homesteads and public infrastructures	. Improvement of flood protection . Minimize loss of property and crops . Loss of homesteads due to dike	+ + M	. Locate to avoid homesteads . Relocation of homesteads
	Employment and economic activity	. Socio-economic gains . Jobs opportunities	+	
Construction of 2 km of stone revetment river training structure downstream of Durgapur	Homesteads and public infrastructures	. Protection of property and crops downstream . Protection of Jaria-Durgapur roadway . Secured communications	+	
	Employment and economic activity	. Socio-economic gains . Jobs opportunities	+	
Floodplain zoning and local river training	Homesteads and public infrastructures	. Protection of property and cropland . Reduced loss of livelihood	+	

Thrust: **Protect homesteads and agricultural land against flooding**

Project Name: **Homestead Raising and Erosion Protection**

Purpose: To raise homesteads in flood-affected areas so as to reduce flood impacts, to construct new homesteads using spoil from channel excavation projects, and to protect the improved homesteads against erosion by waves and flowing water.

History: The project was first raised in the Northeast Regional Water Management Plan under an initiative for Flood- and Erosion-Affected Villages Project (FEAVDEP). A pre-feasibility level report was done in Phase 1 of NERP. It identified approximately 500 flood-affected villages in the Kangsha Basin area.

Description: Some 60% of the Basin area is flooded annually with the depth of flooding reaching three meters in places. Homesteads are clustered into villages constructed on higher land and raised platforms. It is believed that 5 to 10% of the homesteads in the area are affected by flooding.

Even homesteads inside flood-protected areas are vulnerable to flooding in a flood that exceeds the design event and in the case of unplanned breaching or public cutting of embankments. Embankments may even increase flood damages in a severe flood by providing a false sense of security and by facilitating increased agricultural production and higher property values.

The project would finance the earthwork required to raise homesteads above the danger of flooding and to protect them against erosion by waves. The project would consist of the following steps:

- Identify the villages in need of support;
- Develop village-level organizations/institutions;
- Undertake an organizational/motivation campaign in the selected villages;
- Construct the earthwork by contracting villagers or through Labour Contracting Societies;
- Develop nursery beds through village-based organizations to grow flood-resistant trees and reed plants;
- Protect the newly filled earthwork from wave erosion; provide trees from the nurseries to the villagers at no cost and transplant them at critical locations; and
- Train the village based organizations in techniques for proper maintenance of the rehabilitated homesteads.

Where channel improvements are being undertaken, such as in the Bhogai and Malijhee Rivers, the spoil earth would be used.

Rationale: Flooding and erosion cause homesteads to subside, which exposes them to further flooding damage and causes their inhabitants to experience additional hardship and poverty.

The program is intended to break the downward cycle of poverty by raising and enlarging homesteads belonging to poor and disadvantaged families and by providing material for erosion protection works. These improved homestead lands and conditions will provide greater security and a basis for income generation, water supply, and sanitation improvements that will help families to accumulate assets; thereby achieving a measure of prosperity and self-reliance.

Environmental evaluation:

Table 8.8 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: The homesteads in these villages provide for essential needs such as sanitation, food storage, privacy, work, space to live, fuel, food, and drinking water. The small surfaces of the homesteads are highly productive, and many of the productive functions are the responsibility of women. In addition a well-maintained homestead promotes better health, safety, and quality of life.

Benefits of the program accrue especially to the poor and women.

Disbenefits: None anticipated.

Areas of Uncertainty:

The exact number of flood-affected homesteads is not known at this time.

Cost: US $ 500,000 to raise 16,000 homesteads and to provide erosion protection for 4,000 homesteads. Costs have been estimated using data provided in the pre-feasibility study assuming that 5% of the homesteads are flooded.

Implementing Agency:

Local government (Union Parishad) and NGOs working with village based organizations.

Implementation Plan:

The program should start with a pilot project to develop and test methodologies, staff capabilities, and experience with outcomes. Full-scale implementation will follow, including the following phases:

- NGO organization/training;
- regional implementation - identify flood-affected villages using support and participation of Union Parishads;

- village implementation - organize community participation, set up and organize local institution, construct earthwork, provide erosion protection, assist with resettlement of improved homesteads.

The program would be coordinated with DPHE/UNICEF water supply and sanitation programs.

Table 8.8: Homestead Raising and Erosion Protection

The intention of this initiative is to reduce flood impacts on homesteads, to construct new homesteads using channel spoil, and to protect homesteads.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Raising of homesteads	Homesteads and public infrastructures	. Protection of household property	+	
	Employment and economic activity	. Enhancement of home based economic activities	+	
	Public health and welfare	. Improved health and welfare conditions . General improvement of socio-economic conditions . Improved situation for women	+	

Thrust: **Institutional strengthening and development**

Project Name: **Kangsha Basin Water Management Project**

Purpose: This project would coordinate the planning and implementation of water management projects in the Kangsha Basin using an integrated basin approach. Its primary responsibilities would be to coordinate the efforts of various line ministries in preparing pre-feasibility and feasibility studies, and to organize and mobilize community participation in project planning and implementation.

The main objective is to find a better way to ensure that projects are technically sound and meet the needs of the people.

History:

Description: Details of the project are provided in Annex A under Institutional Perspective. Briefly, it would consist of a core staff of professionals led by a project team leader, plus other staff assigned from line ministries as required. Most of the project personnel would be national staff except for a project monitor and an expatriate institutional/planning advisor. Short-term input of specialist advisors, especially in river morphology, will also be required. A number of Community Organizers would be retained to organize the Project Coordination Committees that are required to mobilize community participation.

The project would include:

- organize the community participation process to review the initiatives and secure a community consensus;
- coordinate the input of all concerned line ministries and NGOs;
- carry the planning of all projects to the pre-feasibility stage;
- present the project plan to concerned authorities and potential donors and secure approval;
- advise donors and their project teams engaged in feasibility studies and project implementation.

Rationale: The present Water Management Plan provides a conceptual strategy for development but has not identified a mechanism to implement it. For example, existing institutions do not have the mandate to coordinate the various ministries at a basin scale nor to ensure that the people are adequately involved in the process. It is unlikely that many of the projects described in this plan will be implemented without an initiative that is focussed on furthering the planning and implementation process.

Benefits: Potential benefits are substantial and will result in better projects through:

- better involvement of local people in project planning and implementation;
- direct accountability to the public and policy makers, and
- integration of regional and local constraints in project planning.

Disbenefits: The only impacts will be beneficial.

Areas of Uncertainty:

The response of donors who would finance projects under the program is not known at this time.

Cost: 1.7 million USD for a three-year program.

Implementing Agency:

Implementation Plan:

It is hoped that a donor will step forward and commit the necessary resources to start such a program. A detailed project design and review of the cost estimate will be required before embarking.

Ideally it would start with the priority projects that are identified in this document. It would be wise to secure agreement in principle from other donors who might be interested in funding projects under the Water Management Plan.

Budgets should be committed for a minimum of three years with provision for annual review.

Thrust: **Protect and enhance fisheries**

Project Name: **Fish Sanctuaries and Beel Improvement**

Purpose: The objective of the project is to enhance fisheries production in the Upper Kangsha River Floodplain by establishing fish sanctuaries in order to protect the existing overwintering grounds. Selected beels will be improved as overwintering grounds through re-excavation and beel embankment.

Currently, there are no fish sanctuaries in the Basin. The project will act as a pilot scheme to demonstrate the effectiveness of the intervention for enhancement of fishery resources in the Northeast Region.

History: New project.

Description: This study identifies 30 beels in the area to be developed as fish sanctuaries to provide secure overwintering grounds. Five beels are in Jhenaigati, ten are in the Malijhee Depression, five in southern Haluaghat, five in Purbadhala, five in Durgapur, and five in Dhobaura area (Figure 23). In selecting the beels, special emphasis has been given to those which are on khas (public) lands.

This study identifies the following beels to be potentially declared as fish sanctuaries:

- Pekua, Hapnoi, Barigai, Ulla Beels in Malijhee Depression;
- Panisana, Pakhla Beels in Dampara area;
- Kabor Beel in Durgapur area.

The Kangsha River between Jaria and Gagra has also been identified as a sanctuary.

Planned engineering works at selected beels include re-excavation to deepen the beels, and construction of embankments to prevent the inflow of new sediment. A programme of tree plantation (*hizal* and *koroch*) on the embankments will also be initiated under the stewardship of women fish processors.

Protected katha will be installed in the sanctuary beels under the management of the local fishing communities. Support will be given to genuine fishermen associations to secure tenure of beels and to implement effective fisheries management measures.

Rationale: More than 60% of the study area is inundated annually, but the productivity of fisheries is relatively low. One of the contributing factors to this poor performance is that almost all the beels and channels are shallow and seasonal. In addition, the few existing perennial beels are usually dewatered by lease

holders, resulting in heavy mortality of overwintering broodstock. Thus, recruitment during the monsoon is low despite the abundance of inundated feeding grounds.

Enhanced fisheries production is very much needed to raise the nutrition level of the local population as fish is the main source of animal protein. The professional fishermen and landless people depend on this open water fisheries for their livelihood and subsistence.

Environmental evaluation:

Table 8.9 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: There will be an increase in fish biomass which will result in increased commercial and subsistence fish production. This will increase income and improve nutrition, as well as generate new employment in production and postproduction. It will also result in more demand for tree branches for katha, and environmental improvement through afforestation.

Disbenefits: The re-excavation of beels would cause loss of agricultural land (and associated food production, job opportunity and income). The sanctuary designation would cause deprivation of income and immediate sources of protein for poor.

Areas of Uncertainty:

Prevention of fishing in the sanctuary is dependent on an effective public awareness programme, securing tenure of beels by genuine fishermen associations, and implementation of fisheries management measures by the associations.

Cost : US $ 1.0 million.

Implementing Agency:

Directorate of Fisheries

Implementation Plan:

The first phase of a study of existing embanked beels in the Sylhet area was carried out during the monsoon in July 1995. This study should be completed during the coming dry season (Jan-March 1996). The results should be used to formulate an implementation plan for the project. It should be implemented through the local fishing communities who would be invested with tenure and management authority for the sanctuaries.

The re-excavation of beels should be located in low value crop land.

Spoil should be transported where it can be used for raising homesteads or be deposited on low quality land purchased at market value.

Job opportunities related to the project should go to destitute fishermen.

The realization of the long-term objective of improved and sustainable fishery will compensate for short-term losses.

Table 8.9: Fish Sanctuaries and Beel Improvement (Development and Protection of Overwintering Grounds)
The objective of this initiative is to enhance fisheries production in the Upper Kangsha River floodplain by protecting the existing overwintering grounds and developing selected beels as overwintering grounds through re-excavation and declaration as sanctuaries.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Spoil disposal	Agricultural land and production	. Loss of agricultural land (and associated food production, job opportunity and income)	L	. Spoil to be transported where it can be used for raising homesteads; spoil to be deposited on low quality land purchased at market value
Sanctuary designation	Fish habitat and production	. Improvement of fish stocks . Loss of resource through poaching	+ M	. Public awareness . Local resource ownership and custodianship

Thrust: **Protect and enhance fisheries**

Project Name: **Fishpass Structure in Kangsha River Improvement Project (KRIP)**

Purpose: The project aims to facilitate fish migration and natural recruitment in the existing Kangsha River Improvement Project (KRIP).

History: First identified in the Kangsha Basin Water Management Plan.

Description: A fishpass structure would be constructed at a selected site in the full flood embankment of KRIP along the Kangsha River.

A detailed feasibility study would be required for the fishpass, including analysis of hydrological data, study of fish migration patterns, monitoring of fish passing through existing KRIP water regulators, computer simulation of water flows through the fishpass, survey of agricultural cropping patterns and land use, and modelling of potential hydrological impacts in KRIP.

At least one of the *beels* and the connecting drainage channel will be declared as fish sanctuary for three years. Every three years one of the *beels* will, in turn, be declared as sanctuary. Fishing rights within the project area will be given to the fisheries community in accordance with DOF's 'New Fisheries Management Policy (1986)'. A programme of fisheries management training and organization in the light of the lessons learnt in the Manu River Project Fish Pass Structure would be implemented for the local fishing community.

A general public awareness campaign will also be conducted.

Rationale: Fish migration is obstructed by the existing full flood control embankment. A fishpass structure would allow biologically programmed life cycles based on migration to be carried out normally, and thus rehabilitate fish stocks and maintain natural recruitment.

Environmental evaluation:

Table 8.10 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: This structure will enhance fish production inside the project by restoring in part pre-KRIP fish migration.

Disbenefits: Loss of agricultural production (and associated food production, job opportunity and income) due to operational fishpass.

Inducing migration can result in ecosystem modification on both sides of the embankment.

Areas of Uncertainty:
Conflict may arise with the farmers if they feel their crops are threatened by the inflow of water through the fishpass.

Cost: Estimated cost of the feasibility study is US $50,000. Cost of the fishpass structure is $200,000.

Implementing Agency:
Department of Fisheries in association with BWDB.

Implementation Plan:
A feasibility study is required.

Structure should be located in less sensitive area.

Analysis and monitoring as well as control flooding and public awareness programmes would prevent social conflicts.

Table 8.10: Fishpass Structure in Kangsha River Improvement Project (KRIP)
The intention of this initiative is to enhance fish migration and natural recruitment into the existing Kangsha River Project.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Construction of structure	Fish habitat and production	. Potential loss of fish habitat	M	. Locate structure in less sensitive area
	Employment and economic activity	. Job opportunities	+	
Operation of fishpass	Agricultural land and production	. Loss of production (and associated food production, job opportunity and income)	M	
	Fish habitat and production	. Inducing migration can change ecosystems on both sides of embankment . Improved fish stocks in the Kangsha Project area (and associated food production, job opportunity and income)	M +	. Analysis and monitoring
	Social harmony	. Social conflict (farmers may perceive bypass causing additional flooding)	H	. Control flooding; public awareness

Thrust:	**Protect and enhance fisheries**
Project Name:	**Kharia River Fisheries Enhancement**

Purpose: The purpose is to enhance fisheries resources in the Kharia River through engineering works and fisheries management measures with full participation of fishing communities.

History: Kharia River was once a major spill channel of the Old Brahmaputra River before its avulsion to the present course. The Kharia originates from the Old Brahmaputra at Char Niamat, has a channel length of approximately 40 km, and 'discharges' into the Kangsha River at Silpur.

After the avulsion, the Old Brahmaputra has been drying and all of its spill channels are being sedimented. Among these the Kharia River has become stagnant and a 5 km section has silted up in the upstream. The river still maintains a deep profile for much of its 35 km downstream reach, but the fisheries resources are very low due to closure of the confluence with the Kangsha. A significant potential exists for enhancement of fisheries production in this large water body through restoration of the fish migration route and ancillary fisheries management and environmental enhancement measures.

Description: The project's engineering works would consist of construction of a single vent regulator (1.52 m x 1.83 m) at the Silpur outfall to act as a water retention structure (WRS). The crest level would be been set at the 1:50 year peak level of the Kangsha River. The purpose of the WRS is: (1) to allow annual filling of the Kharia channel during the pre-monsoon and early monsoon periods with back flow from the Kangsha River (which will also carry in fingerlings and broodstock of some migratory species to replenish fish standing crop), and (2) to retain water during the dry season by closing the regulator during the late monsoon to prevent drainage. Local catchment runoff will help to maintain the water level.

Seventeen sanctuary katha will be installed at 2 km intervals along the length of the river channel. These will be managed by the local fishing community.

Fisheries management rules will be enforced to prohibit fishing with current jal and other destructive fishing methods and gears. The fishery will be managed to provide a high level of productivity for subsistence consumption by local people and sustainable harvesting of commercial species by professional fishermen with secure tenure and access.

Rationale: Many large water bodies in Bangladesh (such as the Kharia River) do not yield high levels of fish production because of the absence of effective hydrology and fisheries resource management initiatives. By sponsoring such initiatives through local community mobilization, improvements in nutrition, income, employment, and general socio-economic conditions of fishing households can be realized.

Environmental evaluation:

Table 8.11 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: The river channel has an average width of 150 m, and the 35 km active reach has an approximate area of 525 ha. A mixed yield of commercial and subsistence species of about 100 kg/ha/yr is anticipated, giving a total production of about 52.5 tons per year. This will generate employment and income and will improve nutrition locally.

Disbenefits. During winter the river fringe is presently used for seed bed and boro cultivation. This practice will likely be affected by the implementation of this project and may result in social conflicts. This practice may not be the best possible utilization of this aquatic resource. Options for multi-purpose use of the river fringe will be investigated.

Downstream fishery would be altered (and associated food production, job opportunity and income).

The project may contribute to a decline in biodiversity.

Traditional fishermen would be affected by this initiative.

Areas of Uncertainty:

No uncertainty is foreseen in this scheme.

Cost: US $ 0.29 million

Implementing Agency:

Bangladesh Water Development Board and Department of Fisheries.

Implementation Plan:

The project requires a pre-feasibility study, followed by a full feasibility study. Study of land use and land ownership of the channel area is required, and a guarantee paper must be obtained from the Ministry of Land making the river channel available for fisheries development. Engineering survey and design for cost estimation is required. Identification of professional fishermen and assistance for organizing a fisheries management association might be facilitated through an NGO. Training of fishermen in fisheries management would also be required, including local traditional fishers in this scheme.

Detailed analysis should be carried out to ensure no significant biodiversity decline.

A seasonal fishery programme should be designed to accommodate river bed farmers.

Table 8.11: Kharia River Fisheries Enhancement
The objective of this initiative is to enhance fisheries resources in the Kharia River through intensive aquaculture with full participation of professional fishermen.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
River closure and construction of regulating structure	Fish habitat and production	. Downstream from closure, fishery altered (and associated food production, job opportunity and income)	M	. Compensation
	Biodiversity	. Potential contribution to declining biodiversity	M	. Detailed analysis to ensure no significant biodiversity declination
	Employment and economic activity	. Job opportunities . Improved local economy	+	
Management of scheme	Agricultural land and production	. Use of river fringe for seed bed and boro cultivation will be affected (and associated food production, job opportunity and income)	H	. Investigate options for multi purpose use of the river fringe
	Social harmony	. Deprivation of existing opportunities of cultivation in river bed . Deprivation of traditional fishermen . Social conflict due to loss of opportunities of cultivation and fishing	H	. Design a seasonal fishery to accommodate river bed farmers . Include local traditional fishers in scheme
	Fish habitat and production	. Improved fishery production (and associated food production, job opportunity and income)	+	

Thrust: **Protect and enhance fisheries**

Project Name: **Shallow Floodplain Aquaculture**

Purpose: The purpose of this project is to introduce the concept of the managed floodplain for enhancing fish production.

Many areas of the floodplain are shallowly-flooded and remain inundated for 3 to 4 months of the year. These shallowly flooded areas are very rich in plankton and benthos but their productivity for fisheries is relatively low due to long migration routes, obstructions by roads, and other problems. The project proposes a pilot program to increase the productivity of local areas by introducing basic aquaculture management practices.

History:

Description: Introduction of culture fishery in the shallow floodplain is a new concept. As such the project should be considered as a pilot scheme.

Five shallow flooded areas which are off the main drainage system and which presently have low productivity would be selected for the program. The drainage inlets and outlets will be closed by fish nets allowing water to flow but not the fish. The outlet could be fitted with a small drainage structure designed to maintain water in the upstream pool. Fingerlings would be released at the onset of the monsoon season and would be harvested in winter.

The project will acquire fishing rights from farmers who own the floodplain land by paying royalty to the farmers. In turn the fishing rights would be granted to the farmers and poor people who depend on fishing for subsistence. A local organization would be created to operate the project.

A sketch of the possible layout of such a project is shown in Figure 24.

Rationale: Enhanced fisheries production is needed to meet the growing demands of the country. Furthermore remaining floodplain areas are under threat from expanding agriculture and from construction of flood-control projects. Consequently the open-water floodplain fishery is gradually declining and will need to be supported with, and in some cases replaced by, more commercially-based culture programs.

Intensively managed fish ponds can produce yields that are 4 to 5 times higher than those of open-water floodplains. Thus there is significant potential for increased productivity of the floodplains if simple culture practices are applied.

The project might constitute a low-cost alternative for increasing fish production.

Environmental evaluation:

Table 8.12 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: If successful the scheme will increase fish production locally (and associated food production, job opportunity and income). Once proven it could be replicated in other areas and could benefit a large number of people.

Disbenefits: By depriving subsistence fishers of traditional resource, social conflicts may arise (land owners and traditional landless fishers conflicts over resource access).

Areas of Uncertainty:

Practical problems of operating such a scheme can only be found by trial. There may be problems of pesticides in the rice-growing areas that drain to the proposed sites.

Cost : Estimated Cost US $ 0.2 million.

Implementing Agency:

Directorate of Fisheries

Implementation Plan:

As the project is a small pilot project it can be implemented with a minimum of study. A brief report is required to identify suitable floodplain areas, to design the methodology, and to design an appropriate monitoring method to determine the programme's effectiveness. The programme would be organized by a local NGO. A local organization would be created to operate the project and to decide on an equitable method for sharing the increased production.

For instance, in order to avoid social conflicts, subsistence fishermen could be hired by land owners to capture fish on contract basis.

Table 8.12: Shallow Floodplain Aquaculture
This initiative is intended to enhance fish production through culture fisheries in the shallow floodplain utilizing available natural foods.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Implementation of project	Social harmony	. By depriving subsistence fishers of traditional resource, social conflict may arise (land owners and traditional landless fishers conflict over resource access, poaching)	M	. Subsistence fishermen could be hired by land owners to capture fish on contract basis . Resource sharing
	Fish habitat and production	. Increased fish production (and associated food production, job opportunity and income)	+	

Thrust: **Protect and enhance fisheries**

Project Name: **Open Water Fry Release**

Purpose: The purpose of this scheme is to achieve immediate enhancement of open water fishery resources through releasing of fish fry. The project will supplement existing programs of the DOF.

History: This is a support to the GOB programme 'Open Water Fry Releasing Scheme'.

Description: Under this project, fish fry will be released in open water bodies selected by the Fisheries Directorate. Initially 1,000 ha of floodplain area will be selected for releasing fry at the rate of 10,000 fry (25 kg of fingerling) per ha. Provision will also be made for proper monitoring to ensure its effectiveness in enhancing the area's fish production. The project will be operated by the NGOs using fish fry purchased from the DOF or private hatcheries. Local fishermen organizations will participate in the fry release and monitoring program.

As this programme is costly and has to be renewed annually, it should be continued only until the effectiveness of other initiatives for enhancement of natural recruitment is proven.

Rationale: Recruitment is low in much of the program area due to long and difficult migration routes, obstruction by embankment projects and roads, and lack of overwintering areas. Conditions will worsen with increased flood control and development for agriculture. There is an immediate demand for fish in the country.

To cater to these needs, an emergency programme like the Fry Releasing Scheme is essential. Existing programs of the DOF are not adequate for the area's needs.

Environmental evaluation:

Table 8.13 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: It is expected that there will be immediate enhancement of fish production in the area (and associated food production, job opportunity and income).

Disbenefits: Release of non-endemic fish species could cause displacement of endemic species.

Areas of Uncertainty:

Uncertainty exists in the mortality of the released fingerlings.

Cost: US$ 2.0 million for a 3-yr programme.

Implementing Agency:
Directorate of Fisheries

Implementation Plan:
Implementation can begin once funding is secured. Discussions will be held with DOF and local fisheries organizations to identify the needy areas and to select the organizations to participate in the monitoring program. The program would be administered by a local NGO with involvement by local fisheries organizations.

To prevent any ecological problem to occur, only traditional species should be released and in combinations and numbers proven acceptable. Monitoring and evaluation should be carried out.

During the dry season, beel owners may benefit more than subsistence fishers. To mitigate this equity problem, some of the beels should be leased to fisher communities.

Table 8.13: Open Water Fry Release

The objective of this initiative is to achieve immediate enhancement of already depleted open water fishery resources.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Fry release	Biodiversity	. Release of non-endemic fish species could cause displacement of endemic species	M	. Release only traditional species and in combinations and numbers proven acceptable . Monitoring and evaluation
	Fish habitat and production	. Increased fish production (and associated food production, job opportunity and income)	+	
Fish capture	Social harmony	. During dry season beel owners may benefit more than subsistence fishers, leading to an equity problem	H	. Some of the beels should be leased to fisher communities

Thrust:	**Protect and enhance fisheries**
Project Name:	**Support to Diversified Fisheries**

Purpose: The purpose of the project is to facilitate and support various initiatives to diversify fisheries by increasing culture fisheries. It aims to try several possible alternatives for new fish crops in pilot projects and to demonstrate the technology to area people in the hope that the pilot project can be replicated on a larger scale. It includes support to fish hatcheries in the Basin so as to increase the availability of fish fry for culture and floodplain fisheries programs.

History: New project.

Description: This project proposes to transfer modern technology to the area people in the following areas:

- Support to fish hatcheries;
- Aquaculture in ponds;
- Freshwater prawn culture in paddy fields and ponds;
- Freshwater pearl culture in paddy fields and ponds.

The focus of the program will be to encourage and support the formation of small enterprises within the scope and ability of poor and landless people. Poor people will be involved in the program by being provided training and support in securing financing.

Support to Fish Hatcheries:
Presently there are five hatcheries in the Basin area. CARITAS has taken up a scheme to develop four more hatcheries in Haluaghat and Dhobaura thanas. It is estimated that as many as 200 small hatcheries may be needed to supply the needs of about 23,800 ponds in the Basin. Furthermore the open water fry releasing scheme adds to the demand for fingerlings. Fish fry and fingerlings are being supplied from outside the Basin area.

The project proposes establishing several low cost fish hatcheries in the area under the private sector. The project will provide training to help local people adopt the production and management methods and to help people secure access to credit. Poor people who have no other access to credit may be supplied with loans with favourable repayment terms to help start the program.

Hatcheries will be small in scale, typically costing 20,000 to 30,000 taka to set up. They will produce fry for local use and will be expected to be commercially viable.

Pond Aquaculture:
This program will support DANIDA's ongoing pond culture programme in several thanas within the study area. This project proposes to extend DANIDA's programme in the remaining thanas. The project will help people to get an adequate number of fish fry, fish feed, and training on pond management and fish diseases.

Freshwater Prawn Culture in Paddy Fields and Ponds:
Prawn have high value and can be cultured in paddy fields and ponds. A successful prawn fishery exits nearby, but has not yet been established within the Basin. The purpose of this project is to demonstrate the feasibility of such a crop in the Basin and to transfer this knowledge to the area people.

Four ponds and four floodplain areas (appr. 4.0 ha) will be selected for a pilot program. The owners will be given training and assistance in securing funding as an incentive to start the program. Training in the development and management of prawn farms will also be available to other interested parties.

Freshwater prawn (Macrobrachium rosenbergii) will be cultured along with *t.aman* crop. Fish crop will be a bonus for the farmers. Unlike shrimp culture in saline water regime in the country's southern belt, the prawn culture in the fresh water regime in the study area will not reduce soil fertility. Moreover, introduction of prawn culture will reduce the use of pesticides and thus maintain water quality.

Prawn culture will require the land to be inundated at least for four months. This factor will restrict the area people from a large scale prawn culture. Moreover, as it will not obstruct crop cultivation, there will be no conflict between fishers and farm labourers.

The project may include establishment of one prawn hatchery in the private sector if prawn culture proves to be viable.

Freshwater Pearl Culture in Ponds:
Natural pearls are a high value crop that is harvested successfully in some parts of Bangladesh. Pearl culture has been tried in other parts of the country but not within the Kangsha Basin. The project proposes to culture pearl mussel in two ponds near Jaria as a pilot scheme. This project will establish demonstration farms to prove the concept for the conditions that exist in the Basin and to demonstrate the culture technique to the people of the area.

Rationale: Alternatives to floodplain fisheries are required to provide adequate supply of protein. Culture fisheries are one alternative and have significant potential for economic gain and increased employment. Fish culture is profitable but has not been developed to its potential because local people are unfamiliar with modern fish farming methods and the potential for profit.

Environmental evaluation:

Table 8.14 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: The project will transfer technology and will motivate people to various forms of small-scale aquaculture on a commercial basis, thus increasing production and economic returns. It will provide employment opportunities. Nutrition will also improve.

Disbenefits: No disbenefit is foreseen.

Areas of Uncertainty:

Cost: US $ 1.0 million for project work plus US $ 2.0 million to establish a revolving loan fund.

Implementing Agency:

Directorate of Fisheries

Implementation Plan:

The project will be organized by a local NGO such as CARITAS. Local people will be recruited to participate in the programs.

A revolving fund for credit will be set up to finance the small business enterprises for poor people who have no access to conventional credit lines. It could be administered by the Grameen Bank or one of the local NGOs.

The program can be taken up without further study as it is small in scale and involves demonstration projects and applied research.

Table 8.14: Support to Diversified Fisheries
The intention of this initiative is to diversify fishery activities to reduce dependency on capture fisheries.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Freshwater prawn and pearl culture development	Employment and economic activity	. Job opportunities . Improved local economy	+	
	Fish habitat and production	. Significant contribution to fish production (and associated food production, job opportunity and income)	+	

Thrust: **Protect and enhance fisheries**

Project Name: **Rehabilitation of Malijhee Water Retention Structure**

Purpose: The purpose of the project is to enhance fisheries resources in the Malijhee Basin by creating an overwintering area and sanctuary upstream of the Malijhee Water Retention Structure.

History: The Malijhee Water Retention Structure was built at Hatibanda by BWDB in 1986 to retain water for dry season irrigation. A flash flood damaged the structure in May 1988, and it has not been repaired. Instead, a groundwater irrigation system has been developed and people have begun to use all of the winter streamflow in upstream areas. Therefore there is little need to rehabilitate the project for irrigation.

All channels and beels in the area are seasonal and there remains no area for fish to overwinter and no means of regenerating the resource annually. As a result the productivity of the fisheries in the area is low. By rehabilitating this structure it can be used to store water to create an overwintering area.

Description: The project work involves rehabilitation of the existing seven-vent retention structure including repair of gates and hoisting arrangements. A simple overflow weir will be added to prevent damage to the structure in the event of a flash flood occurring while the regulator gates are closed. Shelter areas will be provided to make the catching of fish difficult.

The overwintering ground covers an area of 100 ha of channel.

The project will be operated by a local fishermen's group.

Rationale: Fish are the major supplier of animal protein to the people of the area. Subsistence fishing is particularly important to the poor. However as stated earlier the area has relatively low productivity due to the lack of overwintering areas. This is especially critical in the upstream reaches of the Kangsha Basin to which migrating fish must travel a long distance. As the Malijhee Water Retention Structure is no longer needed for irrigation water supply it can be used to provide overwintering grounds for broodstock.

Environmental evaluation:
Table 8.15 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: There will be net annual increase of 3.0 tonnes of fish by this project. It will also generate 50 person days/yr of employment for poor fishermen.

Disbenefits: There may be conflicts between fishermen and area farmers, who may wish to use the water for irrigation once the project is restored to operation. This conflict will need to be resolved during the pre-feasibility study before proceeding with the project.

As the impounded area is contained within the channel banks, there will be no impact on agriculture.

Areas of Uncertainty:

There may be conflict with the farmers who may wish to use the water for irrigation. It may be possible to design the project to provide some storage for local irrigation use as well as for fisheries, but this would increase the scope of the project. The issue needs to be addressed during the pre-feasibility study.

It is not certain whether local people will respect the sanctuary and agree to avoid catching of fish during the dry season.

Cost: US $ 0.60 million

Implementing Agency:

Bangladesh Water Development Board and Directorate of Fisheries.

Implementation Plan:

Because the project concept proposes a new use for the existing project, and because there may be conflicts between farmers and fishermen, a pre-feasibility study is recommended. Its primary purpose will be to develop a conceptual design and management plan for the project and to secure support from local people. The pre-feasibility study may be followed by a brief feasibility study to develop the design and cost estimate of any engineering works that may be required, especially the design of an overflow spillway to protect the project against sudden flash floods, and to set up the local management structure.

The possibility of involving an NGO in the initial stage (say for 2 years) to should be considered.

Table 8.15: Rehabilitation of Malijhee Water Retention Structure The objective of this initiative is to enhance fisheries resources in the Malijhee Basin.				
Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Rehabilitation of retention structure	Employment and economic activity	. Job opportunities	+	
Water control	Social harmony	. Water user conflict between fishers and farmers as water would not be available for irrigation	H	. Use groundwater to irrigate
Sanctuary designation	Fish habitat and production	. Improvement of fish stocks . Loss of resource through poaching	+ M	. Public awareness . Local resource ownership and custodianship

Thrust: **Improve management of surface water use**

Project Name: **Rubber Dam for Irrigation**

Purpose: People in the border reaches of the smaller tributaries use the dry-season flow in these streams for irrigation water supply. They construct small earthen dams annually to create an impoundment and store the water for use throughout the dry season. These dams are washed away every year. In this project, the existing earth dams would be replaced by small inflatable rubber dams which would be more durable and permanent. They would only have to be re-inflated at the start of the dry season and would collapse automatically to permit passage of a severe flood that overtops the structure.

The objective of the project is to secure the availability of irrigation water in the northern area and thus to enhance production of winter crops.

History: This is a new proposal which was identified during preparation of the Water Management Plan for the Kangsha Basin.

Description: This project proposes to construct rubber dams in the Malijhee (Marisi), Nitai, and Lengura Rivers to retain water in the channel to facilitate irrigation in the lean period.

To test the viability of the concept under local conditions, a pilot rubber dam across the Lengura River would be constructed.

To optimize the use of irrigation water, area people should be encouraged to adopt non-rice high value crops which use less water than rice. The rivers carry small flows and which are not sufficient for the demand.

The project includes work by COs to help facilitate implementation of the project and to encourage the adoption of non-rice crops.

Rationale: Though small, the rivers (Malijhee, Chelakhali, Bhogai, Nitai, Someswari and Lengura Rivers) carry flows in winter. At many locations, people construct earthen cross-dams on rivers to retain water for irrigation. Usually the earth is sandy, and these dams often fail; especially if there is a heavy shower in the catchment. Farmers make a large investment in irrigated crops and they simply cannot afford the loss. Moreover, in some years, the farmers cannot organize themselves to construct the dam and the land remains fallow during the winter season.

Rubber dams are an attractive permanent alternative to replace the annually-constructed earthen dams. They consist of a rubber bag that can be inflated to block the flow and can be deflated to release water and to lie flat out of the way during high flows. They are more flexible in operation and maintenance than conventional water retention structures. They can be constructed in lengths up

to 100 m, and because they have no intermediate piers, they cope with debris that would clog a conventional structure. They are also cheap, costing about 40 to 50% less than a conventional structure.

Conventional water retention structures do not work well in the border rivers because they cannot be opened quickly enough to accommodate flash floods and they are therefore vulnerable to overtopping and damage. BWDB has constructed two conventional water retention structures - one on the Malijhee River at Hatibandha and the other on the Chelakhali River at Sanyashibhita - and both have been damaged by flash flooding. Furthermore such structures are not economic for small tributaries.

Two such rubber dams are under construction in Bangladesh on the Bakkhali River at Jhilanza and on Idgaon Khal at Idgaon Bazar (both are near Cox's Bazar in the southeast of the country). However they have not been proven for flashy flood hydrology and debris problems of the Kangsha Basin. The durability of rubber dams for debris-laden streams is also unknown and for these reasons a pilot project is recommended.

The people of the northern part of the area are poor, partly because their winter crops are not secure. Winter crops are more productive and profitable than are summer crops, but they require irrigation. Rivers are the only source of water for irrigation as no groundwater is available in most of the piedmont plain.

To alleviate poverty in the area, it is required that this area should be provided with dependable irrigation supply with suitable water retention structures on small rivers. People of the Lengura River area have requested that a control structure be built. There are presently two dams that serve about 730 ha and compete for water supply; they would be replaced with a single cross-dam and distribution system that services the entire area.

Environmental evaluation:

Table 8.16 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: The pilot project is expected to increase crop production on about 730 ha by ensuring the reliability of winter water supply for irrigation to this area. It will also prove the feasibility of the concept for application to the border streams and will resolve the conflict which presently exists over use of the water. The ponded water upstream of the dam will help to harvest a short fishery crop.

Disbenefits: This type of project will lessen the water resources of downstream users. This can result in diminished crop production and reduction in fish habitat, adversely affecting both farmers and fishers downstream of the dam. There is the potential for social conflict between upstream and downstream users.

Areas of Uncertainty:

It is not certain how rubber dams will be accepted by the local people. There is a risk of contention with downstream people and for this reason an existing site, where earthen dams are presently constructed, will be developed.

Costs: US $ 1.70 million for the pilot project only.

Implementing Agency:
Local Government Engineering Department and Department of Agricultural Extension.

Implementation Plan:
A conceptual level design has been developed for this project. Upon confirmation of funding and confirmation of the site on the Lengura River, the project could proceed directly to feasibility study. The following works are required to be done during implementation and monitoring:

- formation of a project committee for site selection, construction monitoring, operation and maintenance of the project, and monitoring of the performance of the project;
- selection of a site for a pilot scheme on Lengura River;
- engineering survey for design and cost estimate;
- design of a distribution network;
- construction of the rubber dam and distribution network;
- community organization of beneficiary groups for optimal utilization of water (water sharing agreements to accommodate all users);
- monitoring of the performance of the project.

After evaluating the performance of the pilot scheme a decision to construct other sites may be made.

Table 8.16: Rubber Dam for Irrigation
This initiative is intended to replace existing practice (construction of earthen dams) for conserving water for irrigation allowing flash flood waters to pass without damage.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Placement of rubber dam	Agricultural land and production	. Increased crop production (and associated food production, job opportunity and income) in command area . Reduction in crop production due to loss of water resources to downstream users	+ M	. Water sharing to accommodate downstream users
	Fish habitat and production	. Increased fish production (and associated food production, job opportunity and income) upstream of dam . Alteration in downstream fish habitat and production	+ M	. Water sharing to accommodate downstream users
	Social harmony	. Social conflict between upstream and downstream users . Loss of livelihood	M	. Water sharing agreements to accommodate all users

Thrust: **Improve management of groundwater use**

Project Name: **Groundwater Monitoring Program**

Purpose: The project will provide a much needed expansion of the present groundwater observation well network. It will facilitate development and improved management of groundwater for domestic, industrial, and agricultural use in a sustainable manner.

History: BWDB has been collecting groundwater levels in the area. But the number and distribution of observation points is presently inadequate and the methodology for observing groundwater levels needs to be improved. Many of the present observation wells are grouped near thana centres and do not serve to monitor the effect of rapid expansion of agricultural irrigation on groundwater. Wells used in the present network measure either the water table fluctuation or the piezometric surface and fail to provide the type of data that a homogenous network would.

Description: The project would install additional monitoring sites to monitor groundwater levels in the Kangsha Basin to supplement the existing network.

To achieve the required accuracy, design of the groundwater monitoring network in the Kangsha Basin should consider the following:

- Density of observation points must be varied according to the geology, topography, and hydrogeology.
- The level of irrigation development should determine the location of the observation wells.
- The wells should be used only for monitoring purposes.
- Each monitoring point should consist of two wells which separately monitor the upper and lower aquifer, except in locations where the intermediate aquilude/aquitard is absent.
- Automatic water level recorders should be used as much as possible and should be set to take weekly recording of the groundwater level or piezometric surface.
- A thorough study of the existing network should be carried out. Existing observation well which meets the criteria required with respect to location and depth should be incorporated into the new network. Final design of the network should be carried out in consultation with WARPO in order to ensure that their requirements for calibrating the groundwater model are met.

Rationale: Groundwater is used intensively and parts of the Kangsha Basin may be developed to their potential. More intensive monitoring data will be required to ensure security of supply in the future and to identify potential shortages before serious problems occur.

WARPO's groundwater model takes into consideration a great many parameters. The output of the model is therefore critically dependent on the quality of the data it uses for the input. Too many assumptions or estimates severely curtail the reliability of the results. The key hydrogeologic parameters used for appraising the groundwater situation in the Basin are based on results obtained from WARPO's special study area at Phulphur. While the aquifer characteristics of this particular area may be typical for parts of the basin there is little basis to develop estimate for the majority of the area.

The inherent dependency on WARPO's groundwater model for assessing groundwater resource availability makes it essential that the required input data be as accurate as possible.

Environmental evaluation:
Table 8.17 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: Substantial improvement in the ability to assess the groundwater resource potential in a region where dependency on groundwater for irrigation is extremely high.

Substantial improvement in monitoring water levels in areas where groundwater abstraction is high due to extensive irrigation.

Enhanced ability to anticipate water shortages caused by over-development of the resource and to allow time to take appropriate measures to avoid possible hazards.

Guarantee the availability of groundwater resource for domestic use.

Important additional lithologic information would be obtained from samples collected during drilling of the observation wells.

Efficient use of scarce water resource leading to increased and sustainable production.

Disbenefits: This intervention has no negative impacts.

Areas of Uncertainty: Nil

Cost: Total cost of a ten-year program is estimated to be US$ 1.9 million composed as follows:

•	Installation:	US$ 1.2 million
•	Data collection and processing:	US$ 50,000 per year
•	Analysis and re-calibration of the groundwater model:	US$ 100,000 in Year 5 US$ 100,000 in Year 10

Implementing Agency: WARPO

Implementation Plan:

Data deficiency for use of WARPO Groundwater Model is required to be identified. A data collection programme, processing and analyses as required by the model is to be chalked out. Groundwater model is to be re-calibrated and model run for different planning options will require to be carried out. Model output will be analyzed thoroughly and appropriate recommendations are to be made.

Table 8.17: Groundwater Monitoring Programme

This initiative is intended to provide a much needed expansion of the present groundwater observation well network. It will facilitate development and improve management of groundwater for domestic, industrial, and agricultural use in a sustainable manner.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Expansion of the groundwater observation well network	Agricultural land and production	. Efficient use of scarce water resource leading to increased and sustainable production	+	
	Groundwater quantity	. Improved management of groundwater in a sustainable manner by providing advance warning of the resource availability and allowing time to take appropriate measures to avoid possible hazards	+	
	Health and welfare	. Guarantee the availability of groundwater resource for domestic use	+	

Thrust: **Improve management of surface water use**

Project Name: **Improved Management of Surface Water Irrigation**

Purpose: The project will attempt to resolve the practical problems of increasing irrigated crop area, diversifying crops, adapting new technologies for intensive cropping, and increasing labour absorption per unit area of land. It will contribute to better and more efficient use of the available surface water resources.

It will develop programmes to expand the area cultivated for non-rice crops that have higher value and use less water than rice. The project will develop tools and approaches for i) efficient management of the limited surface water resource, ii) expansion of irrigated area to high value and labour-intensive non-rice crops, and iii) improvement in the productivity and stability of more intensive cropping patterns.

History: The project is a new initiative to manage the available surface water for irrigation more efficiently.

Description: An interdisciplinary team will analyze the use and management of irrigation water supply in typical small irrigation projects in the basin, with respect to the project operation and on-farm water use. Technical, agricultural, environmental, socio-economic, and institutional aspects will be considered. It will identify the gap between the potential and actual use of surface water for irrigation. The team will examine and evaluate the farmer-managed surface water irrigation systems and the organization of committees or agencies that supply the water. The study should highlight the constraints in the irrigation systems and opportunities for improvement.

The team will identify the irrigation potential and develop improved management systems. Considering the water availability and land suitability, the team will recommend technical, agricultural, environmental, socio-economic, and institutional solutions to increase the area and productivity of irrigation using the available surface water and groundwater. These solutions will be tested and confirmed through a pilot/demonstration project (say in the Lengura River area). The project will not necessitate large physical facilities or expensive investments.

The research should include:

- quantification of the present use, available supply, and distribution system;
- conflicts with other water users;
- process of water control and allocation among crops and farmers;
- the role of water users' association;
- the interaction between agencies and farmers;
- finance and cost recovery mechanism;
- the factors influencing farmers' choice of crops;
- seasonal water and crop production methods;

- water conveyance structures and on-farm management of water;
- adoption of non-rice crops, especially vegetables, to optimize water use and maximize production.

Optimal use of surface water necessitates the provision of reservoirs for storage in order to achieve a better distribution of water over time. Feasibility of rubber dams for small-scale irrigation control structures should be studied including the identification and mapping of potential areas to be irrigated using water from the storage.

Expected outputs include:

- Improved irrigation management systems for efficient use, equitable distribution, control of irrigation, and rational use of water at the proper time in conjunction with improved cultural practices.

- Development of farming groups for the cooperative management and effective use of surface water.

- Diversification of crops through intensive cropping of high value non-rice crops

- Improved crop production practices and better on-farm productivity through efficient management and judicious use of inputs.

- Promotion of appropriate fertilization and cropping patterns, improved crop management and cultivation practices, and efficient nutrient management.

Rationale: There are a large number of small irrigation projects in the basin. They are not operated efficiently and do not make optimal use of the scarce surface water and groundwater resources. However, little is known about how water is managed and used at the local level or what practical changes can be made to improve the situation. Therefore, research is needed to better understand these processes at the local level and to define more effective water management strategies.

Large areas in the Basin rely on perennial rivers for supply of irrigation water to crops during the winter and pre-monsoon seasons. According to the Irrigation Census of the Agriculture Sector Team, 28,920 ha of land were irrigated in 1991 using surface water.

This surface water is, however, poorly managed and used indiscriminately. Farmers in the head and middle reaches habitually take more water than they require, depriving tail end farmers and forcing them to keep their land fallow. Deliveries to farmers at the lower end are unreliable.

In some areas farmers use both surface water and groundwater to irrigate their crops. This conjunctive use complicates the delivery of surface water. The deliveries are planned and implemented without considering groundwater availability, causing shortages in some areas and excessive water use in others. Including available groundwater for irrigation would permit the irrigated area to

be increased and the available resources to be used more efficiently, as farmers use groundwater only when there is no surface water available.

Sound use of water is vital in an area where it is scarce. Equitable and efficient delivery of surface water is important for productivity of the resource and for its long-term sustainability.

Environmental evaluation:
Table 8.18 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: Efficient management and equitable distribution of the surface water will contribute to the productivity of the land and its long-term sustainability. Improvement in the use of surface water will bring substantial benefits through increasing the production and alleviating poverty in the local farming community. These changes will bring:

- more profitable opportunities in farming;
- increased output per unit area of land by means of diversifying crops, thus bringing secondary benefits to the rest of the rural economy;
- increased participation by women in high-value crop production.

Labour absorption per unit area of land will be more than doubled by growing another rice crop after the monsoon rice is harvested.

Disbenefits: There will be no negative impacts of the project.

Areas of Uncertainty: Nil

Cost: The project cost is estimated at US $ 450,000.

Implementing Agency:
Department of Agricultural Extention (DAE) working with BWDB and LGED can undertake the overall responsibilities of implementation. Physical and biological scientists can be included in the team. A foreign specialist in irrigation and on-farm water use will advise the project.

Implementation Plan:
After identifying a funding agency, the project will proceed in the following stages:

- field research in a number of existing project locations by an interdisciplinary team;
- site selection to identify a demonstration project;
- streamflow gauging for at least one dry season to confirm water availability for the demonstration project;
- site-specific studies and implementation in the demonstration project.

Table 8.18: Improved Management of Surface Water Irrigation

The objective of this initiative is to increase total irrigated land, to promote crop diversification, to adapt new technologies for intensive cropping, and to increase labour absorption per unit area of land by using available water more efficiently. It will contribute to better and more efficient use of the available surface water resources.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Increased total irrigated land	Agricultural land and production	. Increase in agricultural production (and associated food production, job opportunity and income)	+	
Extended services to farmers	Agricultural land and production	. Efficient use of scarce water resources lead to increased crop production (and associated food production, job opportunity and income)	+	

Thrust: **Expand domestic water supply and sanitation facilities**

Project: **Piped Water Supply in Kangsha Basin Urban Areas**

Purpose: The purpose of the project is to increase the population coverage of safe water users for all domestic purposes in the Kangsha Basin's urban areas through expansion of the existing piped water supply network, and to introduce the system in those urban centres where it is not available now.

Current Status

Of the Kangsha Basin's 11 urban centres, piped water supply is limited to Netrokona and Sherpur towns. The other nine urban areas are yet to receive this essential urban service.

The feasibility study conducted in 1991 in Netrokona and Sherpur towns in connection with the rehabilitation and expansion of the existing water supply and sanitation facilities reveals that only 15% of the Netrokona town population are receiving piped water supply. In Sherpur town its coverage is only three percent.

A project under the name "Eighteen District Towns Water Supply, Sanitation and Drainage Project" is now expanding the piped water supply networks in Netrokona and Sherpur towns. One of the objectives of this project is to bring 50% of these two town population under the coverage of piped water supply system by year 2000.

The project will provide Netrokona town with one overhead water tank, one production well, one treatment plant and 4.5 km of distribution lines. In Sherpur town, there will be one overhead water tank, one iron removal treatment plant and three km of water supply distribution lines.

Rationale

Safe water and sanitation are vital for the improvement of health, productivity, efficiency and quality of human environment. Though most of the population of area's urban centres are using safe water for drinking purpose, a very large percentage of them are using surface water for other domestic purposes. Surface water becomes polluted due to increasing urban population, and its use for any domestic purpose is detrimental to health.

To ensure use of safe water for all domestic purposes and better hygiene practices, running water is essential. Due to urbanisation water demand for domestic use and household sanitation has been growing rapidly, and this demand cannot be met with the existing hand pump system. Moreover, the supply of piped water is perceived to be one of the most essential urban services in today's context and will become increasingly important as urban populations increase through the planning period year 2015.

In view of these considerations, it is essential not only to expand the piped water supply system in Netrokona and Sherpur towns but also to introduce this system in the basin's other urban areas. The following conditions also favour the introduction of this facility in the other urban centres:

- Bangladesh Government is going to re-introduce *Upazila* system when these centres will be the centres for rural administration and development;
- The groundwater table is declining and shallow hand tube wells will become inoperative;
- As reported, the groundwater contains iron almost in all urban centres. It is expected that iron contents will be reduced in the piped water supply as supply will be made from deep tube wells and the water quality will be improved greatly;
- Use of sanitary latrines will increase. This requires more water at hand for flushing. Piped water supply will provide that facility;
- There is electricity in all urban centres;
- All urban centres are in the floodplain and poses no problem for laying the distribution network. Use of locally available PVC pipe reduces dependency on foreign currency.

Description

The GOB's target is to bring 50% of the population living in district towns and 10% of the population in the *thana* centres under piped water supply by year 2000.

Of the 11 urban centres of the basin, Netrokona and Sherpur towns are the district towns and the other nine urban areas are *thana* centres. The ongoing project expects to bring 50% of the Netrokona and Sherpur population under piped water supply system by year 2000. However, there is no programme to introduce this supply system in any of the *thana* centres.

The proposed project (Piped Water Supply in Kangsha Basin Urban Areas) is intended to bring 60% of the Netrokona and Sherpur town population under piped water supply, and to introduce this system in nine *thana* centres to cover 20% of the population by year 2015.

By 2015 population will be incresed to 148,000 in Netrokona and Sherpur towns and 137,000 in nine *thana* centres. To cover 60% of these population of Netrokona and Sherpur towns, and 20% of the nine *thana* centres under piped water supply system, the proposed project will require 11 production wells, 22 test tubewells, 11 pump houses including pump installation, two overhead water tanks, 60 km of pipe lines and 45 street hydrants.

The project will also address the mechanisms to ensure recovery of O&M costs, as necessary for sustainability.

Environmental Evaluation

Table 8.19 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits

The project will increase the use of safe water for all domestic purposes resulting in improvement of public health and sanitation. It will add comfort to the daily life of women who perform most of the domestic works using water. The piped water supply will provide water at hands relieving them from fetching water from outside.

Disbenefits

None

Uncertainty

None

Cost

The approximate total cost of upgrading the water supply for all 11 urban centres is US$ 4.0 million which also includes cost of social mobilization.

Implementing Agency

According to the existing institutional arrangement, DPHE is responsible for the domestic water supply in the area. However, as per a decision of the Government of Bangladesh, Netrokona and Sherpur municipalities are now taking over water works from DPHE. DPHE's role will be limited to seeing that municipalities use the infrastructures in the intended manner.

This study supports the government's decentralisation plan and recommends that the Netrokona, Sherpur and Durgapur municipalities (recently Durgapur *thana* centre has been declared as municipality) should implement this project in their respective jurisdictions. In the other eight urban centres where there is no municipality, DPHE should be the key implementing agency for this project.

However, experience indicates that service sustainability can be achieved through gradual user involvement up to full user management of services. Empowering beneficiaries with responsibility, authority and control over decisions that effect their lives will greatly improve the service conditions of this essential urban facility. Recognizing this, the study emphasizes the need for beneficiary participation including women from the beginning of the development of the system so as to develop a sense of ownership in the beneficiaries' minds. This will lead them to actively participate in the maintenance and management of the system.

Implementation Plan

A feasibility study of piped water supply for each of the *thana* centres will be required as a pre-requisite. The study in addition to other works will compute water tariffs and assess the users' willingness to pay water taxes. The study will also prepare a work programme ensuring an active participation of the beneficiaries in the programme.

Table 8.19: Piped Water Supply in Urban Areas of Kangsha Basin

This initiative is intended to expand the piped water supply system in Netrokona and Sherpur Towns as well as in the nine *thana* centres under the coverage of this system.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Increased treated piped water supply coverage	Health and welfare	. Improved health . Women's work load reduced	+	

Thrust : **Improve management of groundwater**
Expand domestic water supply and sanitation facilities

Project Name : **Rural Water Supply in Kangsha Basin Area**

Purpose: The project would support and accelerate existing programs of DPHE and UNICEF to install new tube wells for domestic water supply, rehabilitate existing tube wells, and train the local people to maintain the wells. The objectives are to ensure uninterrupted supply of safe water for domestic purposes in the Kangsha Basin along with a mechanism for community maintenance of hand tube wells. Specific targets are:

- to reduce the population/tube well ratio to the level of 120 by year 2000 and 100 by 2015;
- to motivate the people to use tube well water for domestic purposes including improving personal hygiene and sanitation;
- to motivate and train selected women members of the community to maintain the tube wells;
- to replace the No. 6 suction hand pumps by Tara pumps gradually.

History: The project was addressed as a concept in the Northeast Regional Water Management Plan. The project builds on the existing efforts of DPHE and UNICEF.

Description: It is intended to provide all people with tube well water and to reduce the number of people per tube well. The No. 6 suction lift pumps will be gradually replaced by force-mode Tara pumps in areas where suction pumps cannot reach the water table. This will necessitate installation of 8,200 new tube wells by year 2000 and another 31,000 by 2015, to meet the needs of the growing population during that periods. Existing programs of DPHE and UNICEF will be strengthened with additional funding.

The estimated number of tube wells needed by year 2000 and 2015 is summarized in the following table.

Estimates of Future Need for Public HTW[1]

Public Hand Tubewell	Number in 1991	New Installation Required	
		2000	2015
No. 6 suction lift	11,873	1,970	22,159
Mini Tara		5,937	3,953
Tara	1,433	252	4,928
Total	13,306	8,159	31,040
Population per HTW	121	120	100

Note: Estimates include rural areas and urban areas which are not serviced by piped water systems.

As women are the main drawers and users of water, their involvement in the selection of tube well sites and their maintenance is imperative. It is also necessary that they have access to maintenance funds and the freedom to use the funds as required. The project includes formation of female maintenance crews, supply of maintenance kits, and training for maintenance.

The program will expand existing DPHE and UNICEF programs with additional funding to meet the targets and timeframes for the Basin.

Rationale: Existing domestic wells will need to be deepened and the pace of constructing new wells will need to be accelerated to meet the targets of GOB. Most of the HTWs that are used for domestic water supply in the Basin are shallow and often run dry in winter. They are also vulnerable to surface contamination.

There were an estimated 13,300 domestic tube wells in the Kangsha Basin in 1991/92, yielding an average of one public tube well per 121 persons. The GOB target is one well to serve 100 persons.

Most (95%) of the HTWs in the Basin have No. 6 suction pumps. These have shallow lift capacity. Shallow suction pumps will need to be replaced with deepset force-mode (Tara) pumps which can lift water from greater depths. About five per cent of the tube wells in the Basin are not functional. These conditions will further degrade as more groundwater is being used for irrigation.

The project addresses one of the most pressing human development concerns in the region. The project is in line with the national goal for *health for all by year 2000*. It will complement an ongoing programme at the national level and is not intended to duplicate efforts. However it may take a long time for the existing

programme to be implemented under the existing institutional and financial arrangement.

Environmental Evaluation Table 8.20 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: Universal coverage of potable water for drinking.

Achieving a population-public tube well ratio of 100:1 in 2015 compared to 121:1 in 1991.

Uninterrupted supply of potable water by installing Tara pumps where the water table is lower during the dry season, especially where it is affected by irrigation withdrawals.

Year-round maintenance of public hand tube wells by integrating community management.

Improved public health and sanitation.

Benefits accrue directly to the primary target groups: the poor, landless, and women.

Disbenefits: Nil

Areas of Uncertainty:

The pace of installation will need to be tailored to the unplanned installation of tube wells for irrigation.

Cost: US $ 5.14 million over 20 years.

Implementing Agency:

The DPHE will be the key implementing agency. Local self-help groups (cooperative societies and NGOs) would be involved in the work of mobilization, motivation, and maintenance.

Implementation Plan:

A study in some detail, say at a feasibility level, should be taken up for the region to coordinate funding and implementation with DPHE and select program areas. Following completion of the program design and confirmation of funding the project should proceed directly to implementation without further study.

Table 8.20: Rural Water Supply
This initiative is intended to improve rural water supplies.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Upgrading of hand tube wells	Health and welfare	. Availability of safe water for all domestic purposes leading to improved health . Women's work load reduced	+	

Thrust: **Expand domestic water supply and sanitation facilities**

Project: **Kangsha Basin Urban Sanitation**

Purpose: The purpose of the project is to increase hygienic sanitation coverage in urban areas of Kangsha Basin, and to introduce piped sewer systems in Netrokona and Sherpur towns.

Current State of Sanitation Sanitation facilities in all 11 urban centres of the Kangsha Basin are limited to septic tanks, sanitary pit latrines, pit latrines and surface (water) latrines. There is no piped sewer system in any of the urban centres of the study area.

The feasibility study conducted in 1991 in Netrokona and Sherpur towns in connection with the rehabilitation and expansion of the existing water supply and sanitation facilities reveals that only 38% of Netrokona town people use hygienic sanitary latrines (sanitary pit latrine or septic tank). About 10% use a moderate quality facility (pit latrine), 33% have poor sanitary facilities (surface latrine) and 19% of the population have no facilities at all.

In Sherpur town, the study finds that only 40% of the population use safe sanitary facilities and 6% use moderate quality facilities. Surface (water) latrines serve about 25% of the population. The remaining 29% of the population have no facilities at all.

The sanitary conditions in the nine *thana* centres are even worse. According to 1991 BBS data, only 18% of the population avail safe sanitary facilities, 56% use non-sanitary latrines and the remaining 26% of the population do not use latrine at all.

A project under the name of "Eighteen District Towns Water Supply, Sanitation and Drainage Project" is under implementation in Netrokona and Sherpur towns. One of the objectives of the project is to bring 75% of the population of these two towns under safe sanitary facilities by year 2000.

Under the project, there is a provision to supply 2167 sets of double direct pit latrines in Netrokona town and 3375 sets in Sherpur town at a subsidized rate to the poorer section of the town population.

Rationale Safe water and sanitation are vital for the improvement of health, productivity, efficiency and quality of human environment. During the last decade, Bangladesh has achieved great success to provide safe water for its people, but the full health benefit of improved access to safe water has not been realized because of general un-sanitary environment and apathy of people towards hygienic practices and excreta disposal. Morbidity and mortality from water and excreta related diseases persist at a high level.

Despite concerted efforts, sanitation coverage remains as low as 40% in the two district towns and 18% in the nine *thana* centres. So, there is much scope to expand such facilities to the remaining 60 percent in the two district towns and 82% in the nine *thana* centres. As the urban population continues to expand, the need for improved sanitation facilities will become ever more pressing.

Description

The national target of Government of Bangladesh for sanitation is to bring 80% of the population under safe sanitary facilities in district towns (10% under sewerage system, 40% under septic tanks and 30% under sanitary pit latrines) and 70% in *thana* centres (30% under septic tanks and 40% under sanitary pit latrines) by year 2000.

The ongoing project is expected to bring 75% of of the population of Netrokona and Sherpur towns, the two district towns of the area under safe sanitary facilities by year 2000. This project has no provision for introduction of piped sewer system in Netrokona and Sherpur towns.

The project being proposed here is to bring 90% of the population of Netrokona and Sherpur towns under safe sanitary facilities introducing piped sewerage system to serve 10% of the population and increasing the sanitary pit latrine numbers to serve 40% of the population by year 2015. It is assumed that septic tanks to be built under individual house owners' initiatives will serve 40% of the population.

In the other nine urban centres which are *thana* centres, the proposed project is intended to bring sanitation to 80% of the population by year 2015, covering 50% of the population through supply of sanitary pit latrines at a subsidized rate to the poorer section of town people. It is assumed that another 30% of the population will be served with septic tanks constructed by individual house owners.

By year 2015 the population in the 11 urban centres of the Kangsha Basin will be increased to 285,000. The proposed project will bring about 15,000 people in Netrokona and Sherpur towns under a piped sewer system and another 46,000 people in all 11 urban centres under safe sanitary pit latrine service. This will require 10.0 km of sewer lines, two sewage pumping stations, desludging equipments and 8,400 sanitary pit latrines.

Environmental Evaluation

Table 8.21 presents the potential impacts and consequences of the project as well as the feasible mitigative measures

Benefits

The proposed project will improve the quality of human environment and health, and reduce excreta related diseases.

Disbenefits

None

Uncertainty

None

Cost

Approximate cost is US$ 500,000 over 20 years. The cost includes US$ 250,000 for development of sewerage system in Netrokona and Sherpur Towns, GOB subsidy of US$ 225,000 (at US$ 27.00 per unit) for the hygienic pit latrine and the promotional cost at US$ 25,000 on advocacy, social mobilization, information transfer etc.

Implementing Agency

According to the existing institutional arrangement, DPHE is responsible for safe sanitation management in the area. As part of GOB's decentralisation plan, the Netrokona and Sherpur municipalities are taking over water and sanitation works from DPHE. DPHE will provide technical advice to them.

This study supports government's decentralisation plan and recommends that the proposed project be implemented by the Netrokona, Sherpur and Durgapur municipalities (Durgapur town though a *thana* centre has been declared as municipality). In the other eight *thana* centres, DPHE will be the key implementing agency.

However, achieving improved coverage in sanitation interventions depends to a large extent on the motivation of the people and this in turn will depend on commitment at all levels. Advocacy at the highest political, social and religious levels through seminars, workshop, meetings and media coverage is an essential first step in order to heighten awareness about sanitation as a major priority. This should be complemented by a strong social mobilization thrust, using multi-sectoral channels such as different NGOs, Ansar-VDP, health and family planning workers, women's groups, religious leaders, teachers and students, etc.

This study recognizes that social motivation is the key to the success for the improved coverage in sanitation. The role of women in sanitation must be emphasized. It is a known fact that it is the women who are directly involved in household sanitation. As such, the study expects that the key implementing agencies will ensure the active participation of women in the mobilisation for sanitation.

Implementation Plan

A feasibility study will be required to identify the area to be served with a piped sewer system, to develop design and cost estimate for engineering works, and to prepare a work programme detailing the people's involvement in the programme.

Table 8.21: Kangsha Basin Urban Sanitation
This initiative is intended to bring 90% of the population of Netrokona and Sherpur and 80% of the population of nine *thanas* centres under hygienic sanitation by year 2015.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Provide sewerage systems, septic tanks and safe sanitary pit latrines	Health and welfare	. Improved health	+	

Thrust: **Expand domestic water supply and sanitation facilities**

Project: **Kangsha Basin Rural Sanitation**

Purpose: The purpose of the project is to provide a hygienic latrine in every household in the rural areas of Kangsha Basin, educate traditional latrine users to change to hygienic units, and motivate those who are not using latrines now.

Current State of Sanitation According to 1991 BBS data, out of 291,000 households in the rural areas of the Kangsha Basin, only 8,300 households (less than 3%) have sanitary latrines. About 53% households use surface (water) latrines and the remaining 44% have no facilities at all.

As seen from the BBS data, about 56% of the rural population of the Kangsha Basin are using latrines although 53% of these are unhygienic. This does indicate, nonetheless, that a large percentage of the population is conscious about the use latrines.

Rationale During the last decade, Bangladesh sucess in the field of water supply has been very impressive. Over 80 percent of the rural population have access to tubewell for drinking water, but the full health benefit of improved access to safe water has not been realized because of general unsanitary environment and apathy of people towards hygienic practices and excreta disposal.

Safe water without sanitation and good hygiene habits cannot be expected to reduce the incidence of diarrhoeal diseases or the resulting mortality. An ICDDRB/UNDP/World Bank study in Bangladesh shows that a 25% reduction in incidence of diarrhoea in children under 5 is possible where there is one hand pump available for 50 users and every family has a sanitary latrine.

Description The Government's goal by the year 2000 is "a latrine in every household". Under the current government programme supported by UNICEF, a subsidy of Tk 130 representing 60 percent of the cost, is granted on the sale of a one- slab and one-ring unit at the DPHE centre.

To achieve GOB's goal of providing "a latrine in every household", a veritable "revolution" in the field of sanitation is needed, given the present coverage of less than three percent only. One of the pre-requisites for the success of this revolution is the application of low-cost and appropriate technologies. Against a background of poverty permeating up to 80 percent of the population, the 'need' has to be backed by technology which is both acceptable and affordable by the community. The 'one- slab and one-ring unit', even when subsidized, will be beyond the affordability of a majority of the people. While retaining this as a possible option, the backbone of the sanitation revolution will be the 'homemade'

latrine using indigenous bamboo and timber. Experience to-date have demonstrated that home-made simple pit latrines using bamboo/timber as construction materials, if built correctly, are hygienic, acceptable and affordable, even to the poorest sectors of the community. The upgraded technology of the 'one- slab and one-ring unit' can be adopted by those who can afford it, or as a subsequent improvement to the home-made design.

The use of low-cost appropriate technologies is not sufficient to ensure improvement in sanitation. Users of traditional latrines and those who do not use latrine at all need to be educated and motivated.

By year 2015 there will be 400,000 households in the rural areas of the Kangsha Basin based on an annual population growth rate of 1.3 percent. Assuming that 16,000 households have currently hygienic latrines (1996), then by year 2015 there will be a need for 384,000 latrines.

This project proposes to supply 200,000 concrete sanitary pit latrines to the rural people at a subsidized rate assuming that the remaining 184,000 units will be home-made simple pit latrines using bamboo/timber.

This project also proposes a massive social programme to create an awareness in the minds of the people about the importance of sanitation and motivate them to use hygienic latrines.

Environmental Evaluation Table 8.22 presents the potential impacts and consequences of the project as well as the feasible mitigative measures

Benefits The project will improve health, productivity, efficiency and quality of human environment, and reduce incidence of diarrhoeal diseases.

Disbenefits None

Uncertainty None

Cost Approximate cost is US$ 1.4 million over the next 20 years. The cost includes a GOB subsidy of US$ 0.8 million (at US$ 4.0 per unit) and a promotional cost at US$ 0.6 million on advocacy, social mobilization, information transfer etc. It is recommended to retain the subsidy. Without subsidy the lower and middle income groups who are its main beneficiaries will find it more difficult to acquire the concrete units. The subsidy would also facilitate the transition from the home-made to the higher level technological option.

Implementing Agency According to the existing institutional arrangement, DPHE is responsible for hygienic sanitation in the area. Its responsibility is limited to the sale of a one-slab and one-ring unit at a 60 percent subsidized rate.

This study also recommends that DPHE be retained as the government agency for implementing this project but that an NGO should also be involved in this task for social motivation and mobilisation.

Implementation Plan

Once the fund is made available, project implementation may go ahead without any further study. As the project's success depends to a large extent on the motivation of the people, an elaborate social mobilisation programme should be designed using multi-sectoral channels such as different NGOs, Ansar-VDP, health and family planning workers, women's groups, religious leaders, teachers, students, etc.

This study recognizes that women are directly involved in household sanitation and as such strongly recommends that they should be actively involved in the mobilisation for sanitation.

Table 8.22: Kangsha Basin Rural Sanitation

This initiative is intended to provide one sanitary latrine for each homestead in the rural areas of the Kangsha Basin by year 2015.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Provide safe sanitary pit latrines and social mobilization to use pit latrines	Health and welfare	. Improved health	+	

Thrust: **Improve management of groundwater use**
Expand domestic water supply and sanitation facilities

Project Name: **Baseline Groundwater Quality Survey**

Purpose: The purpose of this project is to implement a water quality monitoring program of the area's groundwater used for drinking and irrigation.

History: Groundwater quality monitoring in the area has been rather sporadic and few samples are available. DPHE and BWDB are presently monitoring the quality of groundwater in the area. DPHE's water quality activities are concentrated in Sherpur and Netrokona

Arsenic contamination in the groundwater of the western part of Bangladesh is a serious health hazard. Current figures for people at risk of arsenic poisoning range from 10 to 50 million. A likely origin of the contamination is a 450 km stretch of pyrite deposit containing arsenic located in West Bengal. This deposit was inactive until farmers began to pump out huge amounts of groundwater for irrigation in the 1980s. As the water level falls, the pyrite oxidizes and releases arsenic in the ground. A likely cause of arsenic contamination in West Bangladesh is seepage of contaminated water from this source.

As a result of this contamination, DPHE recently analyzed samples taken from 4 (four) hand tubewells in the Kangsha Basin's Mymensingh and Netrokona areas and found levels of arsenic below 0.01 mg/l. The number of samples is too small to draw definite conclusions.

Description: The objective of this initiative is to monitor possible toxic contamination in the groundwater used for irrigation and also to monitor both bacterial and toxic contamination in urban and rural drinking water.

The program will test a number of irrigation wells for toxic contamination. This requires testing the samples in Khulna where DPHE has adequate testing equipment.

In rural areas, the program will primarily include testing of new tubewells for bacterial contamination. These tests may be performed by the DPHE Engineer. In addition, a number of existing wells will be tested at the DPHE Khulna facilities for toxic contamination such as arsenic, fertilizers, etc.

In urban areas, all existing tubewells will be initially tested for toxic contamination as well as all new tubewells. In addition, a program will include a capacity development component to ensure that DPHE will carry on with the monitoring of bacterial contamination once the project is phased out. A long term bacterial contamination monitoring program is necessary in urban areas as the groundwater quality may deteriorate rapidly as the urbanization rate accelerates.

The project will supply equipment for bacterial contamination testing.

Rationale: Virtually all the population of the basin use groundwater for drinking. Groundwater is also intensively used for irrigation. The presently available analytical data is insufficient to produce a comprehensive and meaningful picture of the groundwater quality for drinking and irrigation purposes in the basin.

There are two major concerns as regards quality of drinking water. These are:

- bacterial contamination (E-Coli); and,
- arsenic level

Except in limited areas in Sherpur and Netrokona towns, people of the area use hand tube wells to withdraw groundwater for drinking purpose. Most of the hand tubewells are situated in the water table in the vadose zone (surface aquilude). Due to poor sanitary conditions, the water table in the vadose zone is subject to bacterial contamination (E-Coli) and may present serious health hazards.

Moreover, groundwater is being constantly contaminated by the use of fertilisers, biocides and industrial effluent. Area's groundwater could also contain heavy metals that harm soil fertility and impact negatively on environment.

Environmental evaluation:
This initiative presents no negative impact.

Benefits: Monitoring of groundwater quality will detect any possible contamination and help to take necessary treatment measures, thus ensuring a supply of good quality water that is pre-requisite for human health. It will also provide warning for possible deterioration of soil fertility and environmental hazards.

Disbenefits: No disbenefit.

Areas of Uncertainty: Nil

Cost: Total cost of one-year programme is estimated to be US$ 2.0 million composed as follows:

- samples collection, analysis and reporting: US$ 1.0 million
- capacity development and equipment supply: US$ 1.0 million

Implementing Agency: DPHE

Implementation Plan:
An inception report is required to assess the number sample points, water quality parameters to be tested and cost estimates.

Thrust: **Protect and enhance natural areas**

Project Name: **Social Forestry**

History: Activity being implemented in some parts of the region by NGOs with assistance from the Forest Department.

Purpose: The purpose is to improve the ecological balance with more tree cover involving poor and destitute women where the participants get some tangible benefit in their life time.

Description: The project involves plantation of 440,000 trees along 300 km of roads, embankments and railway. This involves 50 km of highway, 150 km of feeder road, 50 km of embankment and 50 km of railway. Number of saplings to be planted has been estimated as per the guideline of the Forest Department.

Site	Length (km)	Saplings/km	Total saplings
Highway	50	1,600	80,000
Feeder road	150	800	120,000
Embankment	50	2,400	120,000
Railway	50	2,400	120,000
Total	300		440,000

Already several national and local NGOs are involved in this program in the region. BRAC is one of the pioneers in this field. It is involved mainly in mulberry plantation which has been integrated with BRAC's employment generation program around sericulture. Other NGOs help groups to plant trees of different species related to fuel, fruit and timber.

Environmental evaluation:
Table 8.23 presents the potential impacts and consequences of the project as well as the feasible mitigative measures

Rationale: With increasing population and increased demand for bio-mass, tree plantation has become a necessity. This is particularly true for the region where forestry resources are scanty. Homestead forest has been the largest source of fuel, timber and house construction materials for the people which meets as much as 70% of the demand for domestic use. With increasing population, continuous fragmentation of homestead platforms, rapid urbanization and changing pattern of land use, tree cover in rural Bangladesh has sharply declined. In this backdrop, the concept of social forestry has evolved. Here, afforestation is no more the exclusive domain of the Forest Department in reserved areas. The whole community is involved in the process.

Benefits: With increased tree cover, the state of the environment will improve. It will add income to the members of the community, supply fuel wood, timber and house

construction materials.

Disbenefits: Nil

Areas of Uncertainty:
Nil

Cost: US$ 2 million

Implementing Agency:
Local community; NGOs will facilitate the programme.

Implementation Plan:
An institutional mechanism has already been developed to steer the process where the Forest Department, the land providing agency, the sponsoring organization and the community have been made partners. Within the framework of this concept, sides and slopes of all roads and dikes will be brought under the purview of the program. For this, contractual agreements are needed with the agencies which own these roads and dikes. Among these are the R&H, BWDB, LGED and Railway. Benefit sharing arrangements as per the guideline of the Forest Department are as follows:

Involved parties	Benefit Share (%)			
	Land Providing Agency			
	R&H	BWDB	LGED	Railway
Land Providing Agency	10	10	0	10
Union Parishad	5	5	20	5
Forest Department	10	10	5	10
NGO	10	10	10	10
Beneficiary group	65	65	65	65
Total	100	100	100	100

The landless and poor women have been particularly targeted to implement the program. One woman caretaker will look after a stretch of 200 meters. In total, 1,500 poor families will become direct beneficiaries.

The NGOs will organize poor women's groups, make linkages with other agencies, negotiate with agencies who own land, mobilize technical and financial resources for implementation of the program and monitor the post-plantation activities. Members of the community plant trees look after them, own them and derive benefits directly from them.

Netrokona district will be covered as a case for intensive plantation. The program involves a period of 3 years. Year 1 will for formation of beneficiary groups, site selection, and training. Year 2 will be for plantation and monitoring. Year 3 will be for monitoring and necessary adjustment for improvement.

Table 8.23: Social Forestry
The objective of this initiative is to improve the ecological balance with more tree cover in the Basin area and generate income for destitute women.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Tree plantation	Ecology	Improved ecological balance; arrest deforestation	+	
	Economy	Significant economic income especially for destitute women through sale of timber wood and fuel materials	+	

Thrust:	**Protect and enhance natural areas**
Project Name:	**Conservation of Biodiversity**

Purpose: The project consists of a package of activities aimed to protect and enhance the biodiversity of the Upper Kangsha River Basin area. They would help identify areas having high biodiversity, representative habitat types, important areas for threatened wildlife species, and development of a conservation and management plan for wildlife of the area. An education programme will help to create and increase public awareness on issues related to conservation and enhancement of biodiversity and to move towards sustainable utilization of natural resources.

History: The program is an implementation of initiatives proposed under the Northeast Region Environmental Management, Research, and Education Centre (NEMREC) in the Regional Development Plan.

Description: The project is designed to highlight the importance of biodiversity in the ecosystems of the Kangsha Basin and will improve the understanding of the local people of the benefits and services received from the various ecosystem types.

The project presents a holistic strategy for long-term protection and enhancement of the environment. Some ground work has already been carried out by the NERP team but needs further action planning to address the issue. Some activities include:

- Develop an institution composed of a dynamic and dedicated multi-disciplinary team responsible for the protection and conservation of biological resources.
- Select areas of high biodiversity value within the Basin and bring them under protection within the framework of existing legislation.
- Identify degraded areas and restore them or take measures to arrest further degradation.
- Initiate plantation programs of indigenous plant species.
- Develop non-formal education packages and training manuals for educating and training local people in the field of conservation.
- Initiate captive breeding programmes of locally-important and internationally threatened animal species.
- Enforce wildlife protection laws and monitor commercial utilization and local consumption of wildlife resources.

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If wild resources are to be managed and their use moved toward sustainability for the benefit of national economies and local needs, then those charged with their management must address many issues. These issues are as wide-ranging as international treaties, domestic policy and legislation, rural community empowerment to manage natural resources, law enforcement, and research and monitoring. Such a holistic approach is difficult but necessary.

Rationale: The natural environment of the Kangsha Basin has experienced serious degradation due to increasing pressures of human use. Wetlands are virtually extinct and a large number of plant and animal species are seriously threatened.

The project area supports 265 species of wildlife representing amphibians, reptiles, birds, and mammals. There has been wide-spread alteration of habitat, loss of wetland area, lack of vegetated area, and lack of perching/roosting areas for colonial birds and large raptors. There is a general lack of public awareness of the values and needs of these animals in the ecosystem. All these obstacles make the task of wildlife management difficult but this challenge should be taken up to restore and conserve biodiversity for the benefit of the human species.

Many plant and animal species are used by destitute people for subsistence. Several wildlife species are economically important too, for example, bull frog, varanus lizard, and common otter; hence increasing their population may be directly beneficial to certain sections of the community. Breeding programs can increase local employment opportunities and nutritional intake.

Several wildlife species act as biological pest controllers. For example the decrease in the population of frogs accelerates the increase in crop pests. Snakes and owls are important to control the rodent population.

The Basin supports some representative habitat types which if not cared now will be irreversibly transformed. Moist deciduous forest, dominated by *sal* (Shorea robusta), is the only forest found in the Basin. Grasslands have virtually gone, with only a few places (less than an acre) reminiscient of the lush past.

Several internationally threatened wildlife species, such as Pallas's Fish Eagle and Bengal Fox, inhabit the Basin area. These species have become locally restricted because of large scale alteration to their habitat resulting from increased human activities. Studying their biology and protecting representative habitats may allow them to survive.

Resource development must recognize that conservation and development are both necessary and interdependent. Conservation and development that build on and seek to learn from existing systems of resource management are more likely to succeed than activities which are proposed and sometimes imposed from outside.

Environmental evaluation:

Table 8.24 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: Establishment of protected areas to continue the natural heritage of the Basin.

Protection and sustainable utilization of the renewable natural resources.

Confirmation and improvement of the GOB's compliance with the various international conventions to which the government is signatory (such as CITES and the Biodiversity Convention).

Increasing the population of endangered and threatened species and other wildlife in general, thus increasing the diversity of the ecosystem and habitat.

Increased employment opportunities and nutritional intake among the local people resulting from initiation of captive breeding programmes.

Creation of opportunities for development of wildlife tourism.

Disbenefits: The project may result in socio-economic losses by depriving local users of traditional resources through protective measures.

Social conflict and loss of resources may occur through in-migration of people seeking resource extraction opportunities.

Areas of Uncertainty:

Some difficulties may arise from forbidding local people from using protected areas for activities such as grazing cattle and collecting fuel. However, opportunities for local employment will increase since the whole effort is to involve the local people in the conservation activities.

Cost: US $ 5 million

Implementing Agency:

Ministry of Environment and Forest

Implementation Plan:

An inception report is required stating the scope of work and detailed cost cost estimate.

Table 8.24: Conservation of Biodiversity

The intention of this initiative is to protect and enhance the biodiversity of the Upper Kangsha River Basin area.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Protected area designation	Employment and economic activity	. Socio-economic losses by depriving local users of traditional resources through protective measures	M	. Job opportunities through the project should go to local resource users . Resources managed on a sustainable basis and local economies developed on their base
	Fish habitat and production	. Loss of resources through poaching	M	. Resource ownership / custodianship arrangements . Public awareness
Protected area management	Biodiversity	. Improved biodiversity with stable and healthy populations of economic species	+	
	Employment and economic activity	. Income opportunities on a sustainable basis	+	
	Social harmony	. Social conflict and loss of resources through in-migration of people seeking resource extraction opportunities	H	. Similar resource management activities elsewhere . Enforcement and penalties

Thrust:	**Expand agricultural production** **Protect and enhance natural areas**
Project Name:	**Pilot Studies for Buried Land**

Purpose: Rehabilitate lands in the piedmont plain which are degraded by the deposition of sandy alluvial soil.

History: This is a new project identified during the study of the Kangsha Basin Water Management Plan.

Description: A program of field trials is included to improve fertility and to establish appropriate uses of land buried in sediments. The work will include the following activities:

- identify land that has been affected and classify the degree of degradation;
- select lands of varying degree of degradation for a series of demonstration trials;
- identify appropriate plant species and crops that can survive the deprived moisture and nutrient regimes;
- carry out discussions with selected groups of cultivators from different ownership classes. In consultation with the cultivators select persons who would like to participate in the program.

For each plot of land a locally appropriate rehabilitation strategy will be developed using existing agricultural and land enhancement technology, in consultation with local people and the land owner. This will involve the identification of techniques needed to improve fertility, soil structure, organic content, and other properties. These techniques will be applied and monitored for two to three years to confirm their effectiveness. Results will be provided to local agricultural workers so that the rehabilitation methods can be applied in other locations.

Methods of land development and management will be developed and soil management trials will be made to test different techniques for bringing the sandy land under comprehensive cultivation.

The program will support and strengthen the efforts of BWDB, Soil Resource Development Institute (SRDI), Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI) and international research institutes working on soil resource management issues to address this problem.

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Rationale: Seasonal floods carry huge volumes of coarse sediments from neighbouring hill areas. These sediments are deposited in the piedmont plain and in the lowlands where the piedmont rivers spills their flood waters. They also occur where flash floods spill into lowlands filling up water courses, ponds, and other low-lying land. A large part of the piedmont plain has been degraded in this way. The problem is likely to increase with continued clearing of the forest in India increasing the runoff of sediment.

The sandy sediments have low organic content and do not retain moisture well; they are low in fertility and this makes it difficult to grow traditional crops on the land. The result is that the land is often abandoned to agriculture.

There presently exist many procedures and cropping strategies which could be used to bring the land back into productivity. These include green manuring, composting, and others. While these techniques are known in a general way no work has been done to identify the particular practices that would best suit the situation of the Kangsha piedmont plain. No work has been done to evaluate the social suitability of these techniques or to introduce them to the local NGOs or farmers.

The present proposal anticipates pilot studies to demonstrate these methods. The proposal does not anticipate large physical facilities or expensive technologies.

Environmental evaluation:
Table 8.25 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: The project will increase soil productivity while conserving the soil, will bring sandy land under cultivation, and will protect soil from the ecological hazards of increased degradation in a large area of the Kangsha Basin. It will contribute to improved habitat of physical and biotic complexes. It will reduce ecological hazards by stabilizing newly-deposited soils against further erosion.

Disbenefits: There will be no negative impacts of the project.

Areas of Uncertainty: Nil

Cost: The project cost is estimated at US $ 300,000.

Implementing Agency:
It is suggested that the Soil Science Division of the Bangladesh Agricultural Research Institute (BARI) might be an appropriate agency to undertake this work. BARI could work through a local NGO especially in extending the work to the poorest of the local landowners.

Implementation Plan:
Once funding is secured a more detailed analysis of program design should be made, followed by implementation of the project in selected areas.

Table 8.25: Pilot Studies for Buried Land
The primary objectiveof this initiative is to develop strategies for crop production and revegetation in the sand buried land in the piedmont plain.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Project implementation (although a research activity, the project will lead to operational projects that will have impacts)	Agricultural land and production	. Improved biological productivity (and associated food or tree production, job opportunity and income)	+	

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Thrust: **Expand agricultural production**

Project Name: **Farming Systems Development**

Purpose: The objectives of the project are:

- to develop a farm production system for the diversification of agricultural production taking into account the changing hydrologic regimes introduced by flood protection;
- to assist and enable farmers to apply the improved farm production system on their own farms.

History: The Northeast Regional Water Management Plan proposed an initiative to develop improved farming systems in the region.

Description: The project would consist of:

- on-farm research to define the problems and develop appropriate methodologies and crops for improved farm management consistent with local hydrologic conditions, socio-economic conditions, support services, land capability, and local farming practices;
- pilot farms at several locations to select and confirm the recommended crop practices and to demonstrate the technology to area farmers.

A study team composed of physical and biological scientists and socio-economic specialists would be created. The team will examine the physical, technical, institutional and socio-economic constraints in the project area. Exploratory and informal surveys will be carried out to establish a baseline condition and to identify the constraints and opportunities. Studies would be done in existing flood-control areas (Kangsha and Thakurakona Projects) and proposed project areas (Dampara and Konapara Projects).

Possible improved farming practices to be evaluated include:

- expansion of improved local rice varieties and cropping systems;
- introduction of more high-value added and labour-intensive crops;
- more intensive livestock production with medium-scale cattle farming;
- increase in the forage and green fodder production;
- diversified homestead gardening;
- greater poultry and duck production;
- improvement of rice-fish culture with increased reliance on more productive fisheries;
- increased production of lowland products;
- improved processing, preservation, storage and marketing.

Farming systems would be developed upon existing farmer practices, knowledge, and resources, and would deal with the whole-farm system and low-input management. Small-scale farmers would be specifically targeted in various integrated activities. The project will not involve large facilities or expensive investments.

The recommended farming systems will be tested on the farmer's field through on-farm trials, multi-location testing, and pilot production programs. Extension services will be involved in these programmes. The on-farm trials and multi-location testings will offer opportunities for working-level contacts between research and extension workers.

Rationale: Improved farming systems are needed to help increase and stabilize agricultural production through better use of natural and human resources. Farmers lack sufficient knowledge of appropriate modern farming technology. Little attention has been paid by planners to the whole farming systems in the Basin area, to development of farming systems suited to local flooding conditions, or to farmers' need of appropriate technologies for all aspects of the agricultural production system. On-farm trials are needed to effectively transfer information on existing technologies in a manner that is appropriate and acceptable to farmers in the flooded area.

The project would support and enhance existing programs of BARI and BRRI. A number of projects for farming system research (FSR) have been undertaken by BARI and BRRI. However none of these FSR sites or sub-stations are located within the Kangsha Basin and none of the programs are targeted specifically toward the changing hydrologic regimes which occur after FCDI projects are implemented.

Environmental evaluation:

Table 8.26 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: The project will create more sustainable agricultural systems and protect biodiversity. It will help small and marginal farmers to increase the productivity of their land.

The project will contribute to the diversification of land use. Diversification of agriculture and protection of biodiversity will lead to better management and utilization of resources and thus to increased food production and stability of food production. This will lead to a large number of socio-economic benefits.

The project will strengthen the national capacity for agricultural research which is essential for the support of national agricultural development efforts. It will also strengthen the ability of BWDB to incorporate agricultural improvement programs into future FCDI projects.

Disbenefits: There will be no negative impact of the project.

Cost: The project cost is estimated at US $ 1 million.

Implementing Agency:

Land and Water Use Directorate of the BWDB would undertake overall responsibility for coordination and management. BWDB is the agency most knowledgeable about the hydrologic changes that will occur after flood protection and has the most direct interest in promoting expansion of agriculture in the project area.

Other agencies that would be involved include:

- On-farm Research Division (OFRD) of BARI, BRRI;
- Bangladesh Agricultural University (BAU);
- Department of Agricultural Extension (DAE);
- Bangladesh Livestock Research Institute (BLRI);
- Department of Livestock Services (DLS);
- Fisheries Research Institute (FRI);
- Directorate of Fisheries (DOF);
- Bangladesh Forest Research Institute (BFRI);
- Soil Resources Development Institute (SRDI).

Implementation Plan:

Upon identification of a source of funding a management committee of the various agencies would be created. Appropriate professionals would be committed to the project under the leadership of a farm management specialist experienced in agricultural development and flood control projects.

Table 8.26: Farming Systems Development
The objective of this initiative is to improve farming systems in seasonally flooded areas.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Implementation of more appropriate farming systems in the flood protected area	Agricultural land and production	. Improved productivity of both cereal and non-cereal (and associated food, job opportunity and income)	+	
	Employment and economic activity	. Improved productivity will generate more employment and income	+	
	Biodiversity	. Crop diversification may contribute to biodiversity protection	+	

Thrust: **Improve Water Transport**

Project Name: **Dredging in the Lower Kangsha Basin Rivers**

Purpose: The purpose is to provide a year-round waterway connection between Jaria and Kalmananda and the rest of the country through improvement of the Updakhali River and the Ghulamkhali branch of the Kangsha River. A minimum draught of 1.5 m would be provided to pass larger country boats.

History: New project identified during preparation of the Water Management Plan.

Description: The project work involves dredging a 6.0 km reach of Updakhali River and a 25 km reach of the Ghulamkhali River near Madhynagar to a depth of 1.5 m over a width of 50 m. Figures 25 and 26 show the extent of the works. Local dredging of shoals may also be required.

Dredge spoil will be used for construction of homestead platforms.

Rationale: Although road transport is becoming increasingly important in the Basin area, river transport remains an important and cost-effective means of transporting bulky materials. However dry-season navigation is affected by low flows and shallow draught in most of the rivers including the lower Kangsha and Updakhali Rivers, which effectively cuts off the Basin area from the rest of the country for several months of the year. Conditions will worsen, especially in the Ghulamkhali River, with the on-going shift in Someswari River discharges away from the Kangsha River.

Kalmakanda and Jaria are important commercial hubs located on the two rivers. They have good river connections with the rest of the country except for short sections on the Ghulamkhali and Updakhali Rivers which are shallow in winter. With relatively minor channel dredging programs, year-round waterway connections can be established.

The project will reduce transportation cost. Large country boats cannot reach Kalmakanda and Jaria in winter due to insufficient depth of water. Goods are transferred from smaller boats to the large country boats and as a consequence the transportation costs increase.

The ports of Jaria and Kalmakanda are located at the upstream limit of backwater from the Sylhet Basin and the limit of dry-season waterway transport.

Environmental evaluation:

Table 8.27 presents the potential impacts and consequences of the project as well as the feasible mitigative measures.

Benefits: Decreased transportation costs will benefit the farmers and fishermen of the area and especially poor people who rely on waterways for transportation.

Homesteads platforms can be built from the dredged spoil.

The work will revitalize Kalmakanda Inland Port, one of the important inland ports and commercial centres of the project area.

Disbenefits: The dredging activity may cause temporary and local disruption of water quality and fish habitat.

Disposition of spoil would result in loss of agricultural land.

Areas of Uncertainty:

It is not certain how long the dredged reaches can be left clear from siltation once the dredging is completed. Maintenance dredging may be required.

Cost:		
	Updakhali channel dredging	US $ 1.0 million
	Ghulamkhali channel dredging	US $ 4.0 million

Implementing Agency:

Bangladesh Inland Water Transport Authority.

Implementation Plan:

A pre-feasibility study would be required for the Ghulamkhali Khal dredging program, for three reasons:

- it involves a considerable cost, and there is inadequate information regarding traffic demand; thus the project may not be economically feasible;
- an alternative, to dredge Dhonakhali River, requires more than twice the excavation but provides a more direct route to Dhaka and therefore needs to be considered in some detail;
- road transport is available to Thakurakona and Jaria, the two ports that would be mostly served by this alternative, and the road/river split of traffic is not well enough defined at the present time.

The suggested dredging program for Updakhali Khal may go directly to feasibility study as it is limited in scope, has a clear purpose, and there is no alternate program to consider. The feasibility study should include the following aspects:

- River traffic survey to assess quantities of goods transported through this route;
- Engineering survey and design for cost estimate;
- Evaluation of sediment quality;
- Identification of spoil disposal sites and possibilities of using this spoil for construction of homestead platforms;
- Timing of dredging to ensure minimal disruption of fisheries.

Table 8.27: Dredging in the Lower Kangsha Basin River
This initiative is intended to improve navigation on the Updakhali and Ghulamkhali Rivers to provide Kalmakanda and Jaria with year round access to centres downstream.

Activity/Site	Important Environmental Component	Potential Impacts and Consequences	Level of Significance	Feasible Mitigative Measures
Dredging	Water quality	. Temporary and local alteration to water quality	L	. Test sediment
	Fish habitat and production	. Temporary and local disruption of fish habitat and loss of some fishery	L	. Timing of dredging to ensure minimal conflict with fish population and fish capture . Compensation to fishers
	Employment and economic activity	. Jobs opportunities	+	
Deposition of spoil	Agricultural land and production	. Modification of soil from spoil runoff	L	. Monitor and control runoff
		. Loss of agricultural land (and associated food production, job opportunity and income)	H	. Select low productivity sites; compensate land owners; rehabilitate site(s) through program of green manuring
Navigation	Employment and economic activity	. Socio-economic improvements . Access to markets and availability of cheaper goods	+	
	Health and welfare	. Better access to health and education facilities	+	

9. PLAN IMPLEMENTATION

The Water Management Plan is a conceptual plan for development of the water resources of the basin. It will require more input from policy makers and more public participation before it can be developed further. This chapter provides some guidelines for securing this input and for carrying forward the implementation process.

A summary of the projects discussed in the plan is provided in Table 9.1. The Table provides a classification of each project by type, the next step for its processing, and a listing of other related projects. These aspects will be discussed below, followed by general suggestions for the next steps.

9.1 Classification of Projects

Projects have been classified based on a number of criteria. The classification system has been developed assuming that there is a need to identify projects that can be implemented early in the development process. Larger and more complicated projects that require substantially more consideration are classified separately.

Class 1 projects are those which can be implemented quickly. They fill an urgent need, either because they are needed to arrest and prevent further damage or because they form a vehicle for learning how to implement other projects of their class. Class 1 projects meet all or most of the following criteria:

- small project with clear concept and scope;
- provide direct benefits to poor or landless people;
- urgent action is required to protect infrastructure, homesteads, and environment from further degradation;
- not dependent on or affected by other projects;
- urgently needed by the area people;
- projects with low risk of negative impacts;
- provides opportunities for learning how to implement other projects of its class;
- can be implemented immediately with a minimum of study;

Class 2 projects have a clear purpose and scope as for Class 1 projects but have less urgency. Specific criteria are as follows:

- they require an intermediate level of analysis;
- they are larger in scope and require a longer time frame for implementation;
- benefits are not immediate or may be indirect and less tangible; for example applied research / demonstration projects whose value is less clear and demonstrable.

Table 9.1: Project Summary

Project	Purpose	Class	Cost US$ million	Next Step	Linkages
Malijhee River Diversion	flood control	3	11.0	pre-feasibility study	Bhogai By-pass
Bhogai River By-pass	flood control	3	20.0	pre-feasibility study	Malijhee Diversion
Malijhee/Bhogai/Kangsha River Channel	drainage	3	4.0	pre-feasibility study	Bhogai By-pass,
Konapara Embankment	flood control	1	1.49	feasibility study	Bhogai By-pass,
Dampara Water Management Project	flood control	1	3.25	implementation	
Chillakhali River Project	flood control	3	2.5	pre-feasibility study	
Someswari River Hazard Management	floodplain	1	1.3	feasibility study, implementation	
Homestead Raising and Erosion	flood control	1	0.5	pilot project, implementation	
Kangsha Basin Water Management	basin management	1	1.7	design and implementation	All
Fish Sanctuaries and *Beel* Improvement	fisheries	1	1.0	design and implementation	
KRIP Fishpass Structure	fisheries	2	0.25	feasibility study	
Kharia River Fisheries Enhancement	fisheries	3	0.29	pre-feasibility study	Kangsha channel
Shallow Floodplain Aquaculture	fisheries	2	0.2	design and implementation	
Open Water Fry Release	fisheries	1	2.0	implementation	
Support to Diversified Fisheries	fisheries	2	3.0	design and implementation	
Rehabilitation of Malijhee Water	fisheries	3	0.6	pre-feasibility study	
Rubber Dam for Irrigation	irrigation	2	1.7	feasibility study	
Groundwater Monitoring Program	water management	2	1.9	program design, implementation	

Project	Purpose	Class	Cost US$ million	Next Step	Linkages
Improved Management of Surface Water	water management	2	0.45	design, implementation	
Piped Water Supply in Urban Areas	water supply	1	4.0	feasibility study	
Domestic Water Supply in rural areas	water supply	2	5.14	implementation	
Kangsha Basin Urban Sanitation	sanitation	1	0.5	feasibility study	
Kangsha Basin Rural Sanitation	sanitation	1	1.4	implementation	
Baseline Groundwater Quality Survey	water supply	1	2.0	implementation	
Social Forestry	environmental	1	2.0	implementation	
Conservation of Biodiversity	environmental	2	5.0	design, implementation	
Pilot Studies for Buried Land	agriculture	2	0.3	design, implementation	
Farming Systems Development	agriculture	2	1.0	design, implementation	
Dredging in Lower Kangsha Basin	navigation	1	5.0	feasibility study	

Class 3 projects are large, complex projects whose scope and concept need further refinement. Examples are the initiatives identified in the Malijhee lowlands where the problems and solutions are not well enough understood to make a decision at this time. These projects require extended planning, extensive public input, and consultation with policy makers before a decision is made to proceed with them. They meet the following criteria:

- they are dependent on or affected by other projects;
- projects are large or complex and involve conflicting interests and different alternatives;
- project scope is not clearly defined (pre-feasibility studies are required);
- extensive input of policy makers and local people is required to define the projects' concept and scope.

A summary of project classes is provided in Table 9.2. There are 13 Class 1 projects having a total investment of $26.2 million. These include 4 projects for flood control and homestead protection, 2 projects to reverse the decline of the basin's fisheries, 4 projects for water supply and sanitation, one project for enhancement of natural area through social forestry, one project to improve navigation in the lower Kangsha basin, and one project for Kangsha Basin Water Management.

Ten projects involving a total investment of $19 million have Class 2 status. These include three projects to enhance and diversify fisheries, three projects to improve water management and one to support water supply programs of DPHE/UNICEF, and two projects to develop and demonstrate improved agricultural practices.

Table 9.2: Classification by Project Priority

Class	Number of Projects	Cost US$million
1	13	26.2
2	10	18.9
3	6 (4*)	38.4 (23.4*)
Total	29 (27*)	83.5 (68.5*)

* - excluding two projects that would not be built if other projects are adopted

There are six Class 3 projects which require further study and evaluation before committing to proceed. Although this group in the smallest in number it could involve the largest investment. The total of all Class 3 projects is $ 38.4 million which includes three overlapping projects in the Malijhee area. The maximum potential investment is $ 23.4 million.

A total of 27 projects, involving a total investment of $ 68.5 million, could potentially be built, discounted for overlapping projects.

9.2 Early Implementation Projects

There are 13 Class 1 early implementation projects. Following is a summary of the projects and a rationale for their selection.

Konapara Embankment:	small project; immediate benefit would be achieved by resolving intense local conflict; low negative environmental impact
Dampara Water Management Project:	small project; highly cost-effective; feasibility study has been undertaken; low negative environmental impact
Someswari River Hazard Management:	protect existing roadways, embankments, and (Phase 1) the town of Durgapur; check new avulsion; very low negative environmental impact
Homestead Raising and Erosion Protection:	immediate and direct flood protection benefits; pilot project is required to guide full-scale implementation; no negative environmental impact
Kangsha Basin Water Management Project:	required for coordination of other projects and for further basin planning to ensure rational, equitable and sustainable use; no negative environmental impact
Fish Sanctuaries and Beel Improvement:	immediate benefits to improved fisheries production; reverse process of fisheries decline; direct benefit to poor and landless; very low negative environmental impact
Open Water Fry Release:	immediate step to replenish the declined fisheries resources which is the main source of animal protein for the people of this country
Piped Water Supply in the Kangsha Basin:	urgently needed for the people of the densely populated urban areas; no negative environmental impact
Kangsha Basin Urban Sanitation:	urgently needed for the people of the densely populated urban areas; no negative environmental impact
Kangsha Basin Rural Sanitation:	urgently needed for the rural people; no negative environmental impact

Baseline Groundwater Quality Survey	urgently needed for the area people; no negative impact
Social Forestry:	direct benefit to poor and landless; enhance environmental conditions; arrest deforestation
Dredging in Lower Kangsha Basin:	negative impacts are temporary and can almost be eliminated by the mitigative measures; arrest channel deterioration; BIWTA is presently carrying out a programme in the area

9.3 Classification by Purpose/Type

A summary of project classification by type or purpose is provided in Table 9.3. Over one-third of the identified water management projects have flood damage mitigation, drainage improvement or river hazard management as their primary purpose. The total dollar value in projects of this type is $44.0 million but as pointed out above the maximum potential investment is $29.0 million as three projects in the upper basin overlap. Eight projects involving a total investment of US$17.0 million are targeted toward water supply and sanitation, irrigation, and better management of groundwater and surface water resources.

Fisheries and environment represent nine projects and $14.4 million dollars of investment. Two projects ($1.3 million) are targeted toward improving agriculture in newly created and flood-protected lands and one project ($5.0 million) is designed to provide navigation improvements. Finally, one project, the Water Management Project costing $1.7 million, is designed to provide an overall coordinating role in water planning and management in the basin.

Table 9.3: Classification by Project Purpose

Project Type	Number of Projects	Cost US$million
Flood control/drainage /hazard management	8*	44.05*
Irrigation/water management	3	4.05
Water supply and sanitation	5	13.05
Basin planning/ management	1	1.70
Fisheries	7	7.34
Environment	2	7.00
Agriculture	2	1.30
Navigation	1	5.00
Total	29	83.50

* includes three projects that are mutually exclusive

9.4 Project Linkages

Several project proposals in the upper Kangsha/Malijhee are inter-related. These include the Bhogai By-Pass, the Malijhee Diversion, and the Malijhee/Bhogai/Kangsha channel improvements, which are all alternatives designed to improve flooding and drainage conditions in the Malijhee lowlands. It could prove that all or none of these could prove feasible, or that a combination of alternatives (such as partial diversion combined with limited channel improvements in the Malijhee River) may be the best solution.

A full pre-feasibility study would be required to evaluate these alternatives and to secure the inputs of policy makers and local people.

The length and height of the Konapara Embankment will depend on the upstream projects. It is recommended that the upstream portion of the Konapara Project, from the border to the Malijhee confluence, be deferred until a decision on the Bhogai Bypass channel is made. The downstream portion of the project could be undertaken earlier for the following reasons:

- the potential reduction in embankment height in the downstream reach is a relatively small factor in the project cost;
- closure of spill channels will be required even if the upstream works are constructed;
- poor people of the area are severely affected by flooding and disputes over flood control in the area and would be directly and immediately benefitted by the project;
- it will take a considerable length of time to implement the upstream works, if they are implemented at all.

The timing of the Kharia River Fisheries Enhancement project would also be affected by the upstream FCDI projects which could change the flows and water levels in the Kangsha River. For this reason the Kharia Fisheries Improvement project should be deferred until the pre-feasibility study for the upstream projects is undertaken. A pre-feasibility level study is also recommended for the Kharia Project.

Impacts in downstream reaches are reduced due to intervening inflows and storage effects. Effects of upstream works are negligible downstream of the Shibganjdhala River confluence.

Changes that are occurring in the Shibganjdhala River are a factor in the Dampara Project. Discharges and flood levels in the Kangsha River are likely to decline over time which could affect the required height of embankments. Modelling indicates that flood stages could be reduced by 0.7 m at Jaria but these changes will take some time to materialize. The magnitude and timing of these changes cannot be reliably predicted nor can they be assured in the long term. Therefore it would be wise to proceed with the Dampara Project based on existing conditions. If the river stages do decline the performance of the Dampara Project will improve.

9.5 Institutional Changes

The Water Management Plan identifies 24 projects as part of the water management strategy. Most of these initiatives have been developed to only a conceptual level. Thus a considerable amount of work will be required to take the planning process forward to implementation.

The basin's problems are quite complicated and the plan will require some time to generate the required support. A good and realizable plan takes a lot of input and constant critical appraisal in the light of new insights and facts. Therefore it is suggested a basin-wide water management project would be implemented to carry on the further planning work that is necessary. Its primary roles will be to coordinate the involvement of the various line ministries that are required to implement the plan, to develop the support and participation of the community, and to carry out the pre-feasibility studies that are required.

9.6 Project Phasing

A phased implementation plan is outlined. The general approach assumed is one which would initiate more urgent projects immediately while undertaking the longer-term activities required to strengthen and develop confidence with the overall strategy. Longer-term activities include reflection, analysis, trying to negotiate a power base— an informal and formal socio-political support structure for the process— and strengthening the database, in addition to actually implementing projects.

Because of the difficulties, uncertainties, and the need to learn, involved in working towards sustainability, it would probably be wise to keep projects as simple and "one dimensional" as possible. The primary objective is to learn through project implementation. If projects have too many components and are too complex, the probability of something going wrong get quite high. And because of the complexity, it may be difficult to learn anything useful from the experience. For example, if there are many components and there are serious problems, it may be difficult to find just what went wrong, why, and how to avoid the same problem in the future.

Phase 1 Works:
This phase could begin immediately with small projects that could be completed within one to two years. The objective is to start activity, to mobilize public support, and to help focus further planning activities. Priority would be given to flood control projects and to fisheries enhancement as these are the most pressing needs of the basin. All projects would focus on community involvement though formation of Project Committees.

Four flood-control projects are included of which one, the Dampara Project, has been carried to feasibility study stage. Pre-feasibility studies have been carried out for the three remaining projects (Konapara Project[1], Someswari River Hazard Management[2], and Homestead Raising and Erosion Protection[3]). The homestead protection program will require several years to implement but a pilot project could be initiated early to provide the basis for full-scale implementation.

Two fisheries projects are needed to enhance the capture fish resource. These have a good potential for helping the poor and for increasing community solidarity.

Dredging in the lower reaches of the Kangsha Basin may be implemented immediately as it has immediate benefit to navigation in the area and also considering that BIWTA has a program in the area that could be easily extended to include the new work.

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[1] Upper Kangsha River Basin Development Pre-Feasibility Study Final Report, Northeast Regional Water Management Project (FAP-6), September 1994.

[2] Someswari River Stabilization Project, Annex of this report.

[3] FEAVDEP Flood and Erosion-Affected Villages Development Project Pre-Feasibility Study, Northeast Regional Water Management Project (FAP-6), Draft Final, January 1994.

Phase 2 - detailed planning:
This phase would start concurrently with Phase 1 and would extend for a minimum of three years. It starts with formation of a water management project using the projects planned under Phase 1 to focus its activities. It involves extension of the planning process, and reflection and dialogue to build a consensus on the development needs of the basin. Steps include:

- formation of the water management project;
- formation of a Kangsha Basin Project Coordinating Committee in accordance with FPCO guidelines;
- start to supplement the existing data bases;
- build on the understanding of how the basin works as defined in the Water Management Plan, with special emphasis on community participation;
- produce a workplan for dealing with existing projects; evaluate every existing project, whether to renovate it, abandon it, or redesign it;
- start (perhaps working through NGOs) to increase the number of grass-roots organizations that work with local initiatives in the basin. It would have the potential to address some of the conflicts in the area;
- conduct a critical review of the Water Management Plan in consultation with local authorities and residents;
- complete pre-feasibility studies and secure sources of funding.

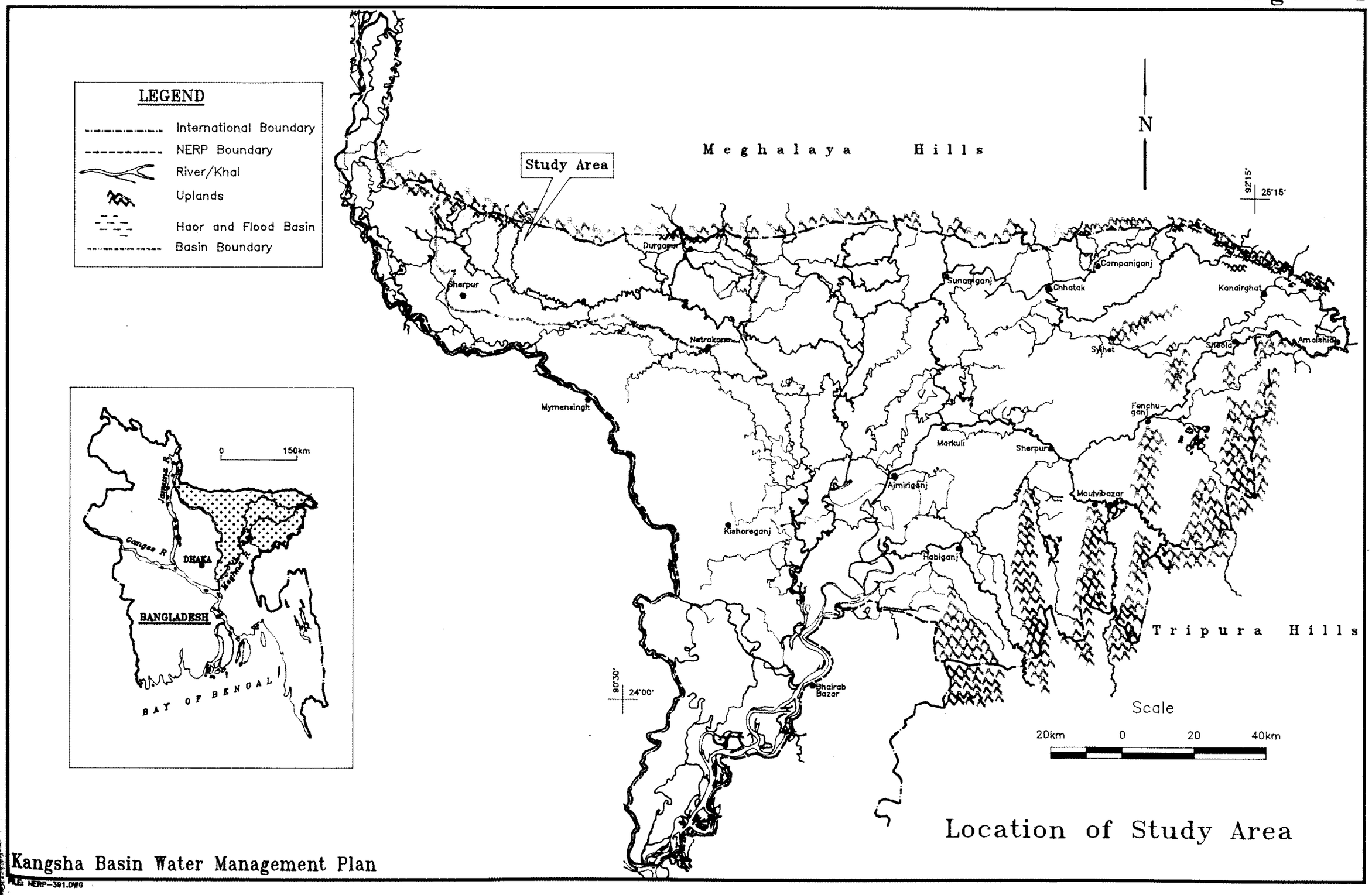
Initially all the "private" projects (like those constructed with Caritas money) would be left alone. An "outreach," public information program would be set up to learn more about these projects and to provide technical assistance to the organization which are involved with them.

Phase 3 - implementation of other projects:
This phase would involve implementation of other projects which are identified under the Water Management Plan or may appear during the Phase 2 work described above. It would continue as long as necessary. Some items such as long-term tasks outlined under the Someswari River Hazard Management would continue in the context of new planning/implementation structures that would be set up in Phase 2. Tasks involve:

- feasibility studies,
- project implementation,
- monitoring to ensure effectiveness,
- update development plan annually.

FIGURES

Figure 1

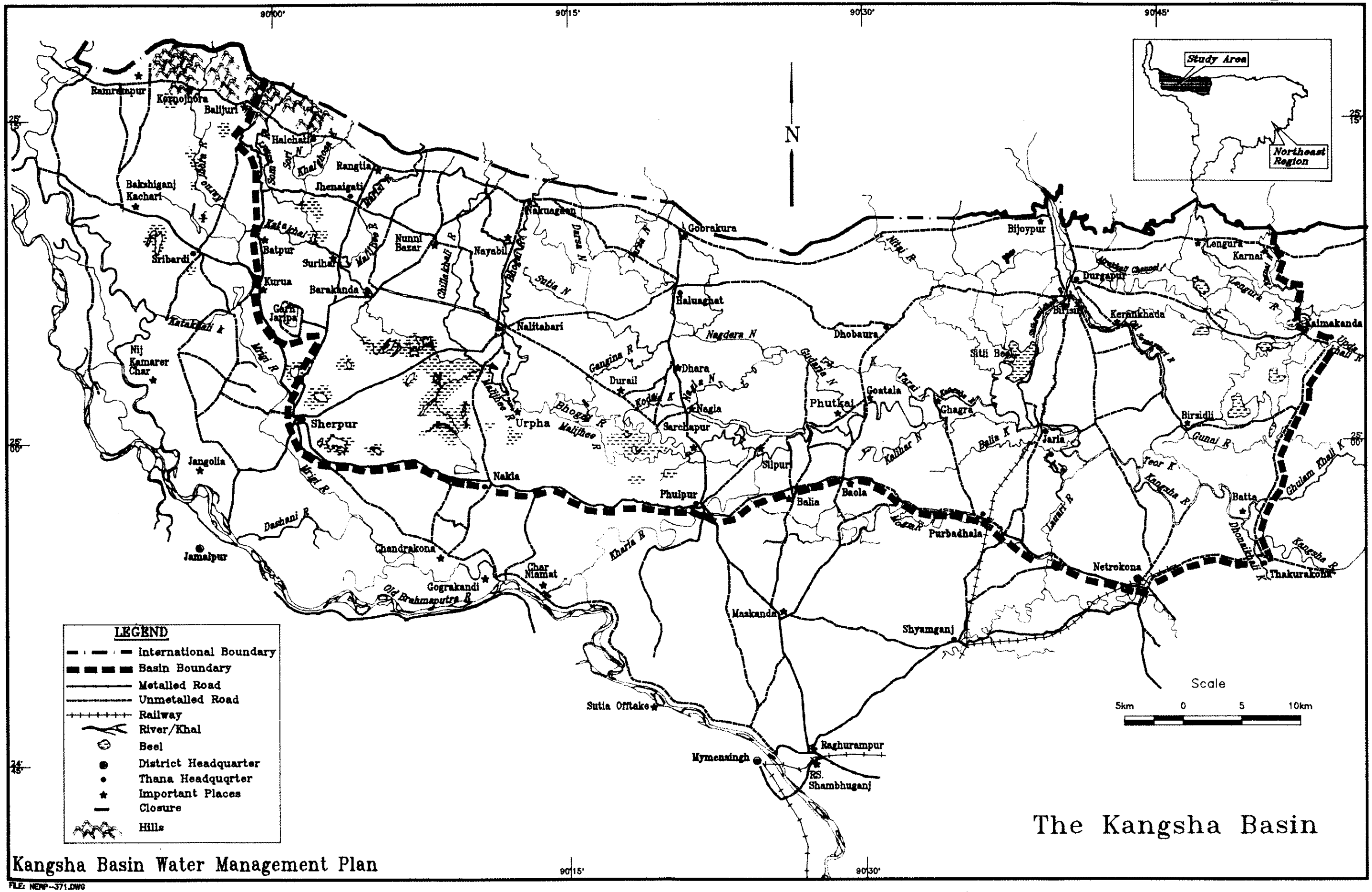


Location of Study Area

Kangsha Basin Water Management Plan

FILE: NERP-391.DWG

Figure 2



The Kangsha Basin

Kangsha Basin Water Management Plan

FILE: NEMP-371.DWG

Figure 3

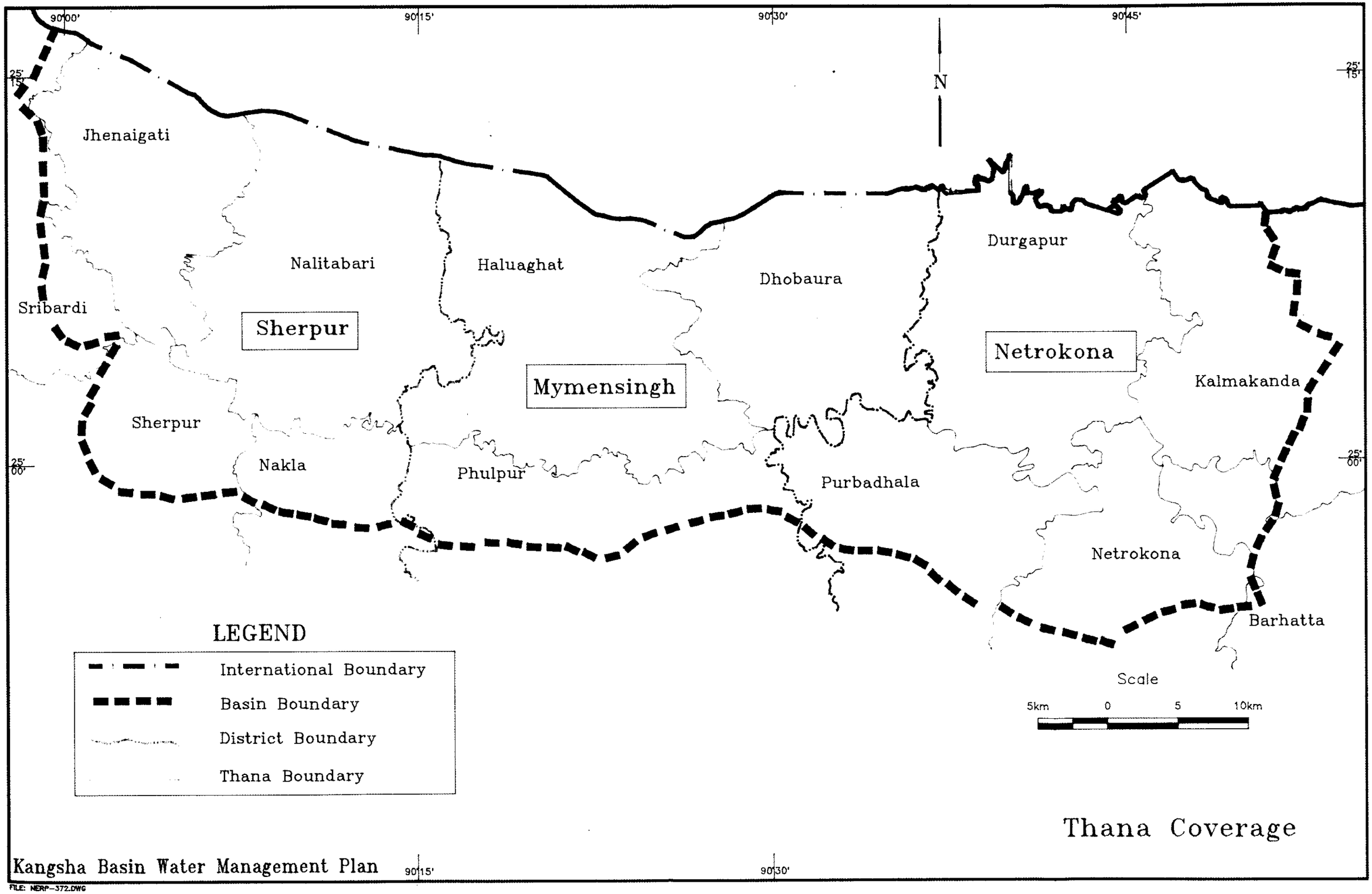

90°00'
90°15'
90°30'
90°45'
25' 15'
25' 00'
N
Jhenaigati
Nalitabari
Haluaghat
Dhobaura
Durgapur
Sribardi
Sherpur
Netrokona
Mymensingh
Kalmakanda
Sherpur
Nakla
Phulpur
Purbadhala
Netrokona
Barhatta
LEGEND
International Boundary
Basin Boundary
District Boundary
Thana Boundary
Scale
5km 0 5 10km
Thana Coverage
Kangsha Basin Water Management Plan
FILE: NERP-372.DWG

Figure 4

90°00' 90°15' 90°30' 90°45'

25° 15'

25° 00'

N

Uplands

PHYSIOGRAPHIC CLASSIFICATION

Legend	Dominant Landform	Physiographic Unit
		Susang Hills
	Piedmont Floodplain	Maghalaya Piedment
	Alluvial Fan	Meghalaya Fans
	Lowland Floodplain	Old Brahmaputra Floodplain

5km 0 5 10km

Scale

Physiography

Kangsha Basin Water Management Plan

FILE: NERP-373.DWG

Figure 5

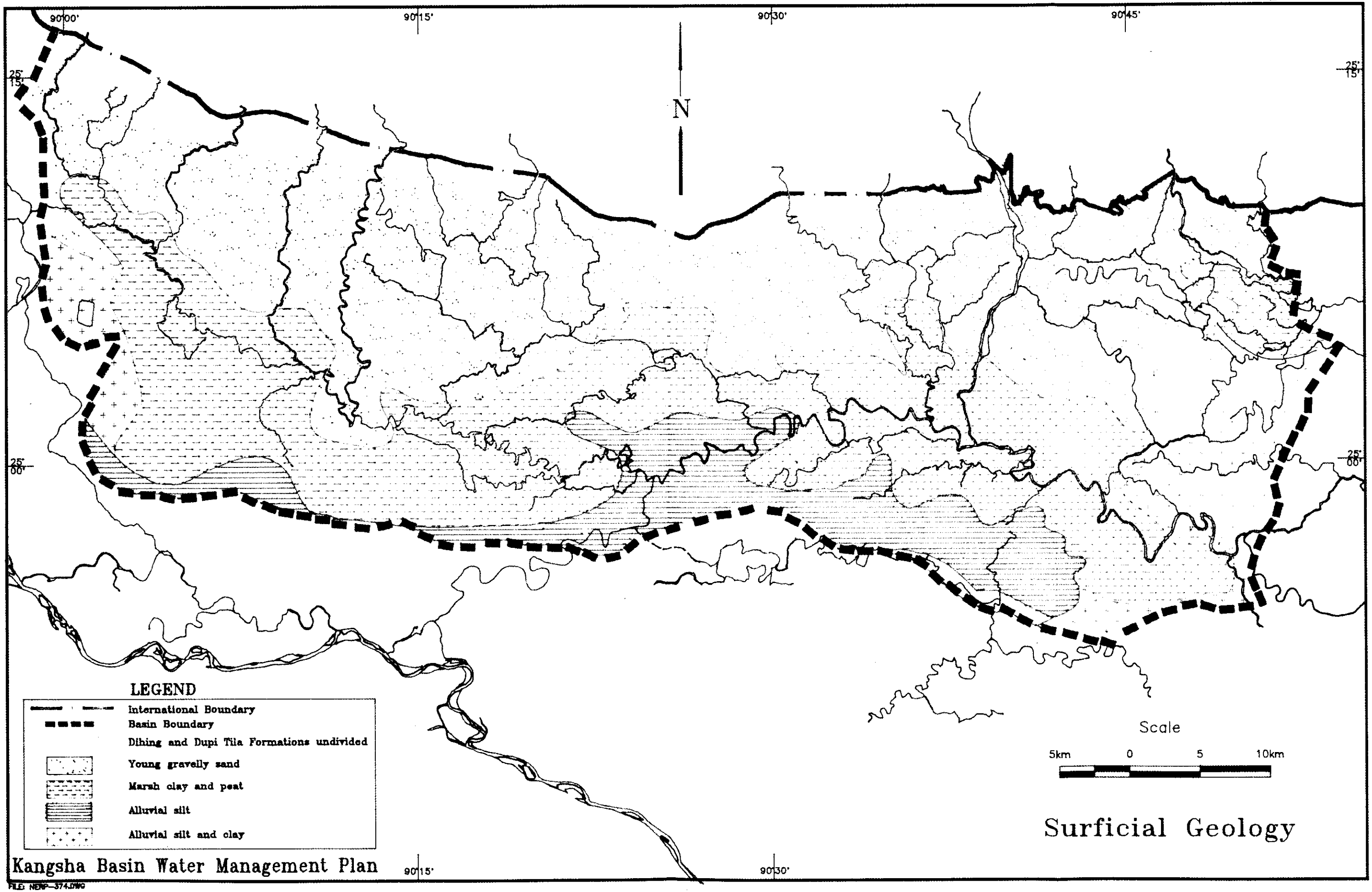

90°00'
90°15'
90°30'
90°45'
25° 15'
25° 00'
N
LEGEND
International Boundary
Basin Boundary
Dihing and Dupi Tila Formations undivided
Young gravelly sand
Marsh clay and peat
Alluvial silt
Alluvial silt and clay
Scale
5km 0 5 10km
Surficial Geology
Kangsha Basin Water Management Plan
FILE: NEWP-S74.DWG

Figure 6

MEGHALAYA HILLS

(INDIA)

N

90°00' 90°15' 90°30' 90°45'

25°15' 25°00'

Jhenaigati
Kalakhal
Nalitabari
Sherpur
Nakla
Sarchapur
Phulpur
Halugaghat
Dhobaura
Durgapur
Kalmakanda
Jaria
Birsidli
Purbadhala
Netrokona
Barhatta
Thakurakona

LEGEND

- International Boundary
- Basin Boundary
- Contour
- River/Khal
- District Headquarter
- Thana Headquater

Note: Elevations are m, PWD

Scale

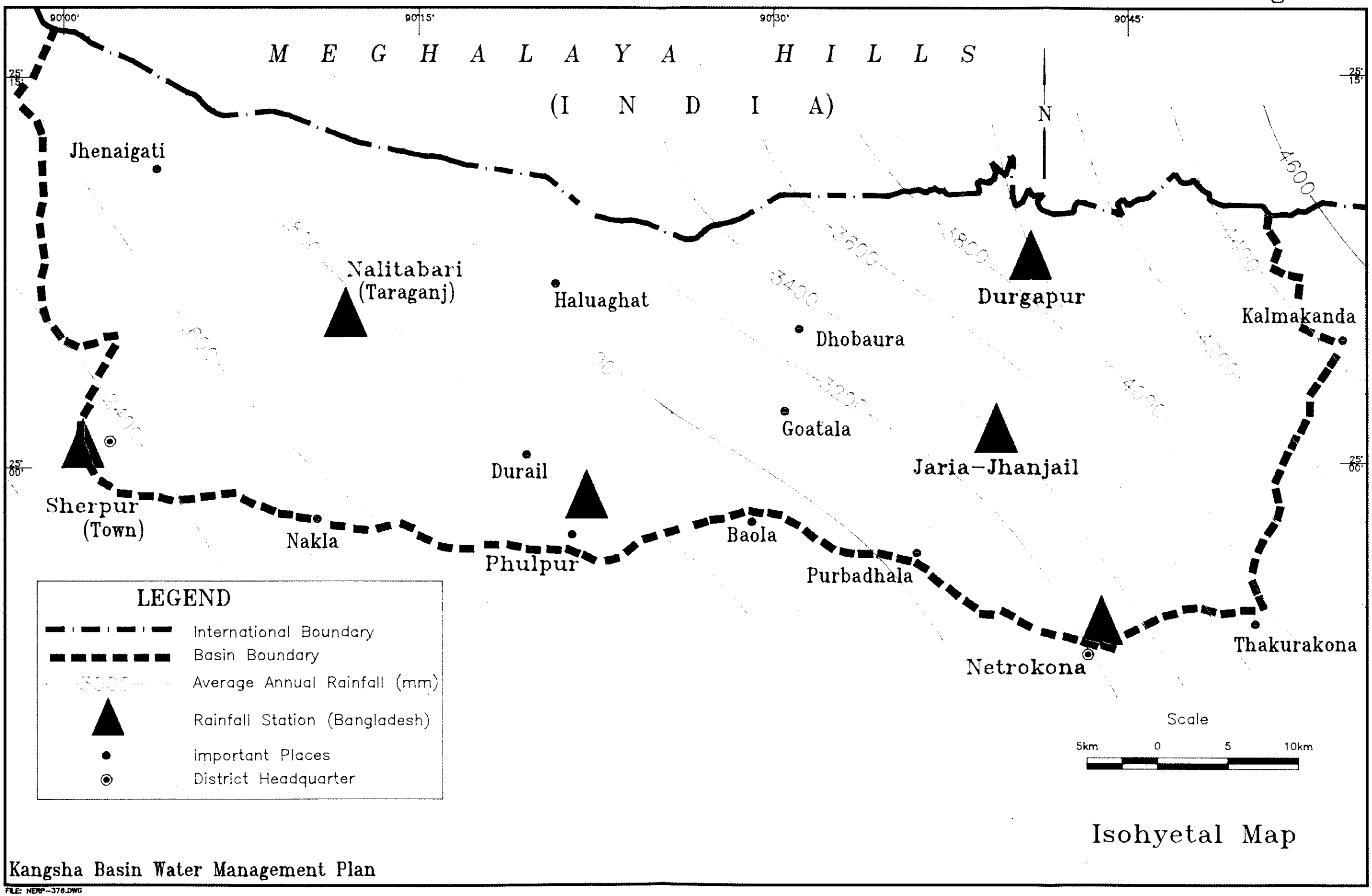
5km 0 5 10km

Land Elevations

Kangsha Basin Water Management Plan

FILE: NERP-388.DWG+BASINCON

Figure 7

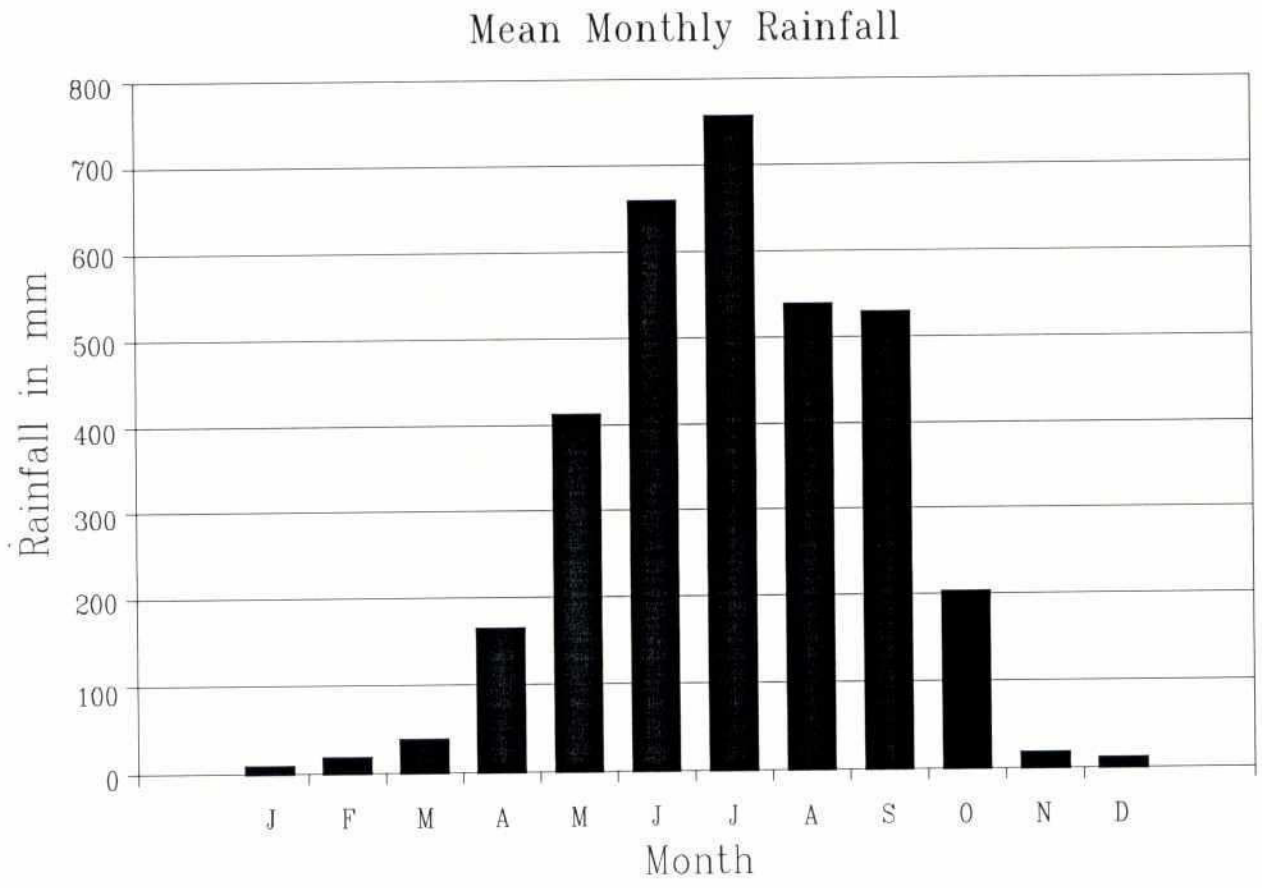


Isohyetal Map

Kangsha Basin Water Management Plan

FILE: NEW-376.DWG

Figure 8

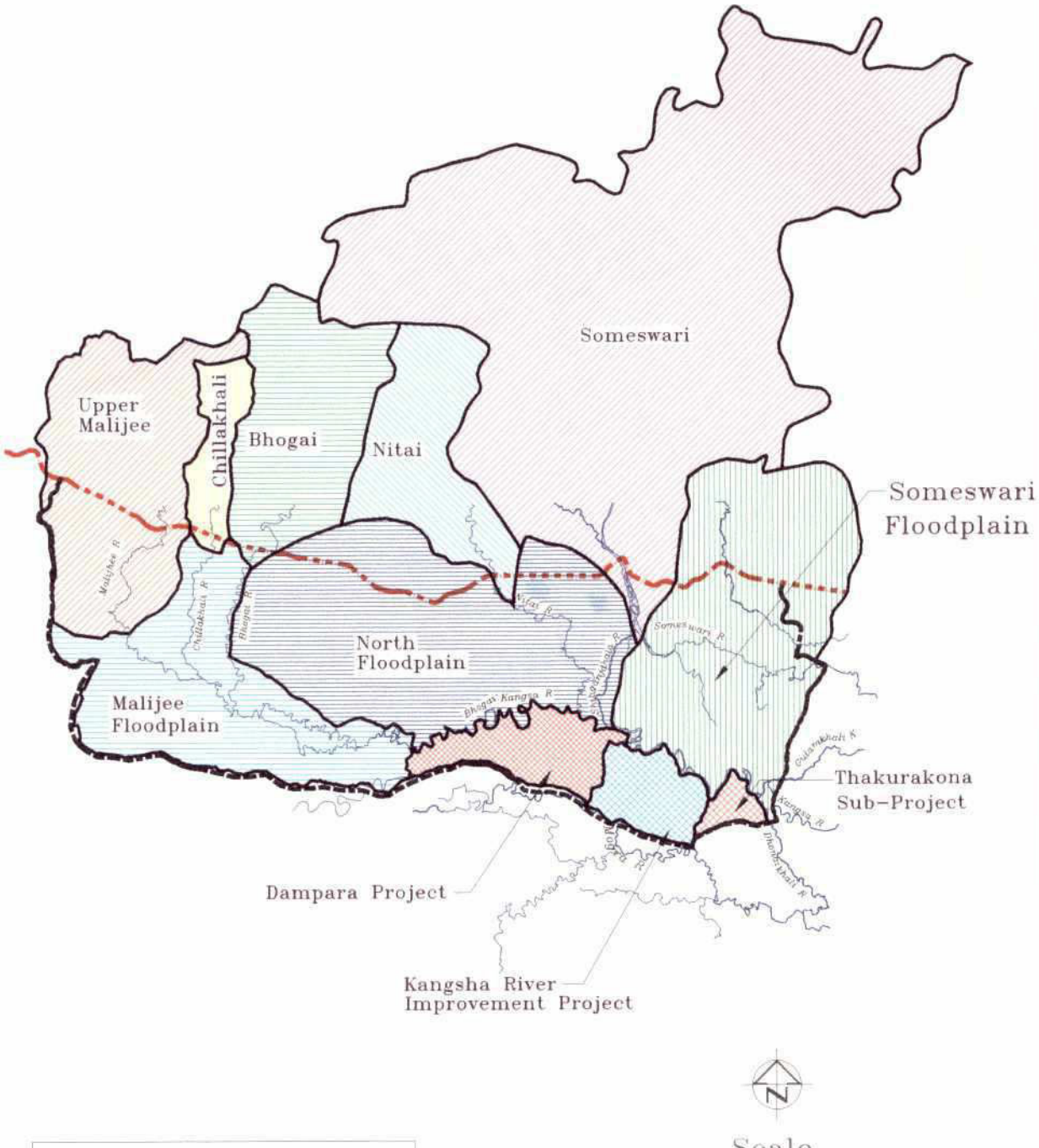


Mean Monthly Rainfall
Station: Jaria-Jhanjail

Kangsha Basin Water Management Plan

FILE: NERP-393.DWG

Figure 9

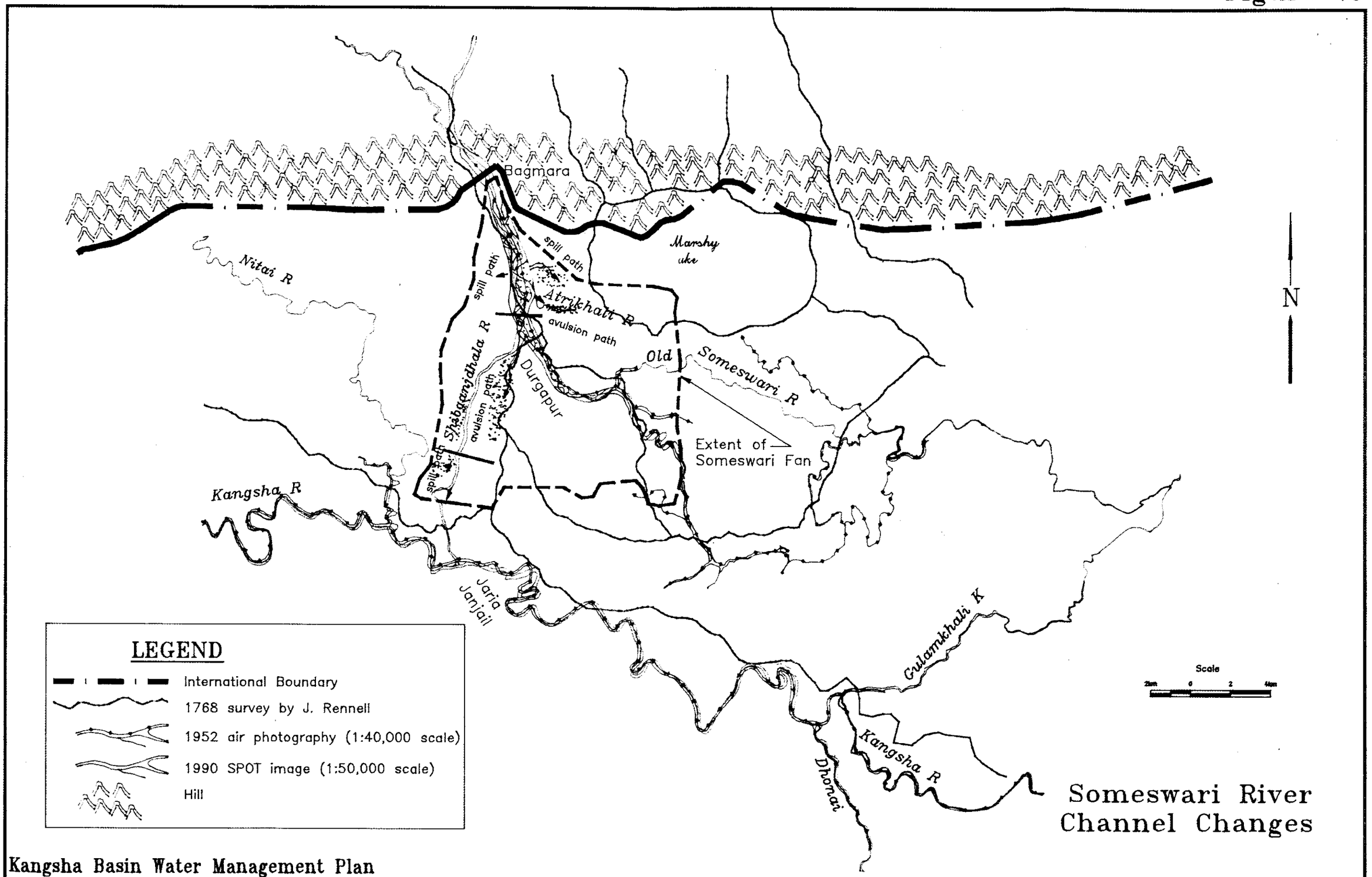


Kangsha River Basin
Tributary Catchment

Kangsha Basin Water Management Plan

FILE: NERP-399 Prepared by: Jalal

Figure 10

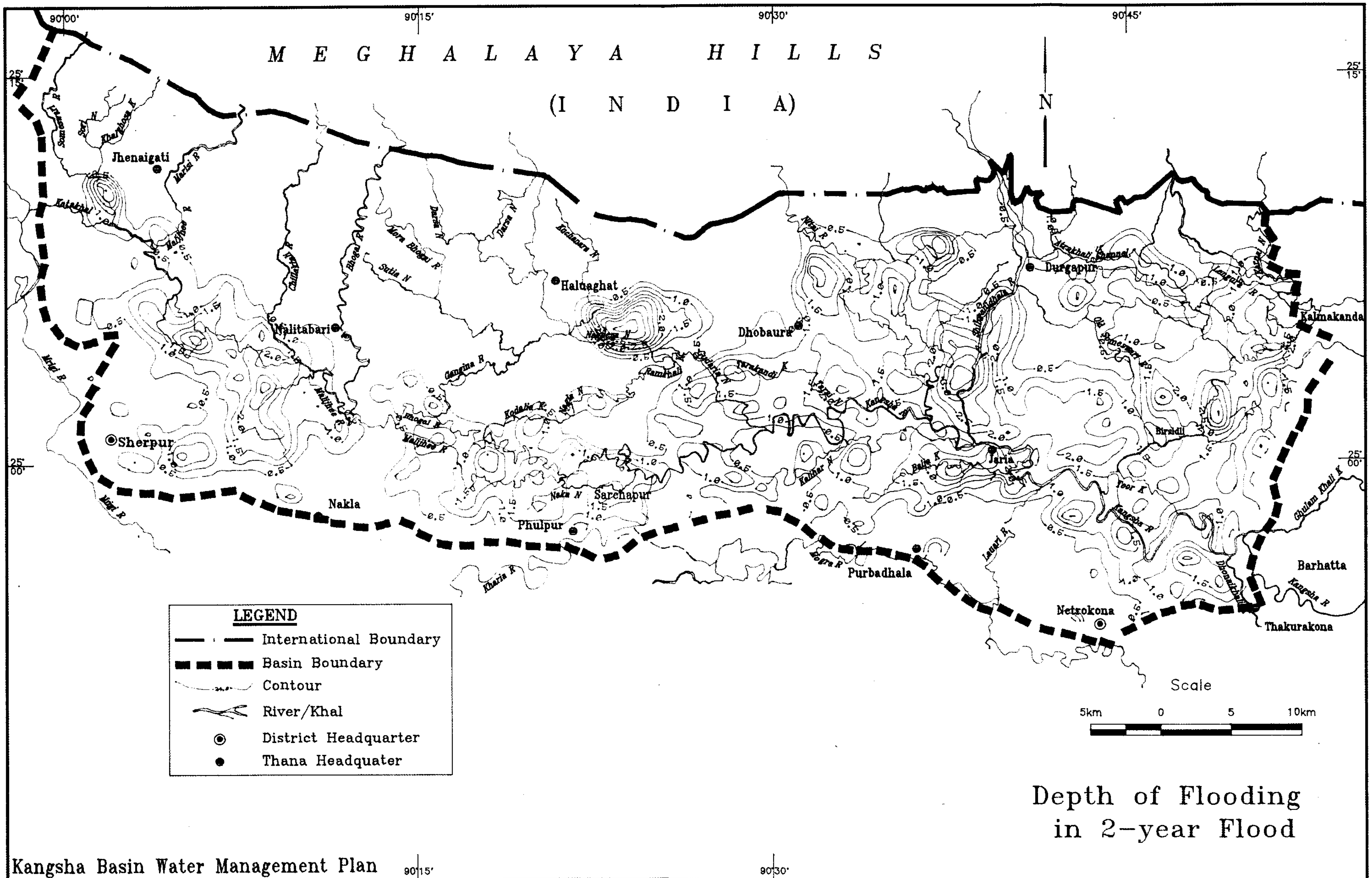


Someswari River Channel Changes

Kangsha Basin Water Management Plan

FILE: NERP--378.DWG

Figure 11



Depth of Flooding in 2-year Flood

Kangsha Basin Water Management Plan

FILE: NERP-376.DWG+FDANN91

Figure 12

90°00' 90°15' 90°30' 90°45'

25° 15'

25° 00'

N

Jhenaigati
Sherpur
Nalitabari
Haluaghat
Sarchapur
Phulpur
Dhobaura
Jaria
Purbadhala
Netrokona
Durgapur
Kalmakanda
Thakurakona

A
B
C
C'
D
E
F
G

LEGEND

A – Overland spills from piedmont rivers
B – Flash flooding of Malijhee lowland
C – Overland spills from Bhogai River
D – Backwater and spill from Kangsha River
E – Protected by Kangsha Project embankments
F – Backwater from Sylhet Basin
G – River shifting and flooding on alluvial fans

LEGEND

International Boundary
Basin Boundary

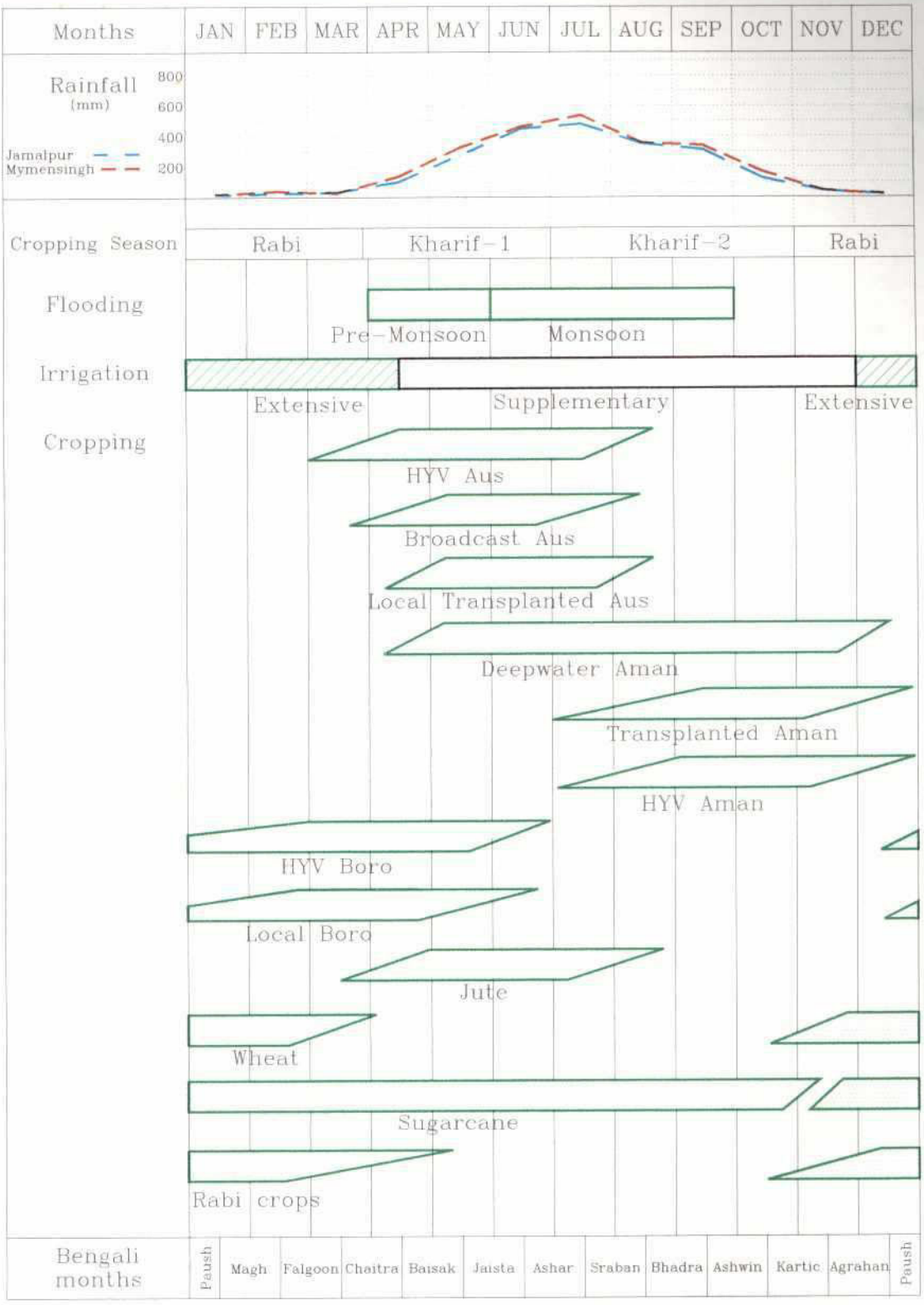
Scale
5km 0 5 10km

Flood Hazard Zones

Kangsha Basin Water Management Plan

FILE: NERP-379.DWG

Figure 13



Major Crop Calendar

Kangsha Basin Water Management Plan

FILE: NEBP-382.DWG

Figure 14

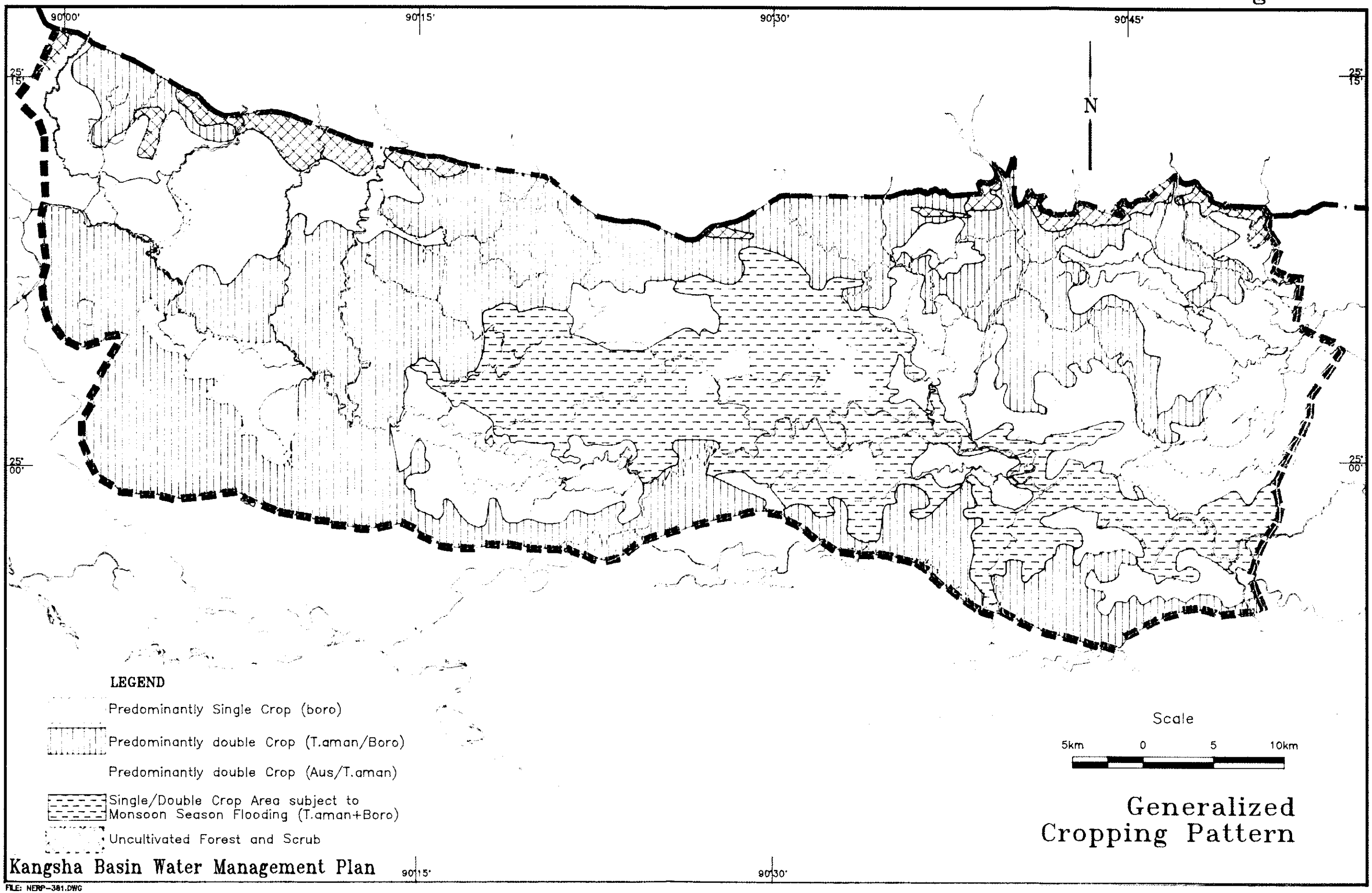
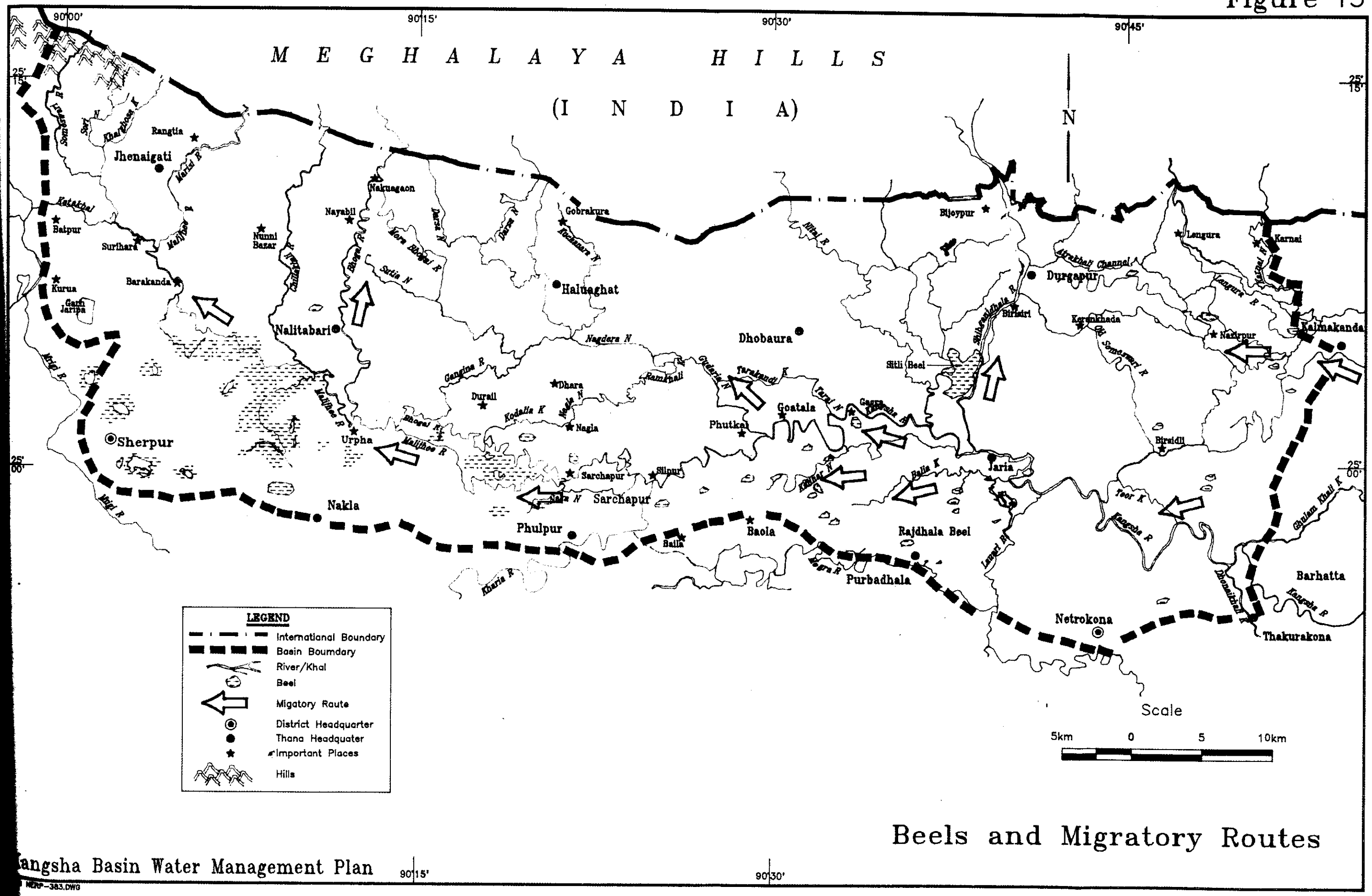

90°00'
90°15'
90°30'
90°45'
25° 15'
25° 00'
N
LEGEND
Predominantly Single Crop (boro)
Predominantly double Crop (T.aman/Boro)
Predominantly double Crop (Aus/T.aman)
Single/Double Crop Area subject to Monsoon Season Flooding (T.aman+Boro)
Uncultivated Forest and Scrub
Scale
5km 0 5 10km
Generalized Cropping Pattern
Kangsha Basin Water Management Plan
FILE: NERP-381.DWG

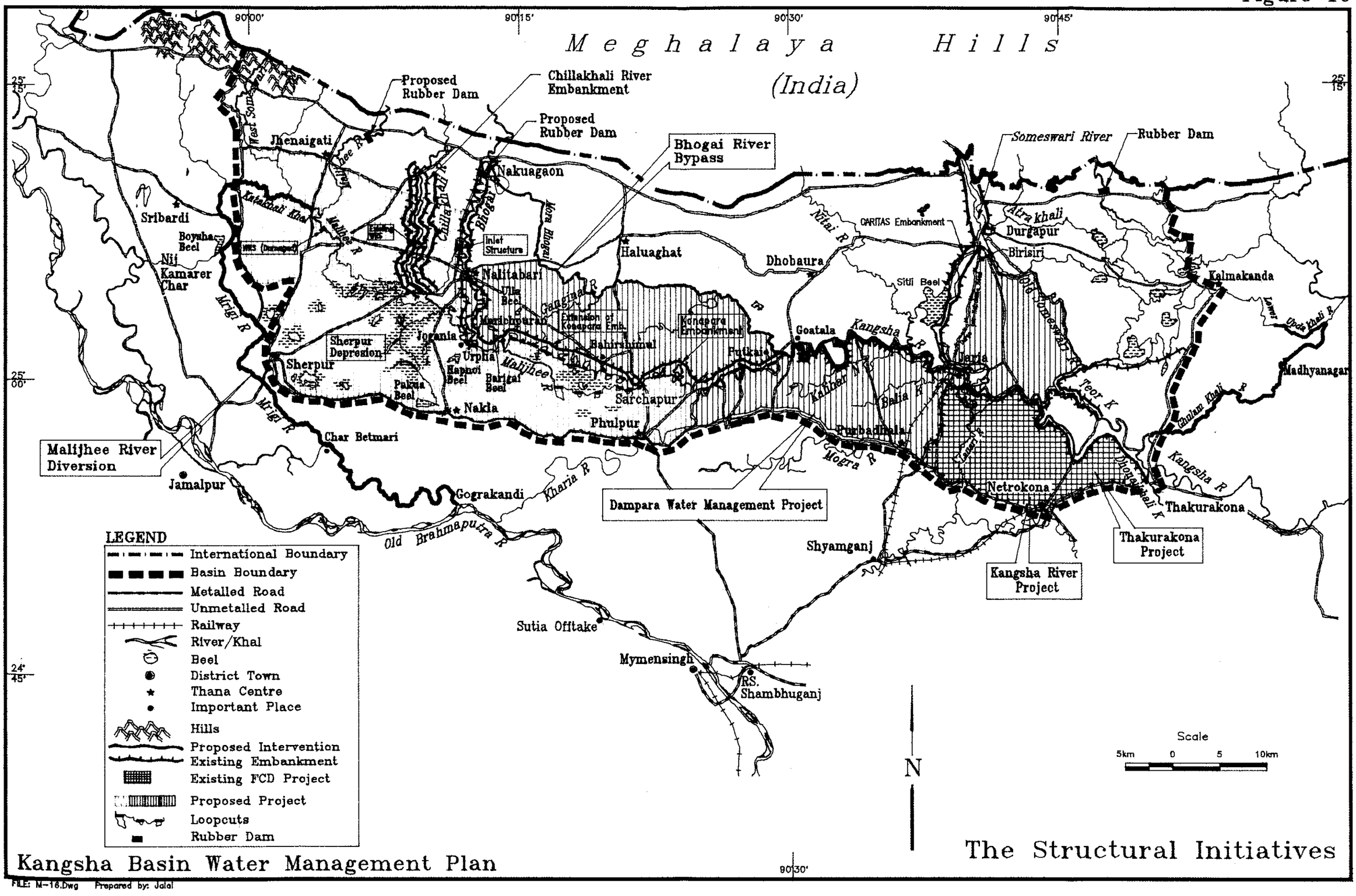
Figure 15



Beels and Migratory Routes

NERP-383.DWG

Figure 16

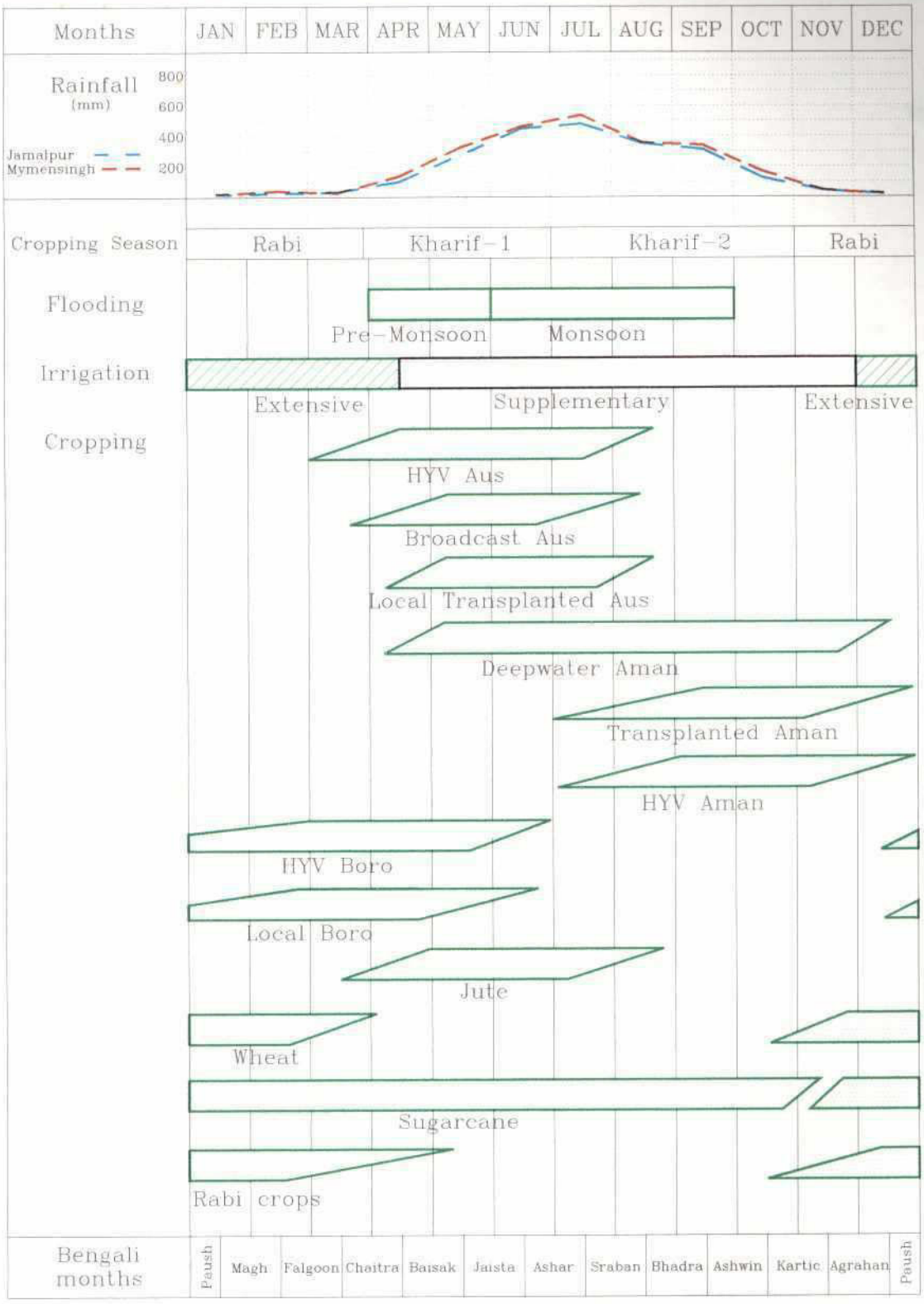


Kangsha Basin Water Management Plan

The Structural Initiatives

FILE: M-16.Dwg Prepared by: Jalal

Figure 13

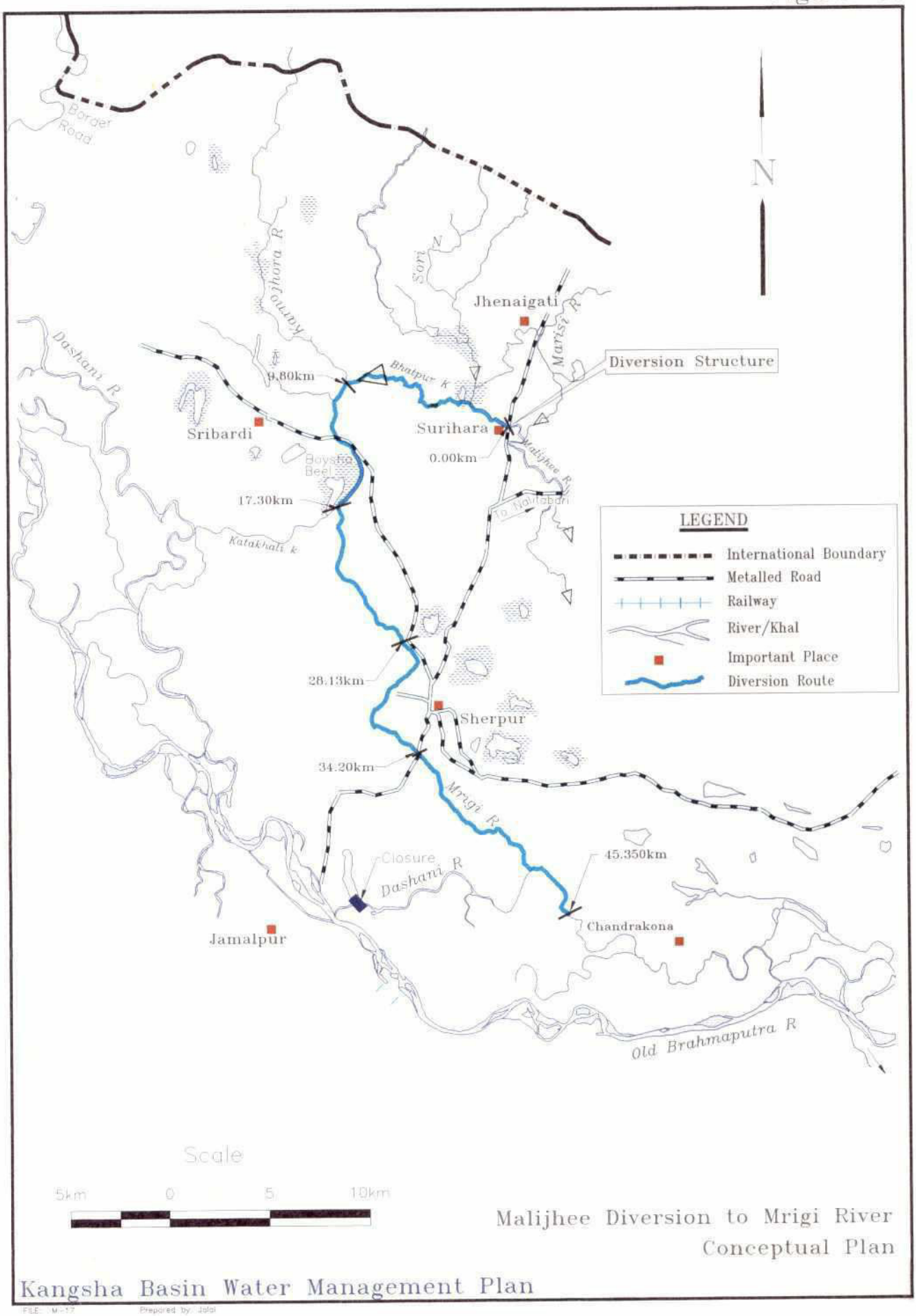


Major Crop Calendar

Kangsha Basin Water Management Plan

FILE: NEBP-382.DWG

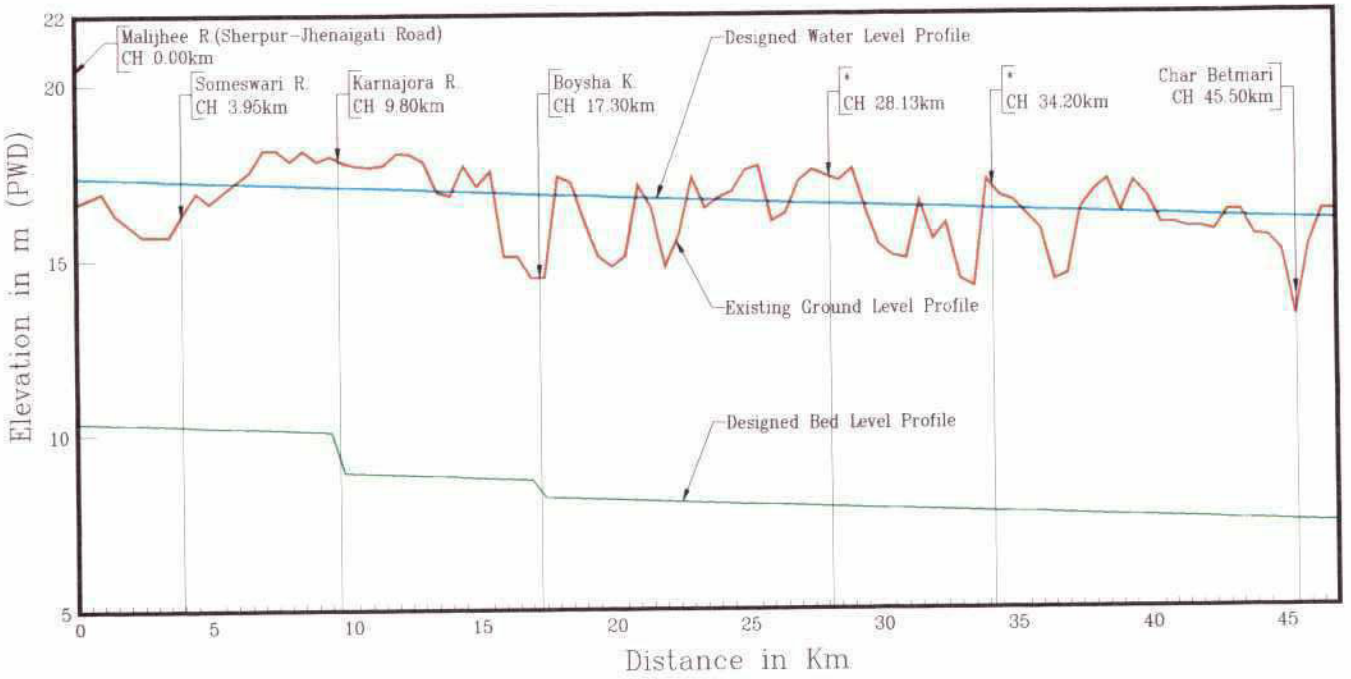
Figure 17



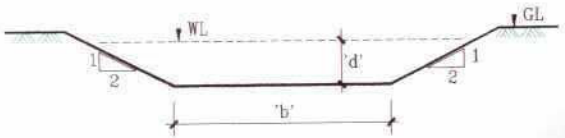
Malijhee Diversion to Mrigi River
Conceptual Plan

Kangsha Basin Water Management Plan

FILE : M-17 Prepared by: Jalal



Reach no	Chainage km	Discharge Q' m^3/sec	Depth 'd'm	Width 'b'm	Water Level m. PWD	Bed Level m. PWD
1.	0.00–9.80	200	7.00	40	17.36–17.07	10.36–17.07
2.	9.80–17.30	299	8.15	45	17.07–16.86	8.92–8.71
3.	17.30–28.13	332	8.65	45	16.86–16.54	9.21–7.89
4.	28.13–34.20	365	8.65	50	16.54–16.36	7.89–7.71
5.	34.20–45.50	398	8.65	55	16.36–16.04	7.71–7.39



Typical Section

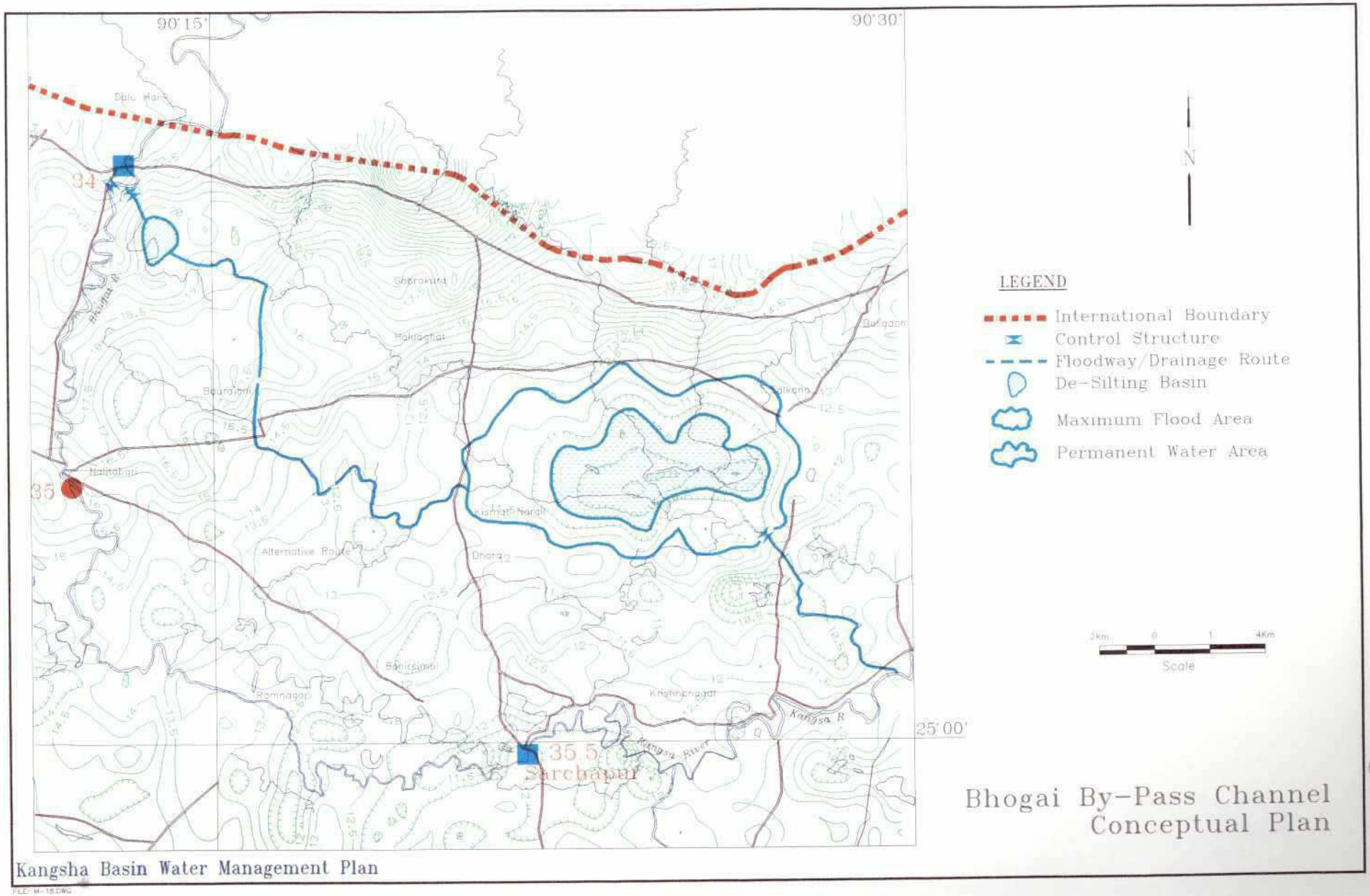
Mrigi River Longitudinal Profile

Mrigi River Longitudinal Profile

Kangsha Basin Water Management Plan

FILE: M–18 Prepared by: Jalal

Figure 18

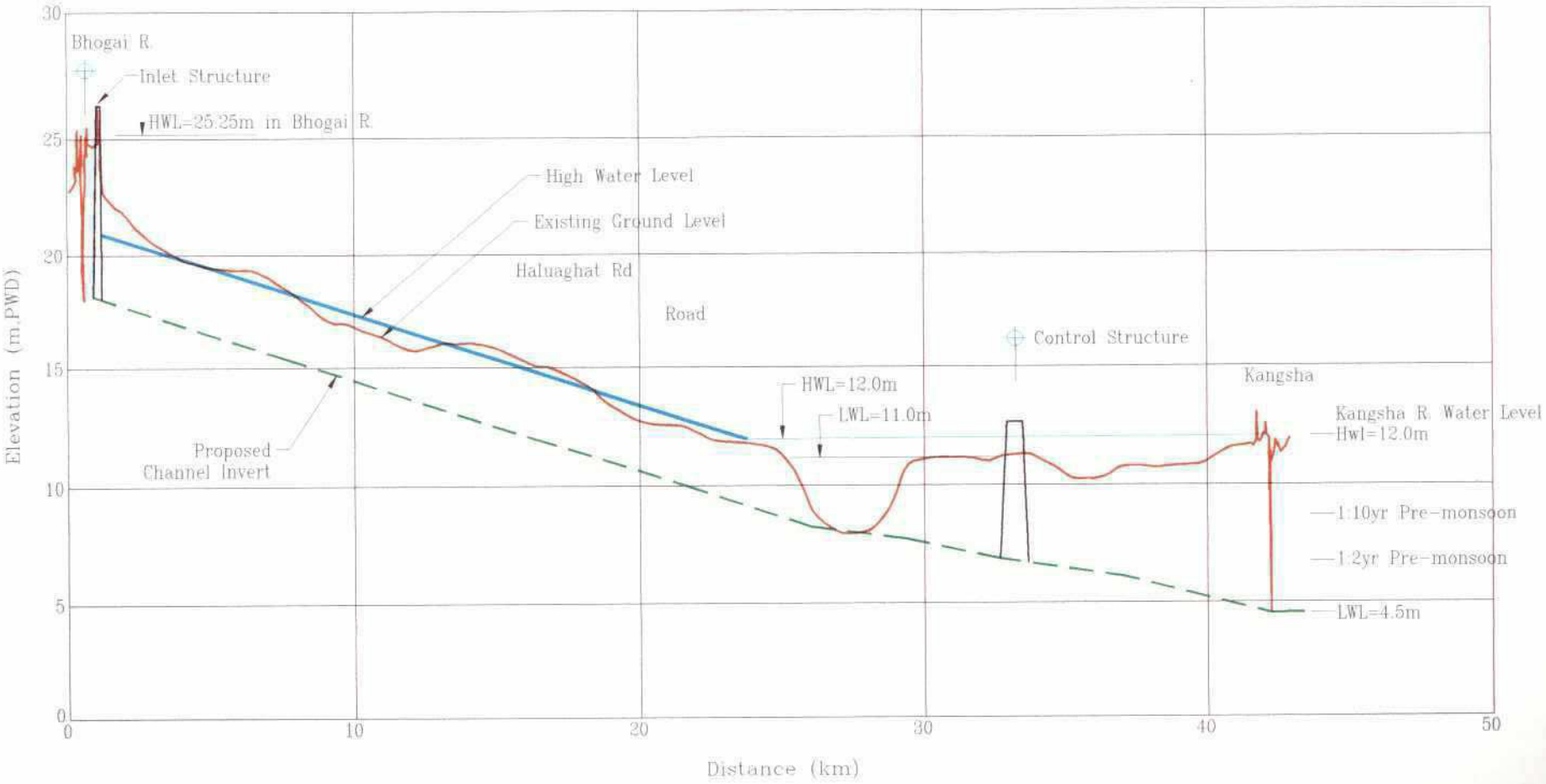


Bhogai By-Pass Channel
Conceptual Plan

Figure 19

Kangsha Basin Water Management Plan

FILE: M-18.DWG

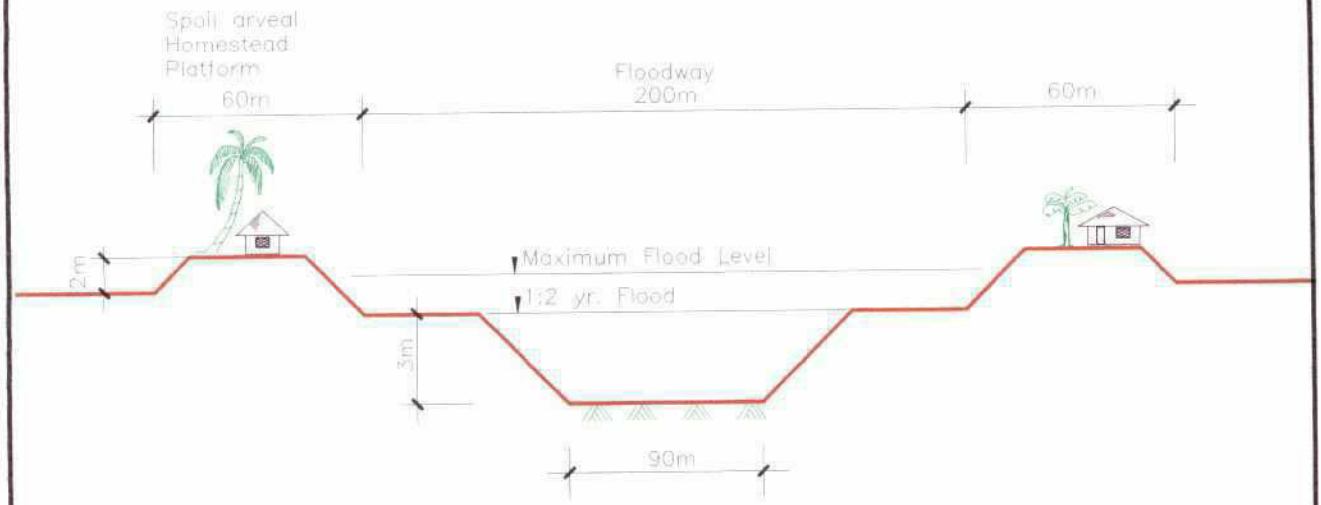


Bhogai By-Pass Channel
Proposed Profile (Conceptual)

Figure 20

Kangsha Basin Water Management Plan

FILE: M-20.DWG



Bhogai By-Pass Channel
Proposed Cross Section
(conceptual)

Kangsha Basin Water Management Plan

FILE : M-21.DWG Prepared by: Jalal

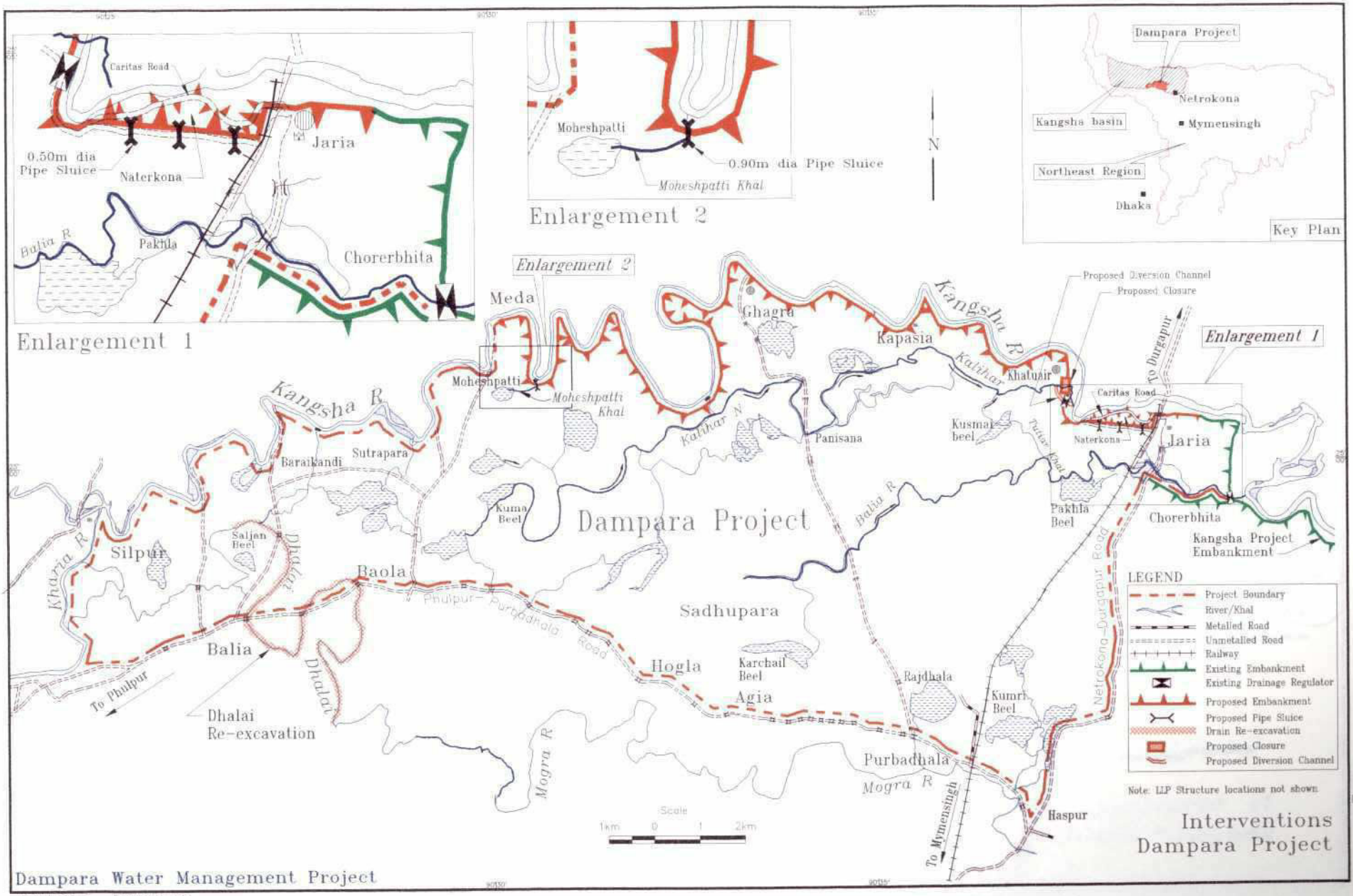

Enlargement 1
Caritas Road
0.50m dia
Pipe Sluice
Naterkona
Jaria
Balia R
Pakhla
Chorerbhita
Enlargement 2
Moheshpatti
0.90m dia Pipe Sluice
Moheshpatti Khal
N
Key Plan
Dampara Project
Netrokona
Kangsha basin
Mymensingh
Northeast Region
Dhaka
Enlargement 2
Meda
Moheshpatti
Moheshpatti Khal
Ghagra
Kapasia
Kangsha R
Kalihar
Khaluair
Proposed Diversion Channel
Proposed Closure
To Durgapur
Enlargement 1
Caritas Road
Naterkona
Jaria
Chorerbhita
Kangsha Project Embankment
Kangsha R
Baraikandi
Sutrapara
Kalihar N
Panisana
Kusmai beel
Tuhuri Khal
Pakhla Beel
Balia R
Kuma Beel
Dampara Project
Kharia R
Silpur
Saljan Beel
Dhalai
Baola
Phulpur - Purbadhala Road
Sadhupara
Balia
To Phulpur
Dhalai
Re-excavation
Hogla
Karchail Beel
Agia
Rajdhala
Kumri Beel
Netrokona - Durgapur Road
Mogra R
Purbadhala
Mogra R
To Mymensingh
Haspur
Scale
1km 0 1 2km
LEGEND
Project Boundary
River/Khal
Metalled Road
Unmetalled Road
Railway
Existing Embankment
Existing Drainage Regulator
Proposed Embankment
Proposed Pipe Sluice
Drain Re-excavation
Proposed Closure
Proposed Diversion Channel
Note: LLP Structure locations not shown
Interventions
Dampara Project
Dampara Water Management Project
FILE: M-22.0wg
Prepared by: Jalal

Figure 22

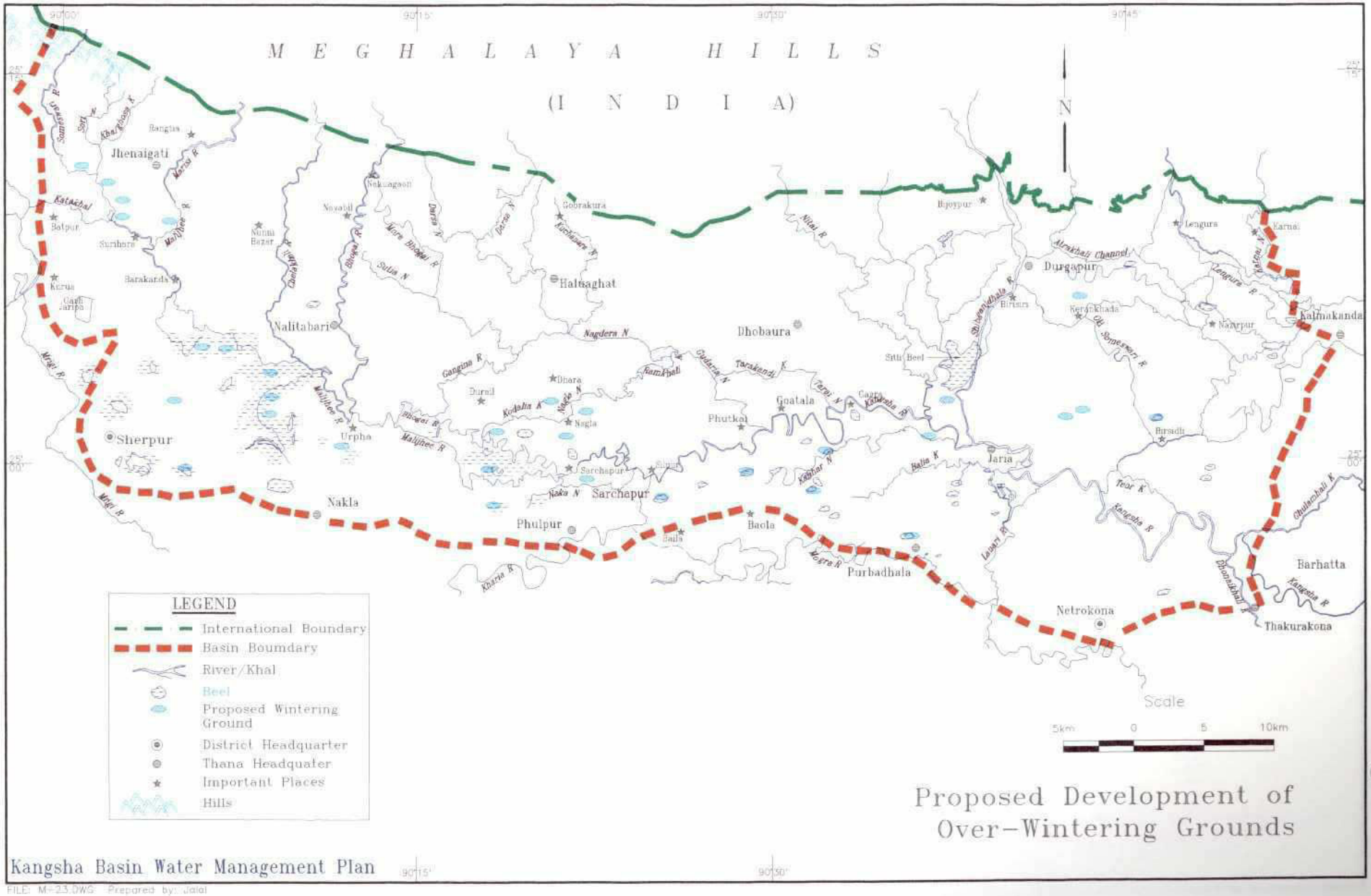
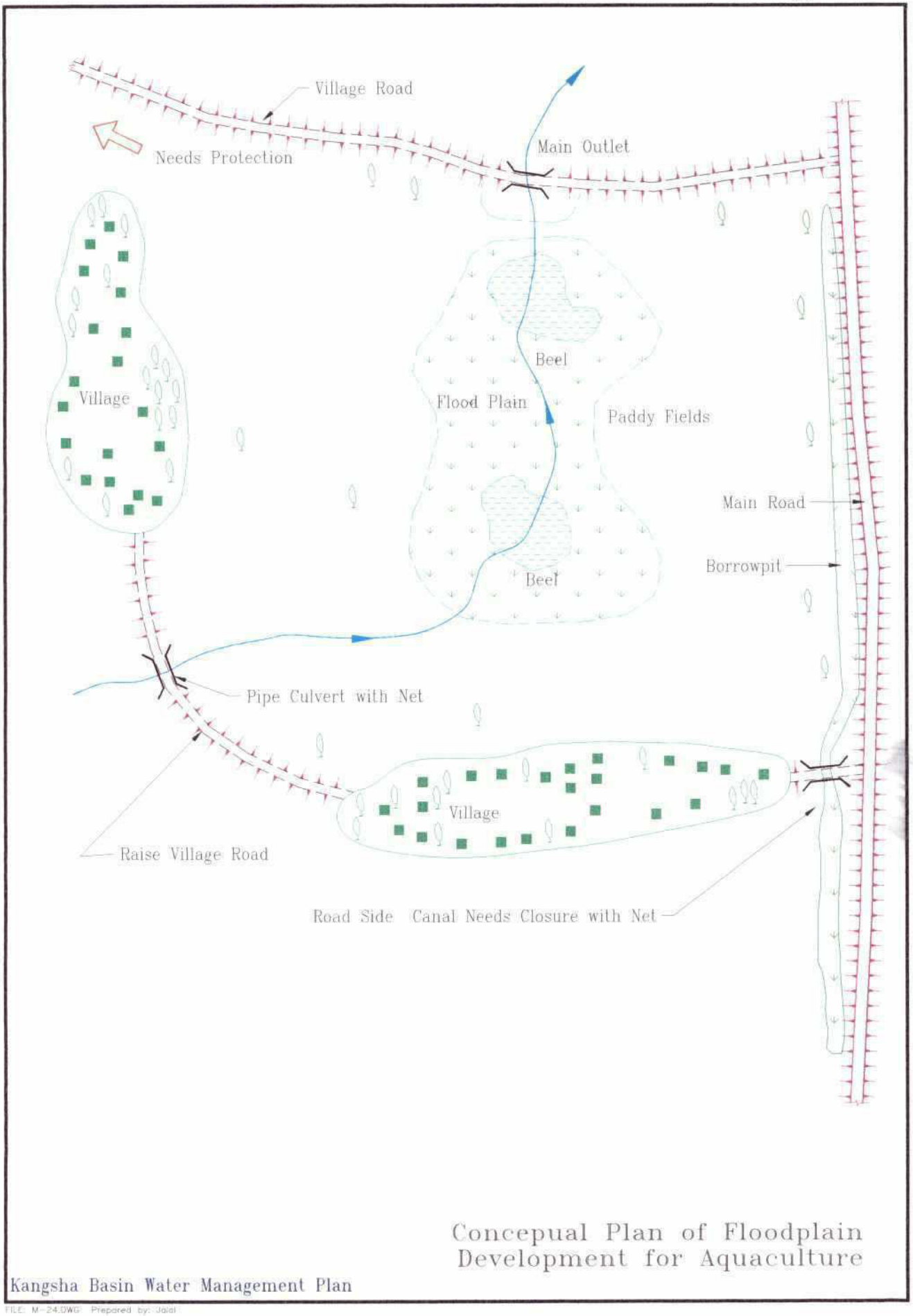

MEGHALAYA HILLS
(INDIA)
N
Jhenaigati
Rangtia
Sherpur
Nakla
Phulpur
Sarchapur
Nalitabari
Urpha
Haluaghat
Dhobaura
Durgapur
Jaria
Purbadhala
Netrokona
Barhatta
Thakurakona
Kalmakanda
Goatala
Phutkal
Bajoypur
Bausi
Baola
Nagla
Dhara
Durail
Nekmagaon
Gobrakura
Nayabil
Nunni Bazar
Barakanda
Batpur
Suribare
Karua
Garo Jaripa
Birsira
Kerakhada
Nazirpur
Bhusadi
Lengura
Karna
Scale
5km 0 5 10km
LEGEND
International Boundary
Basin Boumdary
River/Khal
Beel
Proposed Wintering Ground
District Headquarter
Thana Headquater
Important Places
Hills
Proposed Development of Over-Wintering Grounds
Kangsha Basin Water Management Plan
FILE: M-23.DWG Prepared by: Jalal

Figure 23

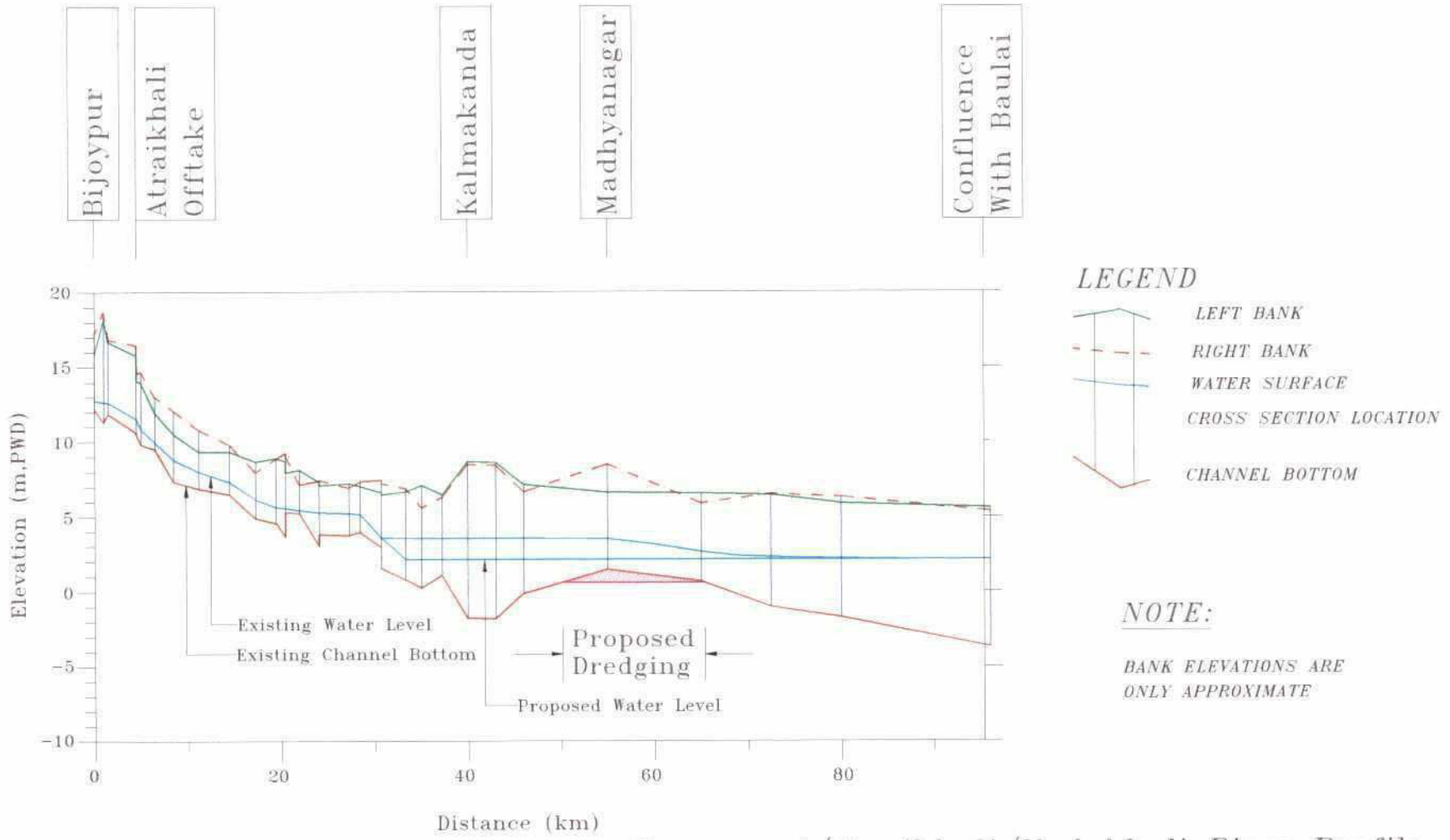
Figure 24



Concepual Plan of Floodplain Development for Aquaculture

Kangsha Basin Water Management Plan

FILE: M-24.DWG Prepared by: Jalal

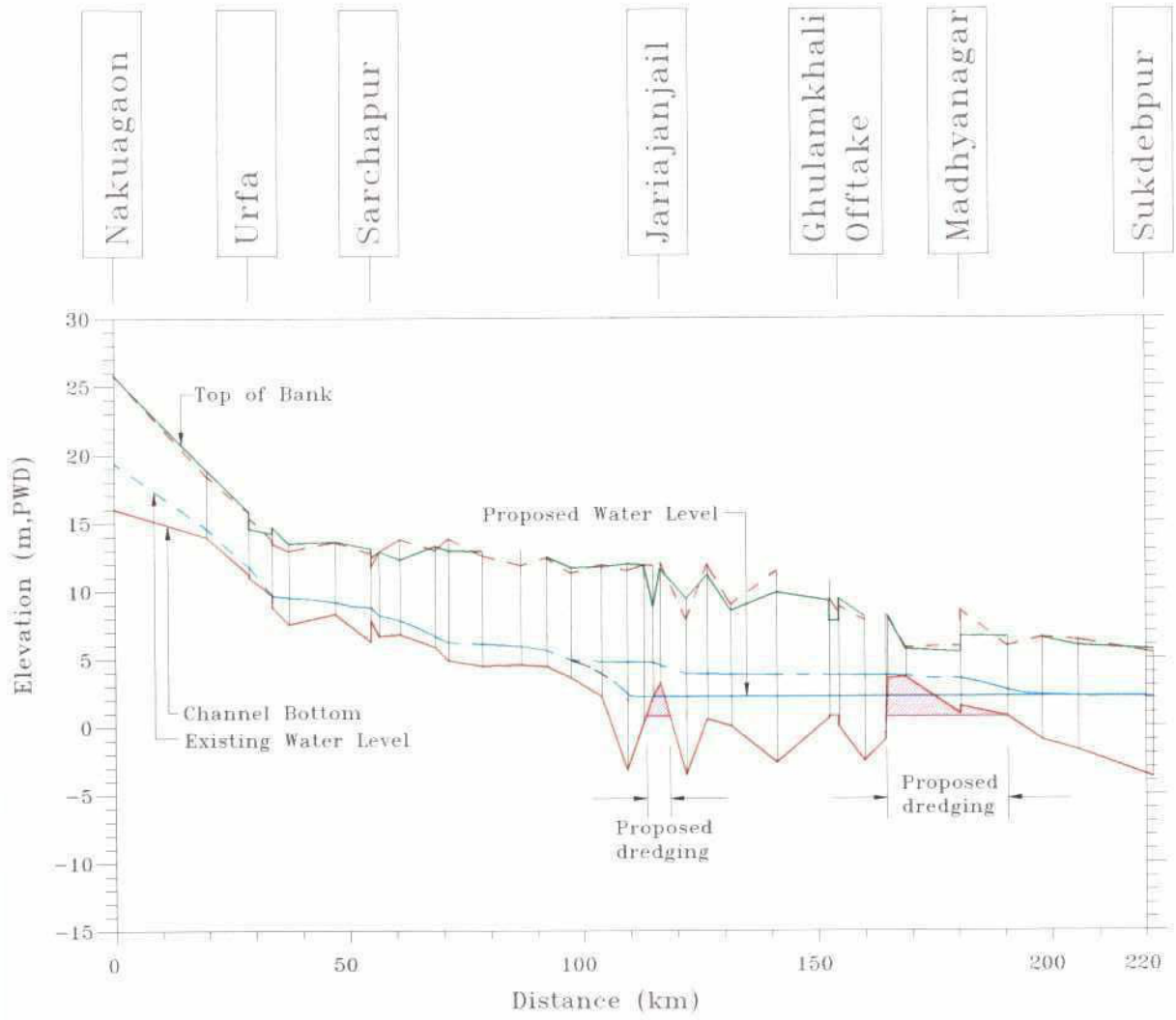


Someswari/Atraikhali/Updakhali River Profile Showing Proposed Navigation Improvements

Kangsha Basin Water Management Plan

FILE: M-25.DWG

Figure 25



LEGEND

LEFT BANK

RIGHT BANK

WATER SURFACE

CROSS SECTION LOCATION

CHANNEL BOTTOM

NOTE:

BANK ELEVATIONS ARE ONLY APPROXIMATE

Bhogai/Kangsha River Profile
Showing Proposed Navigation Improvements

Figure 26

Kangsha Basin Water Management Plan

FILE: M-26.DWG