MACH

Management of Aquatic Ecosystems through Community Husbandry

Hydrology Study Report

February

A project of the Government of Bangladesh
Sponsored by USAID
Project Partners:
Winrock International
Bangladesh Centre for Advanced Studies (BCAS)
Center for Natural Resource Studies (CNRS)
CARITAS Bangladesh

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
ADC	Additional Deputy Commissioner
AC	Assistant Commissioner
AIGA	Alternate Income Generating Activities
AMAN	Rice planted before or during the monsoon and harvested in November or December (B.Aman: broadcasted aman, T.Aman: Transplanted aman
AVRDC	Asians Vegetable Resource and Development Center
BARI	Bangladesh Agricultural Resource Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Center for Advanced Studies
Beel	Deeper area / depression in a floodplain which, if inundated during rainy season, becomes a large sheet of water.
Boro	Rice planted in winter and harvested during April to June
BRAC	Bangladesh Rural Advancement Committee
BRE	Brahmaputra Right Embankment
BUET	Bangladesh University of Engineering & Technology
BWDB	Bangladesh Water Development Board
CARE	Cooperation for American Relief Everywhere
CARITAS	CARITAS Bangladesh (International NGO)
CBFM	Community-based Fisheries Management
CERP-II	Second Coastal Embankment Rehabilitation Project
Charra	Stream
CIMMEYT	International Maize and wheat improvement Center
CNRS	Center for Natural Resource Studies
COP	Chief of Party
CPP	Compartmentalization Pilot Project
CPUA	Catch Per Unit Area
DAE	Department of Agricultural Extension
Daha	Deeper part in Beel / Depression
DANIDA	Danish International Development Agency
DC	Deputy Commissioner (administrative head of a district)
DCF	Department of Fisheries
DFID	Department for International Development
DISTRICT	An administrative unit containing two or more sub district (Thana)
DLRS	Department of Land Record and Survey
DPO	District Fisheries Officer
EGIS	Environmental and Geographical Information System
EMAP	Environment Management Action Plan
F0	Flood Depth from 0 – 30 Cm
F1	Flood Depth from 30 – 90 Cm
F2	Flood Depth from 90 – 180 Cm
F3	Flood Depth from 180 – 360 Cm
F4	Flood Depth from 360 + Cm
FAO	Food and Agriculture Organization of the United Nations
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCD/I	Flood Control & Drainage/Irrigation
FLID	Fisheries & Livestock Information Department
FMC	Floodplain Management Committee
FSMF	Fish Seed Multiplication Farm
FRSS	Fisheries Resource Survey System
GDP	Gross Domestic Product

GIS	Geographic Information System
GNP	Gross National Product
GOB	Government of Bangladesh
GPS	Geographical Positioning System
GRP	Gross Regional Product
Haor	Large depression in a floodplain, inundated during rainy season and become a large sheet of water
HKI	Helen Keller International
HYV	High Yield Variety
ICLARM	International Center for Living Aquatic Resources Management
IFADEP	Integrated Food Assisted Development Project
IPHN	Integrated Public Health & Nutrition Program
ISPAN	Irrigation Support Project for Asia and the Near East
IRS	India Remote Sensing
IUCN	International Union for Conservation of Nature
Jalmohal	Section of River /A semi-closed or closed water body or group of water bodies owned by the Government and are usually leased out for Fishing
JMBP	Jamuna Multi-purpose Bridge Project
Khal	Canals
Kum	Deeper part in the river/ scour holes
LGED	Local Government Engineering Department
LGC	Local Government Committee
MACH	Management of Aquatic Ecosystems through Community Husbandry
Mahajan	Money Lender
MAM	Name of firm
MIS	Management Information Systems
MLGC	MACH Local Government Committee
MPO	Master Plan Organization (Now WARPO)
Mouza	Geographical Unit for Land record and Management
NGO	Non-Government Organization
NSP	National Surveillance Project
NWADP	North-West Agriculture Development Project
NWADS	North-West Area Development Study
NW-DIF	North-West Fisheries Development & Investment Forum
NW-FDP	North-West Fisheries Development Policy
NWFEP	North-West Fisheries Extension Programme
ODA	Overseas Development Administration (UK)
PARISHAD	Council
PIRDP-II	Pabna Irrigation & Rural Development Project, 2nd Phase
PRA	Participatory Resource Assessment
RDRS	Rangpur/Dinajpur Rural Services
RPT	Result Package Team (Project Monitoring and Review Unit of MACH)
RRA	Rapid Rural Appraisal
SADP	Second Agriculture Development Project
SER	South East Region
T Aman	Transplanted rice harvested in November/December
TFP	Third Fisheries Project
THANA	Smallest administrative unit in Bangladesh, Sub-Districts
UFO	Upazilla Fisheries Officer
UNO	Upazilla Nirbahi Officer (Sub – District executive Officer)
UNDP	United Nations Development Programme
UPAZILLA	Sub-Districts
UP	Union Parishad (local government unit)
Uthan baithak	Community level small meeting with members of village households.
WFP	World Food Programme

WINROCK	Winrock International Institute for Agriculture Development
WRMC	Wetland Resource Management Committee
USAID	United States Agency for International Development

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EXECUTIVE SUMMARY

A. OVERVIEW

The overall goal of MACH is to *promote ecologically sound management of floodplain resources (fisheries and other wetland products) for the sustainable supply of food to the poor of Bangladesh.*

Hydrology study is essential for the proper management of wetlands. Change in productivity, fish and other aquatic resources, eco-system and biodiversity largely depend on hydrology regime. Wetlands ecosystem also depends on the upper watershed hydrology. Degraded watershed caused high runoff and less infiltration, which is one of the causes of insufficient water availability in the dry season. Also, the high sediment inclusion from the degraded watershed into the wetlands causing rapid filling of Haor consequently impacting biodiversity and eco-system of the Haor at large. For this reason, from the beginning of the project, MACH has been giving importance to hydrology study of wetlands as well as upper watershed.

The scope of the work included installation and operation gauging stations to measure stream flow and water levels in the Haor/Beel/River, operation of meteorological station to measure rainfall, surveys to convert all recorded water levels to a common datum and sampling of water and sediment. Also, historical data of water levels, rainfalls of the sites has been collected from the WARPO.

B. HAIL HAOR HYDROLOGY AND WATER RESOURCES

Before the MACH project intervention in Hail Haor there were some other projects undertaken in the site. First feasibility study of Hail Haor Irrigation Project was conducted by the Consulting Engineer with the assistance of Berger Associates, USA in 1967. Another report was prepared in 1976 based on the first feasibility study. Then in 1980, a report presents the results of a review of the feasibility and definite project report on the Hail Haor Irrigation project prepared in 1976. The main physical components of the plan were flood protection, drainage improvement and irrigation.

Stream System and Characteristics

Total catchment area of Hail Haor is around 60,000 Ha. The Bilashi Chhora with a drainage basin area of about 12,600-hectare (21% of the total Hail Haor catchment area) is the largest stream tributary to the Hail Haor. Approximately 40% of this catchment lies in India. The second largest stream is the Udna, which has a catchment area of about 8,600 hectare. Other large and dominating Chhoras are Gabur, Shaon, Sial, Jag, and Kai on the eastern side and Alia, Boula, Por, Boro, Patria on the western side of the Hail Haor.

The largest river north of Hail Haor is the Kushiyara River. The Barak River, the principal source of the Kushiyara River has a drainage basin of about 2,590,000-hectare, around 40 times larger than the Hail Haor drainage area. Monu River is a tributary of the Kushiyara River. Its principal tributaries are the Dholai or Doloi, which collects the drainage from Rajkandi and Balishira ranges of hillocks. Shaka Borak River and Kamarkhali Khal, which passes through Boro Haor, north of Hail Haor, connect the Kushiyara River with Gopla River.

Hydrology Overview

Rainfall

Average annual rainfall over the Hail Haor is around 2200 mm. Rainfall analyses showed that the dry season of the year 2000 has received much rain than the year 2001. The early rainfall of March hampered project intervention works like re-excavation of beels. However, 2001 dry season was normal as usual.

Water level

Water level analyses showed that water remains very little in the dry season but there is a sharp rise of water from May. Peak level occurs in between July and August. In the dry season, 1999, water level was very low; draught prevailed for a long time leaving some small pockets of water in the Haor.

Water Area

A bathymetry survey was conducted for the Hail Haor in December 1999 to prepare DEM of the site. The result of the DEM run is presented in the report, which is prepared by the GIS division of BCAS. Monthly average flood extent of the Hail Haor has been analyzed. The water extent of the haor at the lowest water level of April was around 3000 hectare whereas the maximum extent in August was 12,000 ha. This monthly analysis will be continued to correlate fish catch with the arial extent.

Stream Discharge

22 Chhoras of Hail Haor were monitored from Nov 99 to Oct 2000. Analyses showed that Maximum flow occurred in the month of June when total discharge was 31.66 cubic meter/sec. Lowest flow (3 m^3/s) remained in the month of February/March. The cause of insignificant flow in the dry season identified as the lower rainfall and the withdrawal of surface water for Boro rice cultivation. It is also depicted from the monitoring, 25% of total yarly flow persists in the dry season. Some Chhoras like Ichamati, Patria, Alia, Aam, Shial, Kakia and Khai have very low contribution in the dry season flow in compare to the their respective yearly flows.

Sediment load

Sediment load of Chhoras have been analyzed. It is observed from the analyses that the Bar, Boula, Joita, Alia carry considerably big volume of silt (1500 to 2600 tons) in the wet season. On the other hand, Bilashi contributes around 24% of the total sediment loading. However, the Bilashi catchment is around 20% of the total Hail Haor watershed.

Rate of soil erosion of different Chhoras sub-watersheds were also analyzed. This is derived in mm for different Chhoras sub watershed from the total volume of suspended sediment contents in the monsoon of 2001 dividing by the corresponding Chhora sub watershed area. Analysis shows that the Jag watershed is the most degraded watershed followed by Shial Chhora. Dewa, Shial, Jag and Khai are the eastern side Chhoras of Hail Haor show high soil erosion rate whereas among the western side Chhora like Joita, Alia, and Boula show high rate of soil erosion.

C. TURAG-BANGSHI FLOODPLAIN

Turag-Bangshi river basin is in the North Central Region (NCR) of Bangladesh. This region is bounded by Jamuna, Padma, Old Brahmaputra and the Sitolakha river: Jamuna on the west, Old Brahmaputra on the north and northeast and Sitolakha on the east. Other important waterways are the Dhaleswari-Kaliganga River, which crosses the southwestern part of the region. Besides these main rivers, the region is drained by many rivers, such as Bangshi, Pungli, Banar etc.

Typical of most low-lying floodplains within Bangladesh the Turag-Bangshi River runs through the site with beels on either side of the river. At the beginning of the rainy season, as floodwaters enter the upstream portions of the Bangshi, water spills over the riverbanks through canals or khals that connect the river to those adjacent beels. Fish, for the most part, move from the rivers to the beel/floodplain areas for spawning or nursing and then into the deeper perennial portions of the beels or back into the river as water recede after the rains. Due to the dry season reductions in water levels caused by mainly Farraka Dam in India, ground and surface water extraction for boro rice irrigation and reduced flows due to deforestation in local and upper-water shed areas dry season water levels in the local rivers and beels are much reduced. In drought years flows cease in the formerly perennial Turag with water and fish only remaining in river pools (called 'kum') and in the deepest portions of the beels (called 'doha'). Annual fish production is dependent in large part on the breeding populations remaining in those kum and dohas.

Within the Turag Site a total of 26 beels exist and have a water surface area of approximately 10,000 hectare at full flood, which is reduced to less than 700 ha at the end of the dry season. The Turag River runs for approximately 30 km and another 28km of khals exist within the site.

Hydrology Overview

Rainfall

Rainfall during the December to March period equals to 2 to 3% of the annual total. In the pre-monsoon period from March-May, 20-25% of the annual total occurs. Also during this period temperature rises to a maximum of over 40 °C. The southwest monsoon begins in the month of June and lasts until October and the rainfall during this period is convective. During this season heavy rainfall occurs over the whole region, relative humidity remains very high. Total annual rainfall shows a minimum value at 1400 mm around Tangail.

Historical Water Levels of Bangshi River

Bangladesh Water Development Board (BWDB) has been monitoring the water level at Kaliakoir and Mirzapur Upazila on the Turag-Bangshi River. Average daily water level has been monitored since 1950 without considering the tidal effect in the river.

Analyses showed that before 1970, dry season and wet season water levels show a normal trend. However, after the year the yearly lowest flows are trending downward while the yearly maximum flows are trending upward. The lowering of flow in the dry season is mainly due to the Farakka barrage impact, deforestation at the upper reach, intensive Boro-rice irrigation, etc. The Farakka barrage has had a significant impact on the major and minor rivers of the region since the barrage began operating after 1970.

Tidal effect in the Turag River

The Turag River has been more heavily influenced by the tide during the last two decades particularly during the dry season. This is due to the lowering of flow in the river during the dry season. Turag is connected with Meghna River through Tongi Khal and the Lakhya River and is also connected with Padma/Ganges through Buriganga.

BWDB data of water levels of Tongi khal and the Buriganga River has been analyzed. Tongi khal has an upward trend for its maximum water level after 1970 whereas Buriganga shows a stable trend. During the last 30 years, the tidal level of Tongi khal in the dry season has increased by approximately 40cm. Therefore, it can be concluded that the tidal effect in the Turag is likely to be caused by the Lakhya River, which is connected with Turag through Tongi Khal.

Water Level Variation in the Beels

The water levels of Mokas Beel usually increase sharply from the end of June and begin to decrease from September. Turag has higher water levels in wet season of 2000 than the 2001. It is also observed that the river experiences tidal effect in the dry season, January to April. In the dry season, Turag virtually has no flow, and it dries to a series of pool, which have been used as dry season refuge of fish.

Inflow and outflow of Mokas beel

Inflow and Outflow of Mokas beel were monitored during the year 2000 and 2001. In 2000 (Jun-Aug), days of inflow from Turag River to Mokas Beel were 15 whereas, in 2001 (Jun-Aug), days of inflow from Turag River to Mokas Beel were 31. Number of Inflow-days is higher in the year 2001 because of the higher water level in the Turag compared to Mokas beel and, the less intensity of local rainfall.

Water Issues

Turag-Bangshi Rivers
By the end of 1999 dry season, portions of the Turag/ Bangshi River had dried to a series of pools. Water no longer flowed in this formerly perennial river. Out of 26 beels in the area, only Kalidaha retained some water. Water shortage in the dry season is the result of a combination of factors including deforestation in the upstream forests and riparian zones, excessive water extraction for 'Boro' rice irrigation and the Ganges upstream barrage at Farakka.

Mokas Beel
Mokas beel lacks dry season water. Mokas is fed by rainwater from its catchment and the Turag River during the monsoon. A large portion of the Beel drains to the Turag at the end of Monsoon. Only a small portion remains in the Beel. The farmers of the surrounding area extract water from the Beel for their Boro field irrigation. An additional problem at this site is industrial pollution from industries on the Dhaka-Tangail Highway. This includes raw wastes from tanneries and garments.

Aola beel
Aola Beel also exhibits dry season water deficits. Farmers surrounding the Beel use shallow pumps to extract water for their Boro rice irrigation, and limited water is retained in the Beel in the dry season. Average water depth in the deepest part of the Beel is around 5m in the wet season and retains only a few centimeters in the dry season. It has been a general practice for some years to construct earthen dam on the connecting canal to store monsoon water. These dams have been disputed by parties who did not see it to their benefit. People living downstream of the dam are deprived of the stored water and hence they were against the dam construction.

Water Extraction
During the 1999 dry season, a survey was conducted on water extraction from the river. It was found over the 30 kilometer section of the river within the project that an estimated 80 pumps were operating, each with a capacity of 6 HP to12 HP. Based on information gathered from pump operators these pumps are run for 12 hours per day over a period of three months. If correct this would amount to a daily extraction of 172 million liters of water. Total extraction from the river over that period would then amount to 155 billion liters of water. This does not include water extracted from deep tube wells operating in the area.

D. UPPER KONGSHAW-MALIJHEE BASIN

The upper Kongshaw-Malijhee basin is partly situated on the Meghalaya Fan and on the Brahmaputra floodplain. Alluvial fans are generally found along the Meghalaya foothills which are located along the northern border of the basin. The Old Brahmaputra floodplain land consists of sediments that were laid prior to the Brahmaputra River's avulsion in the 18th century. The topography slopes from the northwest to the southwest with land elevations varying from 31.5m, PWD to 5.0 m, PWD.

The Sherpur project site is a flash flood prone area. The farmers of the site suffer repeated heavy damage of their crops by the flooding from Shomeswari, Malijhee and Chellakhali Rivers. Flash flood occurs in these rivers more than once per year and spills over a large portion of the project area.

Flash flood discourages the use of the intensive pond aquaculture in the area. Continued flood damage to the monsoon crop would force farmers to shift to dry season boro. The resulting increasing in abstraction of surface water and groundwater for irrigation would cause damage to wetlands and environment during the dry season.

Hydrology Overview

Areas under study by the project include water levels at seven stations in the rivers and one rainfall gauge at Tinani Bazaar. The water level gauges are at 1. Dholi beel, 2. Malijhee River, 3. Chellakhali River, 4. Kapasia Bridge, 5. Baitkamari bridge, 6. Kewta beel and 7. Tenachura khal.
The Kapasia and Baitkamari stations considered as the outlets of the river system. Once Kongshaw-Malijhee basin fully drained to Shomeshowri river of Netrokona District but it has been changed recently. Shomeshowri River at Jhenaigati Upazila is characterized as Pagla river (mad river) for its nature of changing course. It has already changed three courses and is flowing in a new channel. The river flows over several beels and meets with Malijhee River at Paglarmukh, a place on the Sherpur-Jhenaigati road. Around 6/7 years before it was the normal course of flow. However, due to the siltation at the Paglarmukh and re-excavation of Tenachura khal at Sreebordi Upazila, Shomeshowri River diverted from Paglarmukh to Tenachura khal. A significant portion of the Shomeshowri River flows to Tenachura. Tenachura khal is connected with Mrigi River, a tributary of Old Brahmaputra River.

Climate: There are no climatologically stations within the basin other than MACH rainfall station. Mymensingh climatological station, though located outside the basin, is the nearest relevant station. Maximum temperatures in the area vary from about 29°C to 40°C with the highest temperatures experienced during the period between March and October. Minimum temperatures range between 16° C and 20° C.

Evapotranspiration: Annual potential evapotranspiration as measured by BMD at Mymensingh is 1506mm with the lowest monthly amount in December (87mm) and the highest monthly amount in April (162mm).

Rainfall: There is an increasing trend of rainfall from south to north of the area. The mean annual rainfall varies from 2800mm to 4400mm. One rain gauge is placed at Tinani bazar in Jhenaigati union. The reader has been keeping daily rainfall records since September 2000. Virtually there was no rain in the dry season, from Jan-April 2001.

Prioritization of Beels for MACH Management Activities

Rapid sedimentation is a problem in Sherpur site. Siltation rate of some beels are very high compared to others. Therefore, in the beginning of Sherpur site activities, considering the sustainability and effective future management MACH decided to concentrate in those beels which have low siltation rate. To prioritize the beels of the system on the basis of siltation, a survey was conducted in September 2000. Beels were prioritized considering the channel network, source of sediment and distance from the channel, deposited bad materials, etc. Also local peoples opinions were highly considered in this regard.

E. SPECIAL STUDY

- ***Feasibility Study of Reopening of Shaka Borak River***

MACH intends to increase natural production of fish and other aquatic biodiversity through ecological management of wetland habitats with active participation of local community. One of the objectives of MACH is to reestablish lost connectivity among the diverse wetland habitats for free movement of fish and other aquatic organisms. Once Hail haor was connected with Kushiyara River and was rich in fish production especially riverine species of fish. However, fish production reduced substantially due to the loss of connection.

Therefore, MACH has taken initiative to study the feasibility of re-establishing connectivity between Hail Haor and Kushiyara River and thereby ensure increased fish production and biodiversity in Hail haor.

Background of Kamarkhali sluice gate construction

The Pakistan water development board had conducted a study on Hail haor and Boro haor during the year 1963 and 1964 aiming to protect the area from the early spring flood and facilitate the area with irrigation. It was concluded in the report as follows:

"1. Damage to harvestable Boro crops in the Hail haor, Boro haor and in the adjacent area, during early spring floods are primarily due to the backflow from Kushiyara through Shaka Barak.

2. For the present cropping pattern, the present drainage efficiency is adequate for post-monsoon drainage. During the spring floods, however, the drainage efficiency of the Gopla River is low due to the backflow from Kushiyara through Shaka Borak and there is drainage congestion.

3. In order to save, damages due to spring floods, a control structure at the intake of Shaka Barak is necessary."

The drainage outlet of the Hail haor is the Gopla river which flows first northward, then swings south-west into the Gunjajuri haor and finally flows through the channel of Ratna river into the Dhaleswari River at a point above a mile upstream of Madna covering a total distance of about 50 miles. It drains not only Hail haor basin but also Gunjajuri haor and Bara haor. The drainage of the area was slow before the construction of sluice gate near Shaka Borak offtake because the capacity of the river was not adequate to drain large volume of accumulation water of the two haors which are fed by number of streams from the surrounding hills and the backflow of Kushiyara.

During monsoon all rivers maintain high stages leaving no scope for gravity drainage for the low lands of the area. In the normal years when early spring floods did not occur and the stage of river Kushiyara was not high, the runoff resulting from the small amount of rainfall on the Hail haor basin is completely drained into the Gopla River which ultimately drains into Surma-Meghna River near Madna.

It is of no doubt that the fish production as well as biodiversity of the Boro haor and Hail Haor will be increased if the lost connection is reestablished through Shaka Borak River. However, the re-opening of Shaka Borak will be devastating without putting a control structure on the river to prevent intrusion of early spring flood of Kushiyara River. The construction of a traditional type under-shot sluice gate will not fulfill our purpose to migrate fish from Kushiyara to Boro than to Hail Haor. A fish friendly spill type gate may be constructed to enhance fish migration.

The only active existing canal connecting Boro haor with Kushiyara is Kamarkhali khal. The existing Kamarkhali sluice is not in favorable condition of fish migration because of its high velocity in the sluice. Therefore, construction of a fish-by-pass is necessary to accelerate fish movement

- ***Watershed Study***

Overview

Hail Haor watershed management plan, prepared by Centre for Natural Resources Studies (CNRS), envisages integrated development of Hail Haor basin and its watersheds spreading over the Satgaon, Foyzabad and Balishira hills ranges of the Sreemongal Upazila of Moulvibazar District. The goal and objectives of the plan is to demonstrate on a sub-watershed scale, improved land and water management practices that are conductive to improving the quantity and quality of water, reducing the sediment inflow into the haor basin, creating congenial habitat for forest-based resources production and long term sustainable utility of haor basin as a productive fishery ground.

In order to achieve the goals and objectives of the program, regular monitoring would be required and conducted. Two types of hydrology monitoring have been conducted; 1. General hydrology monitoring comprising discharge, sediment load, rainfall monitoring at a lower frequency of the representative 20 Chhoras of the entire Hail haor system, and 2. Intensive hydrology monitoring of selected two Chhoras sub watershed, Joita and Jag, at a higher frequency to characterize rainfall-runoff and sediment loading relation of different land use pattern. This section will cover the intensive monitoring only.

For intensive hydrology monitoring, both the Chhoras were divided into three sub watersheds. The divisions were done mainly on the basis of land use.

Rainfall

The presence of two hills, Shatgaon and Balesera hills on the west and east side of the Hail haor influence the local rainfall pattern. The orographic effect on the Joita Chhora watershed causes more rainfall than the Jag Chhora watershed.

Rainfall and Flow

Hilly streams are usually flashy in nature. Both Jag and Joita Chhora flash in a small rain. One-meter rise in water levels usually occur in a half an hour moderate rainfall. To catch this peak flow intensive monitoring of three hours interval was conducted. General monitoring exclude this situation. Discharge at all sections of Joita Chhora increased sharply with rainfall and dropped after the rain. However, in the Jag Chhora at the upper reach run-off don't occur quickly as the rainfall intensities. This is because of the dense forest cover of the Lawa hills, upper reach of the Chhora.

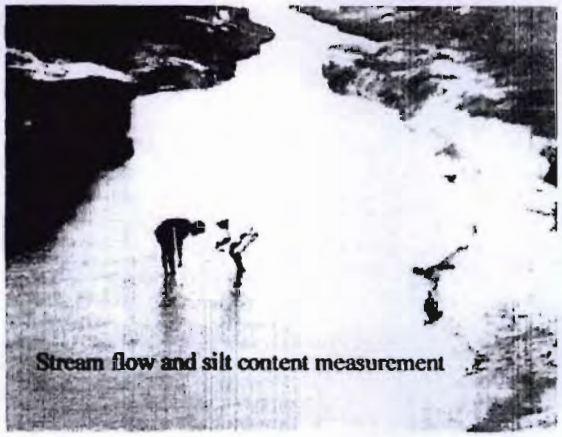
Sediment Loading

Joita Chhora: For better understanding, silt content per 1000 m3 of water was computed. Percentage of silt in the flowing water was almost same in the Tea road section (middle reaches) as well as Lemon garden section (upper reaches). Analyses also show the same tendency of increased silt contents with rainfall event. On the other hand, metal road section (lower reaches) varied with others. The change of silt content didn't follow the rain event always. Silt content was higher in this section compared to other sections mainly due to the land use of the surrounding area, bank erosion at many places along the channel reaches. General land use of the section is mainly homestead garden, potato and other vegetable garden. Soil erodes easily at this area with a small rainfall event. Also, huge volume of water passes through this section and this causes bank erosion at many places of the channel.

Jag Chhora: Percentage of silt content per 1000m3 of flowing water of Jag Chhora is relatively lower than the Joita Chhora. Also the fluctuation of silt content was quite related with the rainfall intensity. This is because of presence of comparatively good vegetation cover in this watershed.

One of the objectives of the study was to understand the status of sub-watershed in respect to soil degradation. Analyses of the two Chhoras. Joita and Jag, showed high siltation rate. The eroded sediments are carried by the streams and ultimately reaching to Haor, filling beels rapidly. If this process keeps continued for a decade several inches of sediment will be pilled up and many beels will lose their perennial nature and thereby lose habitats. Therefore, sediment intrusion into the haor needs to be stopped immediately.

Activities of Hydrology Study


Stream flow and silt content measurement

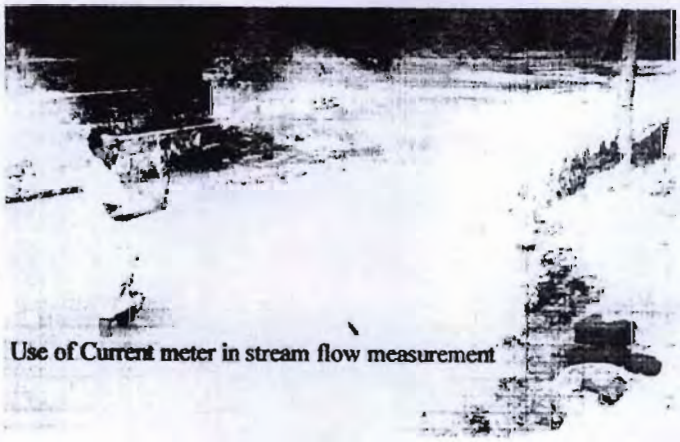
Sediment trap

Water level gauge

DGPS survey

Bench mark

Rain gauge


Use of Current meter in stream flow measurement

Water level gauge

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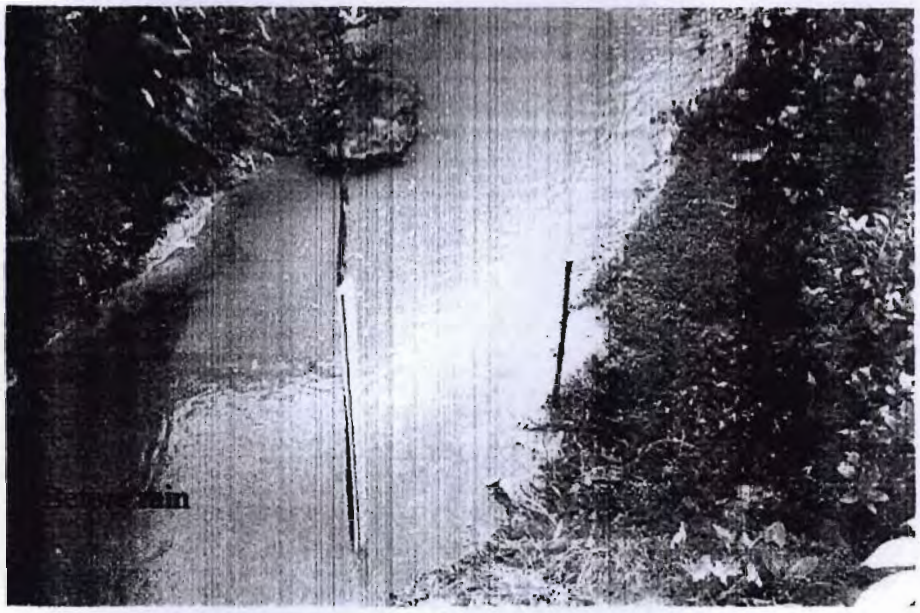

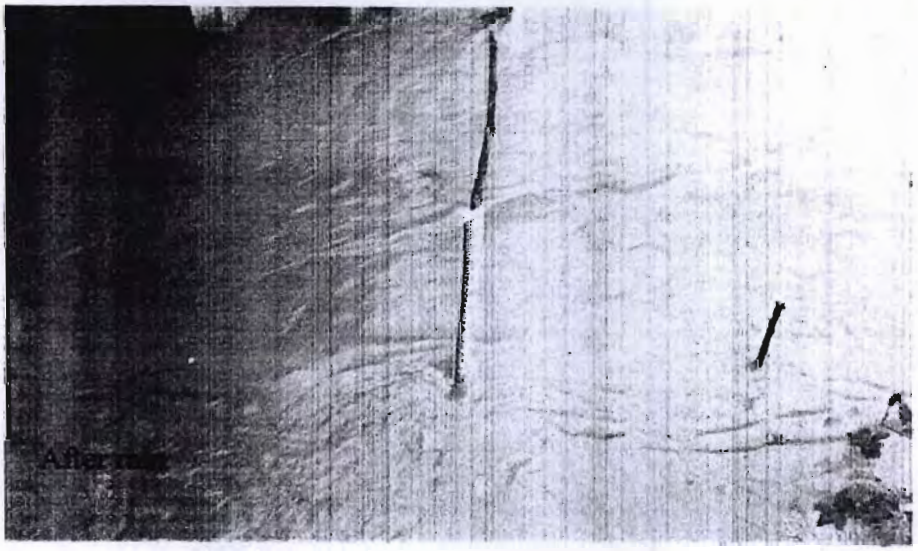

Joita Chora upper reach:
Before and after 8mm of rainfall in an hour

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Management of Aquatic Ecosystem through Community Husbandry (MACH)

Hydrology Report

 # Hail Haor, Sreemongal
 # Lower Turag-Bangshi Floodplain
 # Upper Kangshaw-Malijhee basin

February 2002

MACH Project Office
House 2 (4th floor), road 23/A
Gulshan-1, Dhaka-1212
Bangladesh

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A. INTRODUCTION

BACKGROUND

The overall goal of MACH is to *promote ecologically sound management of floodplain resources (fisheries and other wetland products) for the sustainable supply of food to the poor of Bangladesh.*

The major purpose of the program is to demonstrate to communities, local government and policy makers the viability of a community approach to natural resource management and habitat conservation in Bangladesh over entire floodplains. In many cases this may involve the surrounding watersheds. The 'community' includes all of those people dependent, either economically or nutritionally on the floodplain and its products. The program emphasizes and works with poorer groups, particularly the fishers. It also includes and involves local government as well as the local elite, to make the program truly sustainable.

The MACH project objective is to establish community-based management for the major water bodies within its working area. This local management, that includes resource users, will mainly be based on the indigenous knowledge and local resources blended with the responsibility towards their future generations. Community-based organizations would be formed that will manage their local resources sustainably and in an environmentally sound manner. MACH differs from other community-based projects in that its goal is to increase the sustainable productivity of all floodplain resources—fish, plants and wildlife—over an entire floodplain ecosystem (beels, seasonal floodplains, rivers) and not just in a single water body. Additionally MACH is aware that many of the wetland problems are actually upper watershed issues. At all MACH sites, the project is involved in working with communities to begin to solve or mitigate those problems. Where feasible (and with community support), MACH will consider involvement in watershed problems. Recognizing that the reduction of fishing pressure is likely to be a critical part of reviving the floodplain fisheries, MACH has included supplemental income generation activities that are focused on fisheries and others directly dependent on fishing.

The project supports local communities in forming and then operating their management committees for the overall management of the physical and biological components of selected portions of floodplain ecosystems. MACH emphasizes the conservation and rehabilitation of degraded or lost aquatic habitats. Major physical interventions consider facilitation of aquatic animal movement into and out of the floodplain, re-establishment of dry season refuges (permanent beels and deep riverine kums or scour holes), short term protection to the animal and plant resources (after adequate assessment of need), work with local industries to reduce pollution and, where feasible, work to reestablish watershed function through re-vegetation and other appropriate methods.

WHY MACH NEEDS HYDROLOGY STUDY

Water is essential for all lives and is used in many different ways- for food production, drinking and domestic uses and industrial use. It is also part of the larger ecosystem on which bio diversity depends. Precipitation converted to soil and groundwater and thus accessible to vegetation and people, is the dominant pre-condition for biomass production and social development.

Hydrology study is must for the proper management of wetlands. Change in production, fish and other aquatic resources, bio-diversity and eco-system largely depend on hydrology regime.

Wetlands ecosystem also depends on the upper watershed hydrology. Degraded watershed caused high runoff and less infiltration which is one of the reason of insufficient water availability in the dry season. Also, the high sediment inclusion from the degraded watershed into the wetlands causing rapid filling of Haor consequently impacting biodiversity and eco-system of the Haor. For this reason, from the beginning of the project, MACH has been giving importance to hydrology study of wetlands as well as upper watershed. To know the actual status of the wetlands different parameters have been measured from the beginning of the project and these will be continued for the remaining project period. These include, water levels of wetlands, rainfall, stream flow, sediment load, siltation measurement etc. Fish production is related to water area which is depicted from the water levels and elevation of the Haor bed. The availability of water in the Haor is derived from the water budgeting of the system, which depends on the rainfall, stream flow and water levels measurement. Uppershed soil erosion and the runoff are being measured by the uppershed hydrology study. Sediment inclusion into the haor as well as rate of filling of Haor is also quantified in the hydrology study.

B. METHODOLOGY

The purpose of the report is to describe the hydrology and water and sediment loading of the MACH site specially Hail Haor site and the hydrologic interaction of the fish resources with the surrounding floodplain. To meet these objectives the following steps were undertaken:

1. Stream flow and water levels were monitored to know the flood extent and the volume of water entering and leaving the wetlands
2. Transfer of water in and out of the Hail Haor were summarized in the form of water budgets to quantify the adequacy of the current freshwater in the system.
3. Quantify the sediment intrusion into the Haor resulted from the degraded upper watershed

The scope of the work included installation and operation gaging stations to measure streamflow and waterlevels in the Haor/Beel/River, operation of meteorological station to measure rainfall, surveys to convert all recorded water levels to a common datum and sampling of water and sediment. Also, historical data of water levels, rainfalls of the sites has been collected from the WARPO.

At the three sites of the project, MACH is monitoring various hydrology parameters described below and these are being used for analyzing project impact.

Hydrology Monitoring at Three Sites			
	Sites		
Hydrology Monitoring	Hail Haor	Turag-Bangshi Site	Upper Kangsha-Malijhi Site
Water Levels	√	√	√
Rainfall	√		√
Discharge of River/Stream	√		
Sediment load	√		
Sediment deposition rate in the Haor	√		
Inflow and Outflow of Beels	√	√	

DATA COLLECTION PROGRAM

Field data were collected to furnish estimates of relevant surface-water, water extent, sediment load, etc. Surface water and water extent are useful and important factors in fish production. Also sediment load measurement gives an idea of soil erosion rate of upper watershed and the rate of filling of the wetlands. The stations that make up the fixed data-collection network are listed in **table 1**.

Table 1: Fixed data-collection stations and benchmarks included in the hydrologic and meteorological data network at Hail Haor, Turag Bangshi basin and Upper Kongshow-Malijhe basin.

Hail haor, sreemongal

Sl. No.	Station	Station type	Location Description	Type of measurement	Operation starting date
1	Cheoradubi beel	Stage gauge	West-Center of Hail Haor	Daily water level	May, 1999
2	Nowa beel	Stage gauge	South of Hail Haor	Daily water level	April, 2000
3	Jethua beel	Stage gauge	North-east of Hail Haor	Daily water level	April, 2000
4	Shomsergonj Br.	Stage gauge Flow meter	North of Hail Haor	Daily water level Discharge measurement	Oct, 1999
5	Bhunobir	Rain	West of Hail Haor	Daily rainfall	June, 1999
6	MACH office	Rain	East of Hail Haor	Daily rainfall	May, 2000
7	Joita metal road	Stage, Flow	West of haor, near the metal road bridge	Water level Discharge measurement	1999
8	Joita Tea road	Stage, Flow	Middle of Joita chora	Water level Discharge measurement	2000
9	Joita lemon road	Stage, Flow	Upper reach of Joita chora	Water level Discharge measurement	2000
10	Jaag Lawa hill	Stage, Flow	Upper reach of Jaag chora	Water level Discharge measurement	2000
11	Jaag metal road	Stage, Flow	Middle reach of Jaag chora	Water level Discharge measurement	1999
12	Jaag Haor	Stage, Flow	Lower reach of Jaag chora	Water level Discharge measurement	2000
13	Boula chora	Stage, Flow	Metal road br.	Water level Discharge measurement	1999
14	Alia chora	Stage, Flow	Metal road br.	Water level Discharge measurement	1999

1	Nowa beel	Lalbag Village	24°19′ 37.113″	91°42′ 17.04″	4.49155 m
2	Jethua beel		24°24′ 15.50″	91°42′ 56.601″	5.5306 m
3	Boulashir	Boulashir Vill.	24°22′ 46.074″	91°39′ 29.135″	3.02968 m
4	Shomsergonj	Shansergonj br. top (railing)	24°27′ 53.564″	91°38′ 11.3814″	11.5627 m

Lower Bongshi-Turag basin, Kaliakoir

Sl. No.	Station	Station type	Location Description	Type of measurement	Operation starting date
1	Mokas beel	Stage gauge	Tinani bazar village	Daily water level	June , 1999
2	Turag river	Stage Inflow and outflow	Near Bori bari village	Daily water level, inflow and outflow to Mokas and Aola beel	April, 2000
3	Aola beel	Stage gauge	Medi asulai village	Daily water level	June 1999

1	Mokas beel	Taltali bazar, Sharkar para	24°04' 55.507"	90°16' 12.225"	4.89 m
2	Turag river	Top of bridge foundation	24°05' 56.000"	90°16' 11.18"	2.7794 m

Upper Kongsho-Malihjee basin					
1	Dholi beel	Stage gauge	Jhenaigati UZ	Daily water level	
2	Malijhee R.	Stage gauge	Near Tinani bazar bridge	Daily water level	
3	Chellakhali R.	Stage gauge	Chellakhali br., Nalitabari	Daily water level	
4	Kapashia Br.	Stage gauge	Nalitabari br.	Daily water level	
5	Baitka mari Br.	Stage gauge	Sherpur	Daily water level	
6	Tinani Bazar	Rain gauge	Tinani bazar	Daily water level	June 2001
7	Kewta beel	Stage gauge	Bakerkanda Village	Daily water level	
8	Votpur br.	Stage gauge	Votpur bazar, shreebordi UZ	Daily water level	June 2001
9					

1	Dholi beel	Jhenaigati UZ	25°09'48.83126"	90°02'22.58309"	17.52
2	Malijhee R.	Tinani Bazar	25°06'55.25503"	90°04'57.11251"	23.4713
3	Chellakhali Br.	Nalitabari UZ	25°03'52.34260"	90°07'30.54369"	19.82299
4	Kapasia Br.	Nalitabari UZ	25°03'39.02108"	90°10'52.75573	20.48431
5	Baitkamari Br.	Sherpur	25°01'59.33067"	90°10'10.88106"	20.33977

INSTRUMENTS USED

- **Raingauge :** Manual stainless steel raingauges were used. Measuremnt were taken on daily basis and in some cases 3 hourly basis

- **Water Level:** Manual wooden meter gauges were installed in the sites. Reading were taken on the daily basis and in some cases 3 hourly basis

- **Stream Flow:** Current meter was used. In general, 'Float' method was adopted to measure flow velocity of streams and the measurement were calibrated with the *Current meter* reading.

- **Sediment Sampling:** Standard sediment sampler has been used (model 5200, DH-48 Sediment Sampler). Usually 1-litter plastic bottles have been used to collect water sample during discharge measurement. Dh-48 Sediment sampler has been used randomly at different site to calibrate or standardize our technique. Collected sample is filtered and dried up and then balanced in a electronic balance to get the specific weight.

SECTION 1: HAIL HAOR HYDROLOGY AND SEDIMENTATION PROCESS

1.1 INTRODUCTION

1.1.1 DESCRIPTION OF THE BASIN

The word *haor* is believed to be a corrupted form of the Sanskrit word *Shagar* (sea) or the Arabic word *Bahar*(sea). There are 35 big haors in the Sylhet Division, some of which merge with one another. The Hail Haor is a low-lying depression, 'Beel' located about 3 km northwest of Sreemongal under the District of Moulvibazar. The Barsijura and Balishira Hills bound the Haor to the east, the Atarmura Range to the south, and the Satgaon Hills to the west. The watershed area of Hail Haor is about 600 square Kilometer (237-sq. mile[1]). All water in the basin originates from the surrounding hills, with approximately 85% from within Bangladesh and 15% from India.

The only natural outlet of the Haor is Gopla River. The Gopla River flows in a northerly direction from the Hail Haor, then swings sharply and flows southwesterly into the Gunjajuri Haor. Gunjajuri Haor drains into Barak River, which flows through Habiganj and enters into Surma-Meghna at Madna. The largest river near the Hail Haor is Kushiyara River. Kushiyara is a branch of the Barak River. Kushiyara flows in a westerly direction for some distance then towards the south and southwest to Fenchuganj where it is joined by the Jury river originating from the Tripura Hills. The Monu River is a tributary of Kushiyara River. Its principal tributaries are the Dholai or Doloi, which collects the drainage from Rajkandi and Balishira ranges of hillocks. Shaka Borak River and Kamarkhali Khal, which passes through Boro Haor, north of Hail Haor, connect the Kushiyara River with Gopla River. Beside these there are numerous hilly streams following into the Haor. Among the hilly streams, Bilashi Chora is the largest stream in the Haor System, making up around 30% of the total catchment area. The entire project area is shown in figure 1.1. The catchment area of different streams is shown in figure 1.2a. The basin area percentage of some Choras in the total Haor system is shown in table 1.1

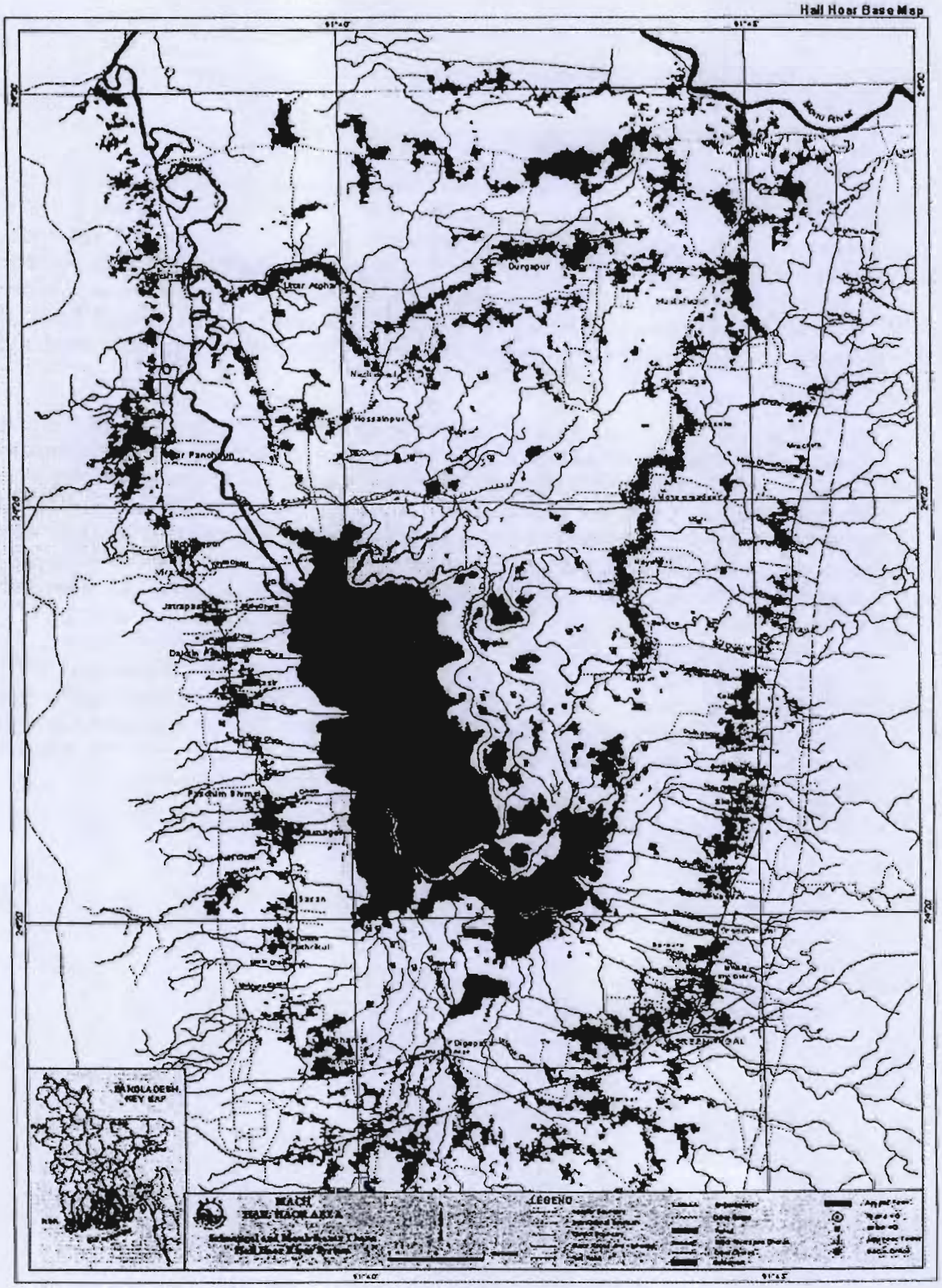

Figure 1.1: Project area of Hail Haor

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Table 1.1 : List of Choras in the Hail Haor System and Their Corresponding Watershed Area.

Choras on the Eastern Side				Choras on the Western Side			
Sl. No.	Chora	Area(acre)	Area (hector)	Sl. No.	Chora	Area(acre)	Area(hector)
1	Sudalia	665	269	23	Udna	21,365	8653
2		960	389	24	Kudali	5036	2040
3	Dud	490	198	25	Alia	1389	563
4		410	166	26	Mukharia	785	318
5	Daya	1,455	589	27	Haira	405	164
6	Bara	546	221	28	Mara	1,235	500
7	Gyasnagar	1,415	573	29		265	107
8		565	229	30	Milua	940	381
9	Narayan	1,125	456	31		365	148
10	Sial	720	292	32	Boula	1,280	518
11	Saon	2,450	992	33	Mota	680	275
12		355	144	34		905	366
13	Chhao	860	348	35	Kaila	295	119
14	Karia	615	249	36		2,005	812
15	Jag	2,540	1029	37		255	103
16	Kai	850	344	38		170	69
17	Janki	1,880	761	39	Banga	1,290	522
18	Shakamura	810	328	40		265	107
19	Burburia	3,610	1462	41		450	182
20	Kakia	1,505	609	42		435	176
21	Ful	4,230	1713	43		690	280
22	Bilas	31,115	12602		Total Area	99,676	40,369
					Additional area		**20,000**
					Total		**60,369**

Source: BWDB, Feasibility Report on Hail Haor Irrigation Project, Vol.1, Annex A: Hydrology, December, 1980

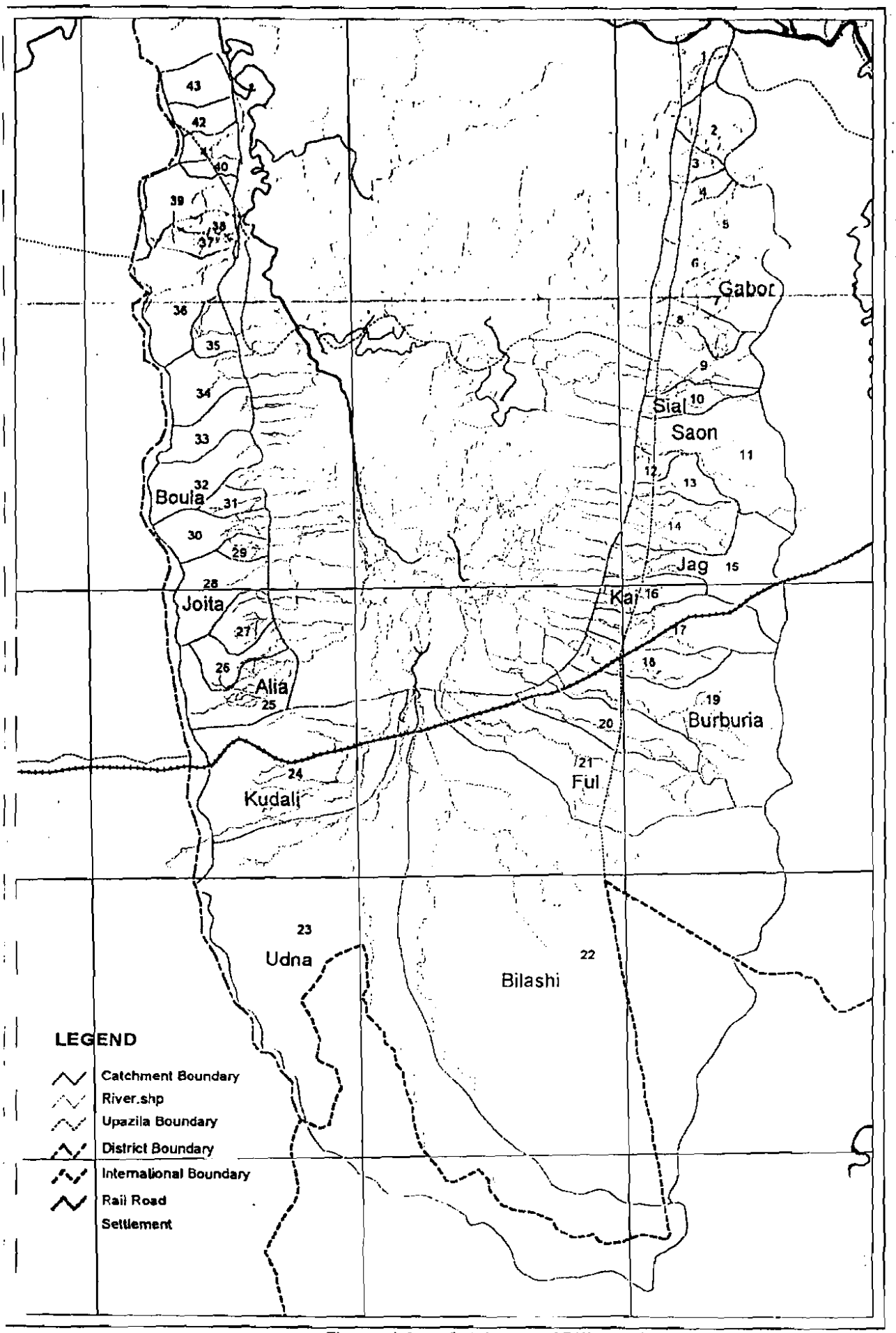

Figure- 1.9a. Catchment of Different Streams in Hail Haor System

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1.1.2 HAIL HAOR: HISTORICAL SETUP

First feasibility study of Hail Haor Irrigation Project was conducted by the Consulting Engineer with the assistance of Berger Associates, USA in 1967. Another report was prepared in 1976 based on the first feasibility study. Then in 1980, a report presents the results of a review of the feasibility and definite project report on the Hail Haor Irrigation project prepared in 1976. This review study was supplemented by additional data collection, new engineering studies and investigations to formulate a number of alternative development possibilities for the project area. The main physical components of the proposed alternative are flood protection, drainage improvement and irrigation.

Kamarkhali Sluice

The land within the project boundaries are sloping to the Hail Haor, from about 25 to 30 ft GTS (Grand Triangulation Survey) along the eastern and south periphery, 50-55 ft GTS along the western periphery and about 25 ft GTS along the northern project boundaries to an unknown elevation in the haor (below 15ft GTS).

In the normal years when early spring floods did not oeeur and the stage of river Kushiyara was not high, the runoff rusulting from the small amount of rainfall on the Hail Haor Basin was completely drained into the Gopla River near Madna. During years when early spring floods occurred, flood water flow backed into Hail Haor from Kushiyara river through Shakaborak and Gopla river and submerged the low-lying lands (elevation varying between 8-15 ft GTS) on the periphery of the Beel where Boro rice was cultivated. During spring, this back-flow created drainage congestion in the Gopla River and delayed drainage of the runoff resulting from the rainfall in the project area. The combined action of the backflow from the Kushiyara and pondage of runoff in the project area caused damage to standing Boro crop on the low-lying areas around the Beel. Therefore, it was concluded that

1. "Damage of the harvestable Boro crops in the project area and in Boro Haor and adjacent area during early spring floods are primarily due to the backflow from Kushyara through Shakaborak.
2. For the present cropping pattern, the present drainage efficiency is adequate for post-monsoon drainage. During spring floods, however, the drainage efficiency of the Gopla river is low due to backflow from Kushiyaa through Shakaborak and there is drainage congestion.
3. In order to save damage due to spring floods, a control structures at the intake of Shakaborak is necessary (Kamarkhali sluice)".

The main physical components of the alternatives development that had been studied were:

Case I: full flood control and drainage improvement
Case II: full flood control, drainage improvement and irrigation

Case I provide protection against flooding from the north (early spring flood from the Kushiyara river system). The main components of the proposal were:

- The north embankment, from Shomsergong to Mouluvibazar.
- a drainage outlet structures on the left bank of the Gopla river at Battala(either by gravity or by pumping)
- excavation and loop cutting of the Gopla

- road improvement

Case II envisages the supply of irrigation water during the winter season, protection against early spring floods from the Kushiyara river system and drainage of the project area during the monsoon season. The main component of the proposal were:

- the north embankment from Shomsergong to Mouluvibazar.
- the Hail haor reservoir embankment
- embankment of both banks of the Lungla river
- The Gopla river embankment
- drainage outlet structure at Pachaun (either by gravity and / or by pumping)
- a pumping station to supply the main canal with reservoir water
- an irrigation distribution system and appurtenant structures
- a main drainage system
- road improvement

Existing Dike on the North and East of Hail Haor

In the main proposal prepared in 1967, it was considered to construct dike around the Haor to serve haor as a reservoir (figure 1.2c). It was written in the report that " a reservoir will be formed by diking the existing beel area and the lower reaches of the Lungla River. The main source of storage water in the reservoir is the Lungla River and its tributaries. The area of the reservoir is 8000 acres with an active storage 112,000 acre-ft."

In the feasibility report of Hail Haor irrigation project prepared in 1980, it was written, "The construction of embankment will ultimately reduce flood fisheries. A deereasing fish cateh is anticipated after project implementation. As fish at present constitutes an appreciable part of animal protein in the diet of the local population, action of the Fisheries Department seems necessary and justified when the project is to be implemented. Regular and continuous production of fry for stocking of the remaining water bodies, tanks and ponds in indispensable."

In mid 80s, implementation works started. According to the project proposal, the following works have been completed so far:

1. Construction of Kamarkhali sluice gate, near 2km offtake of Kushiyara River.
2. The north and east dike inside the Haor. The design and location of construction were changed from its original plan of 1967.
3. Embankment from Shomsergong to Mouluvibazar. It is implemented according to the original plan. This was done only improving the existing road.
4. Improvement of Bhunobir-shomsergon road (metaled road).

Which are not completed yet but was in the original plan:

- Drainage outlet at Pachaun
- Sluice on the Gopla at Pachaun
- Pumping plant for irrigation near Motigonj.
- Irrigation canals

The dike was constructed in the Haor for the purpose of storing water during the dry season. However, drainage facilities outside the dike was considered but not implemented yet. Therefore, a huge volume of water coming through many streams of Balishira Hills is draining out by some openings in the dike. One of the openings is Joinka outlet on the northeast boundary of dike. Joinka canal drains about 10 streams like, Sial, Gabur, Narayan, etc.

Impacts of the Dike and Sluice Gate on the Hail Haor

The construction of sluice gate at the intake of shakaborak has great adverse impacts on the bio-diversity of Hail Haor. The Hail Haor and its adjacent Boro Haor was rich in river fish species beeause of its past good channel connection with the Kushiyara River. After the construction of sluice gate, the early monsoon fish migration from the Kushiyara to Hail Haor through Boro Haor, Gopla river has stopped because the gate remains closed during this time.

The dike inside the Haor has great impact on the hydrology of the Hail Haor. It has obstructed the natural flow of the eastern side choras. It has changed the natural flow direction of eastern side choras. Now, a number of eastern choras flow towards northwest and meet with Joinka gang and the combined flow crosses the dike at a point and drained to Gopla gang. Some other eastern choras flow toward southwest direction and cross the dike at some points. However, in the peak monsoon, water flows over most part of the dike. Also, the channel morphology has been changed by the human interventions. Most of the channel reach has been straightened over time, which is causing rapid runoff of the watershed.

Also the dike has caused the high silt deposition outside the dike. Many perennial water bodies outside the dike have lost their character due to the high sediment deposition.

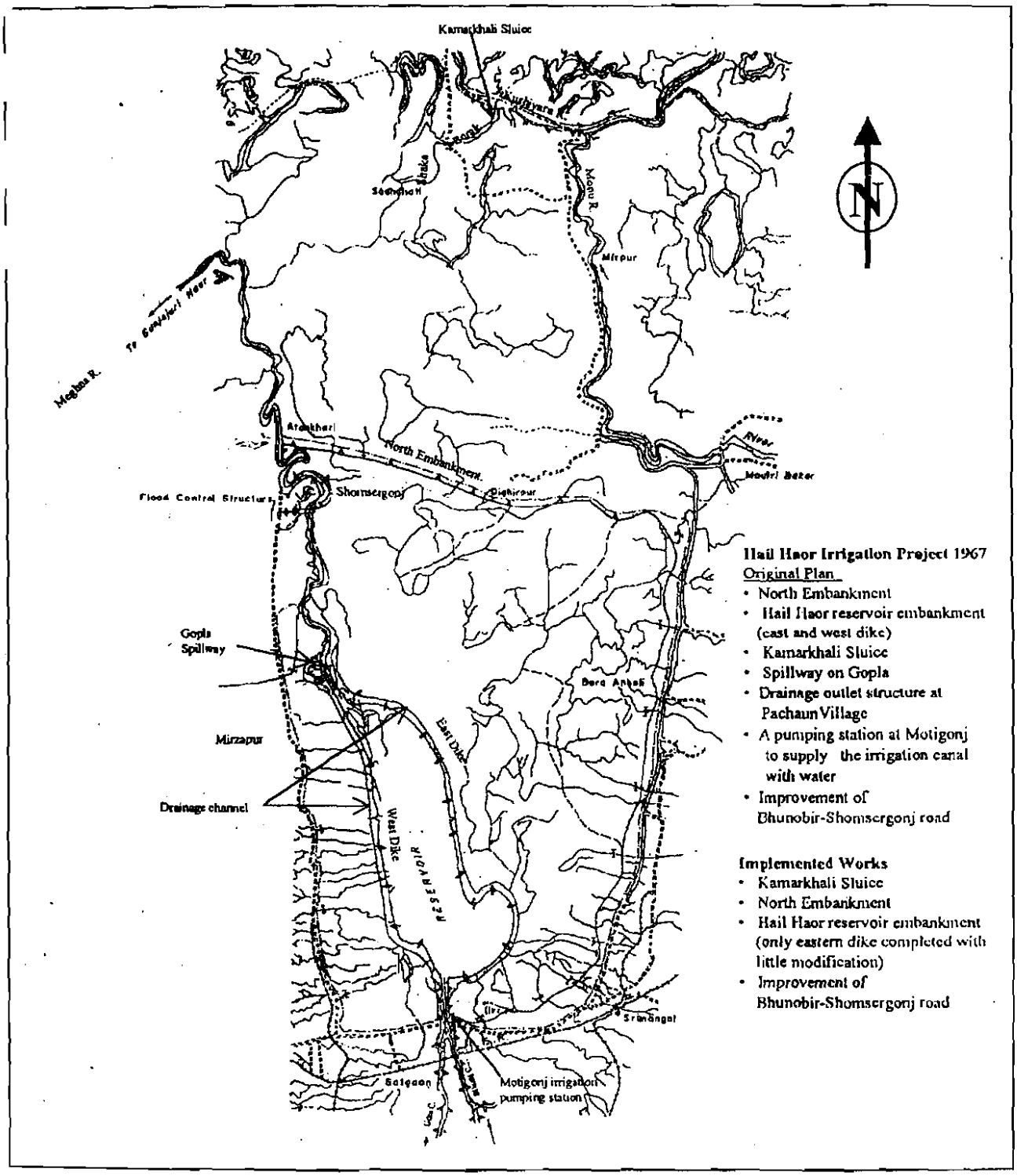

Figure 13: Hail Haor irrigation project plan 1967. It was proposed to construct dikes around the Hail Haor to store water in Haor for irrigation. The Kamarkhali sluice gate and north embankment was proposed to protect the area from early spring backwater effect from Kushiyara. Kamarkhali sluice, north embankment and eastern dike in the Haor was constructed in the 80s.

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1.1.3 STREAM SYSTEM AND CHARACTERISTICS

Total catchment area of Hail Haor is around 60,000 Ha. The Bilashi Chora with a drainage basin area of about 12,600-hectare (21% of the total Hail Haor catchment area) is the largest stream tributary to the Hail Haor. Approximately 40% of this catchment lies in India. It originates in the Atarmura Range at an elevation of about 150 meters and flows north for a distance of about 20 km entering Hail Haor on the south side. The second largest stream is the Udna, which has a catchment area of about 8,600 hectare. Udna meets with Bilashi at Bilashi Bridge on the Dhaka-Sylhet highway and the combined flow becomes the Bilashi. The three other main streams, Kudali Chora, Ful Chora and Burburia Chora, have a combined drainage area of about 5,200 hectare. Other large and dominating Choras are Gabur, Shaon, Sial, Jag, and Kai on the eastern side and Alia, Boula, Por, Boro, Patria on the western side of the Hail Haor. Choras on the eastern side of the Haor originate in the Borsijura and Balishira Hills, flow westward into the Haor. The overall length of the streams range from a minimum of about 2 km to a maximum of 10 km. While the Udna-Lungla-Bilashi system has a length of around 15-20km.

The western Choras originate from Satgaon Hills. The length of these streams range from a minimum of about 1 km to a maximum of about 6km.

The largest river north of Hail Haor is the Kushiyara River. The Barak River, the principal source of the Kushiyara River has a drainage basin of about 2,590,000-hectare, around 40 times larger than the Hail Haor drainage area. Monu River is a tributary of the Kushiyara River. Its principal tributaries are the Dholai or Doloi, which collects the drainage from Rajkandi and Balishira ranges of hillocks. Shaka Borak River and Kamarkhali Khal, which passes through Boro Haor, north of Hail Haor, connect the Kushiyara River with Gopla River.

1.1.4 FLOW PATTERN IN THE HAIL HAOR

Hail Haor is a low-lying depression surrounded by hills on its east, west and southern side. All streams originating from these hills flow towards Haor. The Gopla River, north of the Haor, is the only outlet of the Haor system.

Due to the BWDB submersible dike on the North and East Side of the Haor, flow from the eastern hills does not pass to the Gopla directly. Therefore, from Sial Chora water flow towards north and northwest direction, the combined flow passes through Joinka Gang and Buda Gang. Around 10 streams join with Joinka Gang.

Flow of stream of Shaon Chora and the streams south of it flow in the south and southwest with the combined flow meeting with Bilashi flow. Around 20 streams join with this flow and there are around 50 seasonal and perennial Beels exist in this flow path.

The Gopla flows in the northward direction and the streams originating from the Satgaon hills join with this flow.

1.2 HYDROLOGY

1.2.1 RAINFALL VARIATION IN THE HAIL HAOR

One manual rain gauge is installed at a local High School in Bhunobir union adjacent to the west of Haor. The school monitors the gauge. Another gauge is in operation at the MACH office, east of the Haor. The reason behind installation of two gauges in the Hail Haor site is the rainfall variation over the two parts of the Haor resulted from the orographic effect due to the topography of the area.

Figure 1.4 shows the monthly variation of rainfall in the Hail Haor during the year 1999, 2000 and 2001. Average annual rainfall over the Hail Haor is around 2200 mm. It is observed from the graph that the dry season of the year 2000 has received much rain than the year 2001. The early rainfall of March hampered project intervention works like re-excavation of beels. However, 2001 dry season was normal as usual.

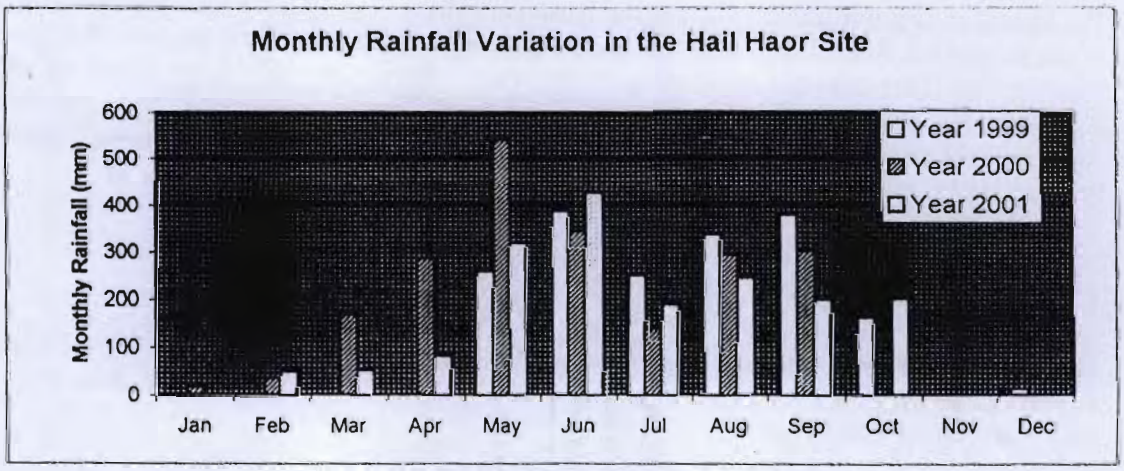

Figure 1.4: Monthly rainfall variation in the Hail Haor site during the year 1999, 2000 and 2001

1.2.2 WATER LEVELS VARIATION IN THE HAIL HAOR

It is very important to know the water level variation inside the Haor for the computation of water area. Besides many other factors, fish catch/production depends on areal extent of the water body. Therefore, in the year 1999, three gauges were installed in the Haor, one in the Cheora Dubi Beel, one in the Beri Beel and another gauge was marked on the pier of Shomser Ganj Bridge, the outlet of Gopla River. Gauge readings have been taken on daily basis since April 99. In the year 2000, another two gauges were installed, one in the Nowa beel in Lalbag village, south of the Haor, and the other in the Jethua Beel, North-east of the Haor. The gauge of Beri beel has been removed because of insignificant variation of water level with Cheoradubu beel. The existing four water level gauges are sufficient to measure water area of the Haor at different seasons. Already monthly inundation maps has been prepared for the year 2001 to compare fishcatch of the corresponding month.

The variation in the haor water level is shown in **figure 1.5a**. **Figure 1.5a** shows that water remains very little in the dry season but there is a sharp rise of water level from May. Peak level occurs in between July and August. In the dry season, 1999, water level was very low; draught prevailed for a long time leaving some small pockets of water in the Haor. However, next year 2000 had comparatively higher level of water. Though the draught disrupted the haor habitats in the dry period if 1999, Haor experienced maximum water level in the wet season comparing the year 2000 and 2001.

Figure 1.5b shows the water levels of Hail Haor at the four gauges in the year 2001. Jethua beel water level is always higher than the other gauges because Jetha beel is located in an isolated high place connected by Joinka gang. It is mainly fed by the rainwater. Some times in a year water entered from Hail haor to Jethua beel.

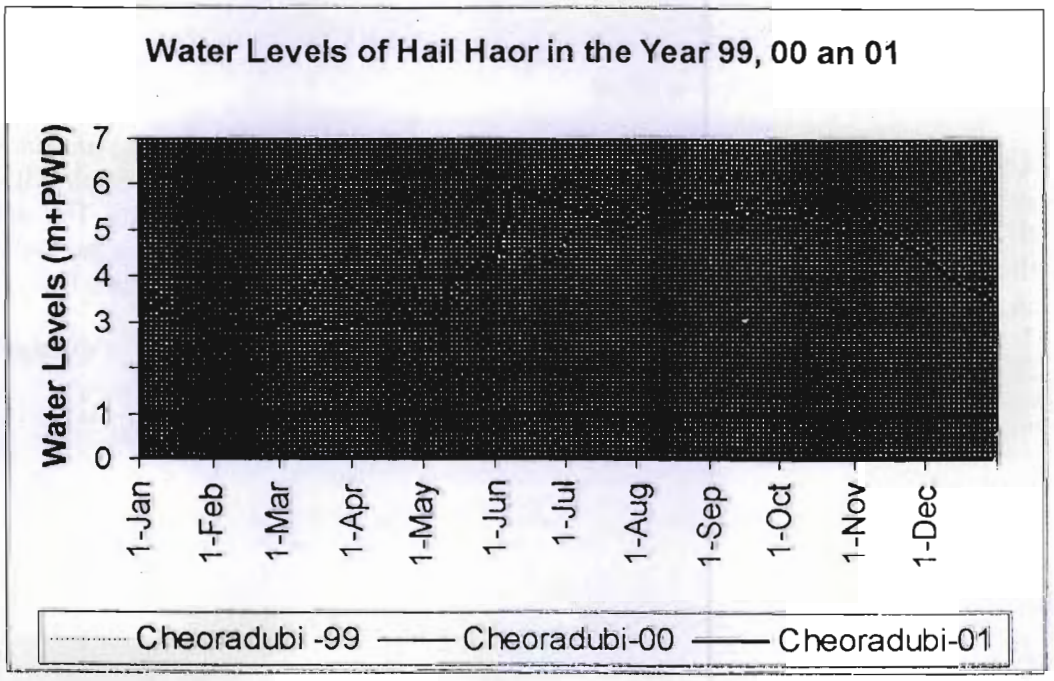

Figure 1.5a: Water level variation in the Hail Haor in the year 1999, 2000 and 2001

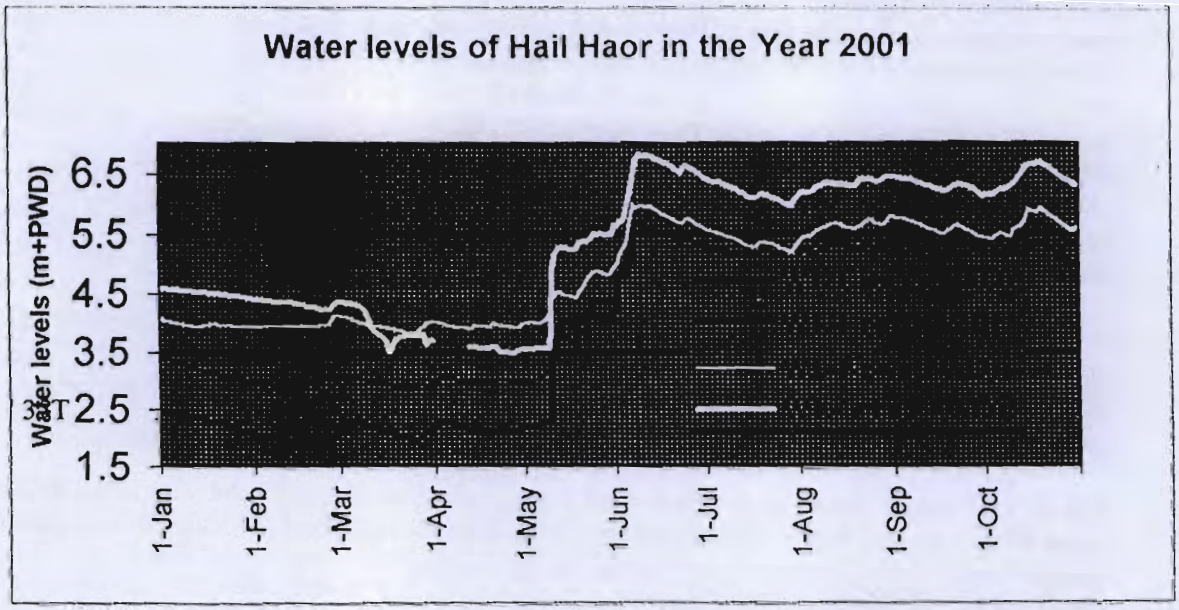

Figure 1.5b: Water Levels at four gauges of Hail Haor in the year 2001

1.2.3 ARIAL EXTENT OF WATER

A bathymetry survey was conducted for the Hail Haor in December 1999 to prepare DEM of the site. The result of the DEM run is shown in **figure 1.6a** which is prepared by the GIS division of BCAS. Monthly average flood extent of the Hail Haor is shown in the figure. The water extent of the haor at the lowest water level of April was around 3000 hectare whereas the maximum extent in August was 12,000 ha. This monthly analysis will be continued to correlate fish catch with the arial extent.

Figure 1.6b shows the classification of lands in terms of water depth in different months of 2001.

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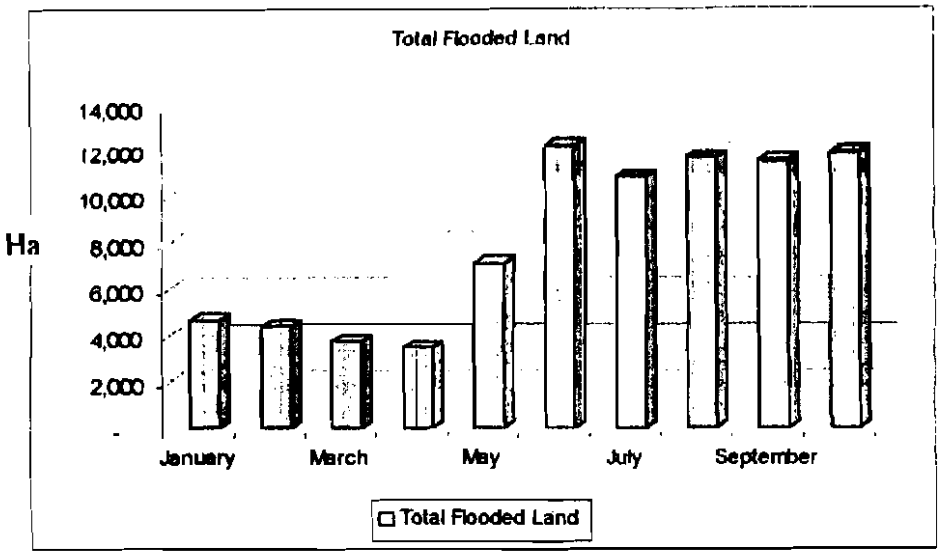

Figure 1.6a: Monthly average water extent of Hail Haor in the year 2001.

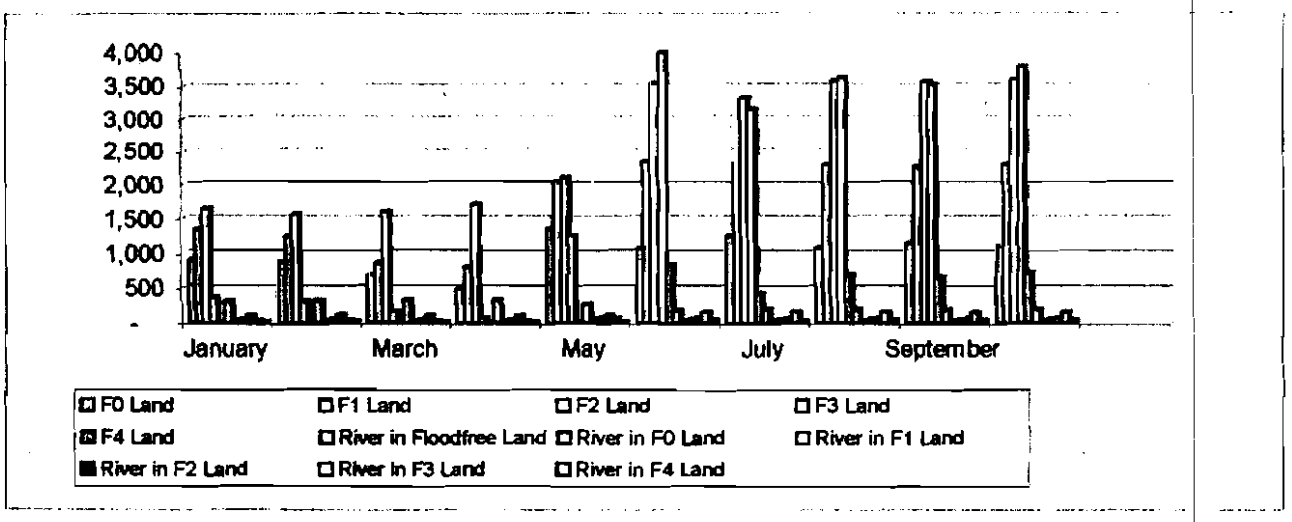

Figure 1.6b: Classification of Hail Haor inundated land based on water depth

1.2.4 DISCHARGE OF CHORAS

Some of the Choras of Hail Haor are seasonal and carry water only in the wet season. others are perennial. Flow in the perennial streams is small in the dry season and does not reach the Haor. This is largely because of withdrawal of water for irrigation.

In the wet season, significant water flows in most of the streams. A total of 10 Choras have been monitored regularly from the beginning of this project, March 1999. These are at a section of Bilashi Chora near the Motigonj Bridge, five Choras from the east (Gabur, Sial, Shaon, Jag, and

Burburia) and four Choras from the west (Alia, Patria, Joita, and Boula). These Choras also carry significant quantity of sediment during the monsoon and sand mining is practiced in each.

The discharges of different streams in Hail Haor are shown in **figure 1.7**. Flow measurement has been done since March /99. From November 99, 22 Charas were included in the monitoring program, among these 2 (Aam and Harpa) were the secondary stream of the Bilash chora. This monitoring was continued till October 2000. After October 2000, 4 choras were taken under monitoring; these are Jaag, Joita, Alia and Boula chora. Chora monitoring includes flow velocities, discharge, sediment sampling. Monitoring frequency was once in a week for general monitoring. However, for the intensive hydrology monitoring, 3 hours interval of samplings was done.

The **figure 1.7** shows that in the dry season, which is considered the period from November to April, flow is considerably low. Major causes of the low flow are low intensity of rainfall during this time and withdrawal of stream flow for irrigation. But in the wet season, from May to October, significant flow persists in the streams.

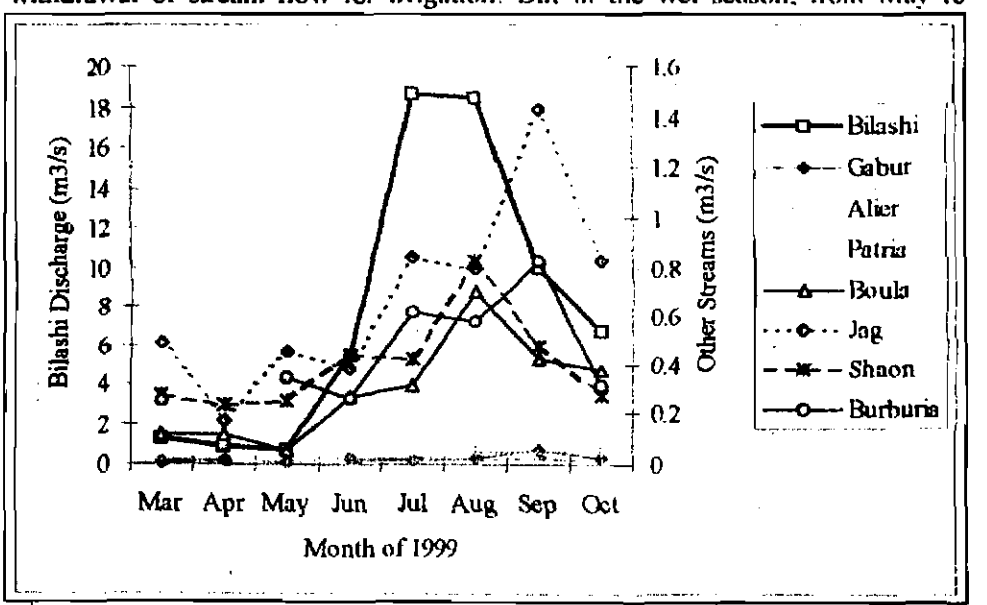

Figure 1.7: Discharge of different streams of the Hail Haor in the year 1999

Table 1.2 shows the monthly average discharge of some 22 choras from Nov 1999 to Oct 2000. Maximum flow occurs in the month of June when average discharge was 31.66 cubic meter/sec. Lowest flow remained in the month of February/March. As mentioned before, the cause of the lowest flow resulted from the lower rainfall and the withdrawal of surface water for Boro rice cultivation.

Table 1.2: Monthly average discharge of charas of the Hall Haor

Name	Nov 99	Dec 99	Jan 00	Feb 00	Mar 00	Apr 00	May 00	Jun 00	g Jul 00	Aug 00	Sep 00	Oct 00	
Bar C	0.38	0.25		0.33	0.26	0.21	0.73	1.87	0.43	0.47	0.51	0.35	
Kalla C	0.03	0.02	0.02	0.02	0.07	0.06	0.15	0.15	0.10	0.10	0.10	0.08	
Boula C	0.21	0.21		0.20	0.10	0.22	0.36	0.71	0.63	0.58	0.52	0.60	
Burchungi C	0.03	0.02	0.03	0.04	0.09	0.07	0.16	0.23	0.21	0.16	0.11	0.13	
Ichamati					0.05	0.06	0.28	0.36	0.33	0.24	0.16	0.24	
Jaita C		0.19	0.12	0.32	0.49	0.17	0.76	1.35	0.88	0.77	0.65	0.70	
Patria C	0.07	0.06		0.07	0.15	0.05	0.24	0.31	0.34	0.23	0.12	0.27	
Alia C	0.37	0.34		0.09	0.13	0.24	1.17	1.43	0.92	0.81	0.70	0.71	
Burburia C	0.18	0.33	0.23	0.22	0.35	0.24	0.77	1.32	0.80	0.72	0.64	0.63	
Phool C	0.12	0.09	0.10	0.06	0.18	0.02	0.24	0.49	0.46	0.35	0.23	0.45	
Harpa C	0.21	0.25	0.12	0.18	0.34	0.22	0.40	0.80	0.60	0.64	0.69	0.71	
Aam C	0.04	0.09	0.05	0.04	0.05	0.02	0.17	0.45	0.29	0.22	0.14	0.12	
Laingla C	0.79	0.87	0.52	0.71	5.10	1.63	2.44	5.23	3.87	2.88	1.88	1.69	
Udna C	0.65	0.32	0.12	0.00	4.32	1.78	2.73	8.15	4.05	2.97	1.90	1.38	
Dewa C		0.15	0.15	0.22	0.75	0.13	0.80	1.73	0.67	0.75	0.84	0.51	
Gabor C	0.39	0.22	0.16	0.27	0.30	0.12	0.50	1.10	0.55	0.72	0.89	0.79	
Shial C	0.05	0.04	0.03	0.05	0.08	0.02	0.34	0.70	0.21	0.21	0.21	0.22	
Shaon C	0.53	0.39	0.31	0.42	0.41	0.39	0.83	1.08	0.69	0.71	0.72	0.62	
Kakia C	0.03	0.03	0.01	0.02	0.13	0.03	0.48	0.81	0.30	0.22	0.15	0.15	
Jag C	0.58	0.44	0.79	0.77	0.48	0.53	1.29	2.32	1.17	1.10	1.03	0.92	
Khai C	0.02	0.02	0.03	0.04	0.03	0.05	0.39	0.47	0.19	0.16	0.14	0.10	
Bilas(Bilas+Lungla+Aam+Harpa)	1.03	1.47	0.99	1.19	5.84	2.11	3.51	7.08	5.33	4.52	3.72	3.56	
Total Discharge	**4.66**	**4.58**	**3.09**	**4.34**	**14.22**	**6.49**	**15.71**	**31.66**	**18.24**	**15.79**	**13.33**		**12.41**

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Table 1.3: Streams (Chora) flow analyses

Name of Choras	Total flow volume (Nov 99-Oct 00)	Volume of Wet Season Flow May Oct(m3)	Volume of Dry Season Flow Nov April	Dry Season flow %	Wet Season flow %	Dry Season chora contributes to the total flow(%)	Wet Season chora contributes to the total flow(%)
Bar C	12,265,533	10,241,213	2,024,319	17	83	3	4
Kaila C	1,918,145	1,502,115	416,030	22	78	1	1
Boula C	8,776,751	7,454,244	1,322,507	15	85	2	3
Burchungi C	2,739,998	2,215,630	524,369	19	81	1	1
Ichamati	3,829,220	3,598,260	230,960	6	94	0	2
Jaita C	14,317,472	11,452,131	2,865,341	20	80	4	5
Patria C	3,889,563	3,344,199	545,365	14	86	1	1
Alia C	14,173,740	12,987,015	1,186,725	8	92	2	6
Burburia C	11,781,809	9,084,792	2,697,017	23	77	4	4
Phool C	5,404,590	4,462,436	942,154	17	83	1	2
Bilas C	12,075,335	9,051,891	3,023,443	25	75	4	4
Harpa C	9,769,331	7,564,802	2,204,530	23	77	3	3
Aam C	3,273,126	2,859,320	413,807	13	87	1	1
Laingla C	56,177,311	35,223,030	20,954,281	37	63	29	16
Udna C	59,224,706	42,770,893	16,453,813	28	72	23	19
Dewa C	14,714,217	11,427,532	3,286,685	22	78	4	5
Gabor C	11,973,195	9,767,528	2,205,667	18	82	3	4
Shial C	4,790,905	4,362,299	428,606	9	91	1	2
Shaon C	13,581,137	9,639,896	3,941,241	29	71	5	4
Kakia C	5,287,669	4,829,846	457,824	9	91	1	2
Jag C	23,227,194	16,612,369	6,614,826	28	72	9	7
Khai C	3,573,559	3,236,362	337,197	9	91	0	1
							0
Bilas(Bilas+Lungla)	68,252,646	44,274,921	23,977,724	35	65	33	20
Total Flow	**296,764,509**	**223,687,802**	**73,076,708**	**25**	**75**	**100**	**100**

Table 1.3 shows the flow analyses of Choras of Hail haor. It is observed from the analyses of all round the year data collection, 25% of total yarly flow persists in the dry season. Some Choras like Ichamati. Patria. Alia. Aam, Shial, Kakia and Khai have very low contribution in the dry season in compare to the their respective yearly flows. Huge boro cultivation as well as tea garden watering are the main causes of this low flow. Earthen dams are usually constructed across the chora to withdraw water. and virtually no water reach to the haor during this irrigation period. Udna and Lungla are the tributris of Bilas Chora and these tributaries always carry considerably good volume of water all round the year. The monitoring places of these choras are near the Indian border however, these measured volume of water couldn't reach to the haor because of the same reason of withdrawal of water in the Bangladeshi portion.

Udna, Lungla and Bilas carry larger volume of silt because of its larger degraded catchment and contribute a bigger percentage of silt of the haor annually.

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1.3 SEDIMENTATION PROCESS IN THE HAIL HAOR

1.3.1 SEDIMENT LOAD OF CHORAS

Surveys indicated that sedimentation has been increasing in Hail Haor. Surveys also have indicated that the dry season water-area has also been decreased. Many small beels inside the Haor have already filled up. This is adversely affecting the bio-diversity and potential fish retention in the Haor. Fish habitant has been reduced due to the reduction of water during the dry season. Therefore, it was essential for the project to know the sediment intrusion to the system.

Two types of observations have been made in Hail Haor to understand the sedimentation process.

- Measurement of suspended sediment carried by the different streams and
- Measurement of deposited sediment from selected streams inside the Haor during the monsoon.

10 Choras have been selected for the suspended sediment load measurement in the year 99, i.e. Gabur, Sial, Shaon, Jag, Burburia in the east, Bilashi in the south and Alia, Patria, Joita and Boula on the west side of the Haor. These streams carry the highest sediment load and have some water flow through out the year. Water samples were collected from these streams randomly during the wet season and the volume and weight of suspended sediment were measured. Obviously flow rates of the streams have been measured during each sampling.

Result and Analysis

Monthly variation of suspended sediment load of Bilashi, Joita and Jaag chora are shown in **figure 1.8a**, **figure 1.8b** and **figure 1.8c** respectively. Bilashi Chora entering into the Hail Haor from the southern side. Its catchment is around 20% of the total Hail haor watershed. Therefore, it carries huge volume of water as well as sediment each year in the wet season. In July, 1999, Bilashi carried around 200 thousand cubic meter of sediment. **Figure 1.8b** shows the monthly volume of flowing water and silt of Jaag chora. Jaag chora originates from the Baleshera Hill and most of its cannhel reach is in Tea estate. It also carries huge sediment each year. In August 99, around 6 thousand cubic meter of sediment were carried by the chora. Joita chora is the western side chora of Hail Haor. It originates from the Satgaon hill. Figure 1.8c shows that Joita chora reached in peak flow in the month of July 99. During this tome it carried around 2 thousand cubic meter of sediment.

Figure 1.8a: Comparison of flow and silt of Bilashi Chora in the year 1999

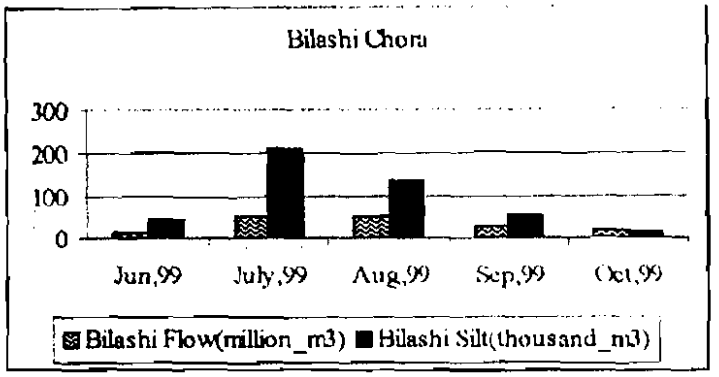
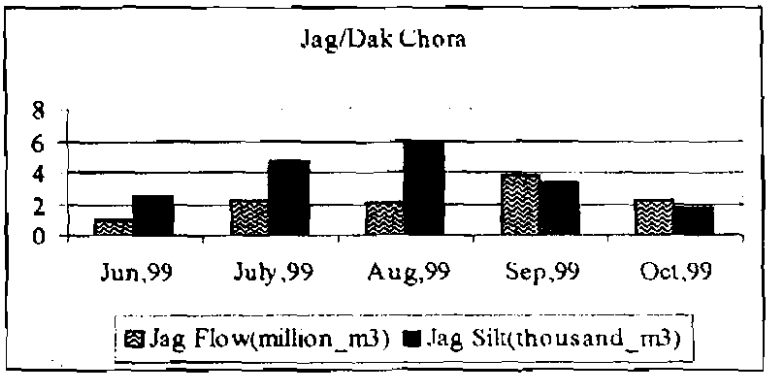


Figure 1.8b: Comparison of flow and silt of Jaag Chora in the year 1999



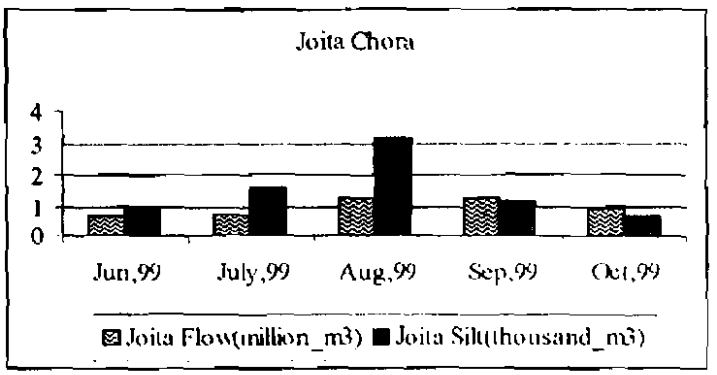


Figure 1.8c: Comparison of flow and silt of Joita Chora in the year 1999

Table 1.4: Silt load of Choras in the wet season and their percentage of contribution to the total silt load.

Name	Total silt load in Tons (May-Oct)	Chora contributes to total silt load (%)
Bar C	2621	5.2
Kaila C	157	0.3
Boula C	1384	2.8
Burchungi C	182	0.4
Ichamati	450	0.9
Jaita C	2088	4.2
Putria C	468	0.9
Alia C	1987	4.0
Burburia C	895	1.8
Phool C	348	0.7
Bilas C (near Indian Bordar)	1551	3.1
Harpa C	1226	2.5
Aam C	309	0.6
Laingla C	8975	18.0
Udaa C	8228	16.5
Dewa C	3094	6.2
Gabor C	1986	4.0
Shial C	1802	3.6
Shaon C	2485	5.0
Kakia C	1769	3.5
Jag C	6598	13.2
Khai C	1353	2.7
*Bilas(Bilas+Lungla+Aam+Harpa)	12060	24.1
Total silt	49954	

* Joint flow of Bilas, Aam, Harpa and Laingla known as Bilas flow near Motigonj Br.

Table 1.4 shows the silt load of choras in the wet season and their percentage of contribution to the total load. It is observed from the table that the Bar, Boula, Joita, Alia carry considerably big volume of silt in the wet season. Though the Phool and the Burburia catchment are among the most degraded catchments, analyses show very low volume of silt load. This can be explained as follows: Both the choras has considerably long reach, around 8-12 km long. On their course of flow there are many sand depositing place where commercial sand mining is going on. For this

reason, lower volume of sediment is coming into the Haor. On the other hand, Bilashi contributes around 24% of the total sediment loading. However, the Bilashi catchment is around 20% of the total Hail Haor watershed.

Figure 1.9: Rate of soil erosion of Hail Haor watershed

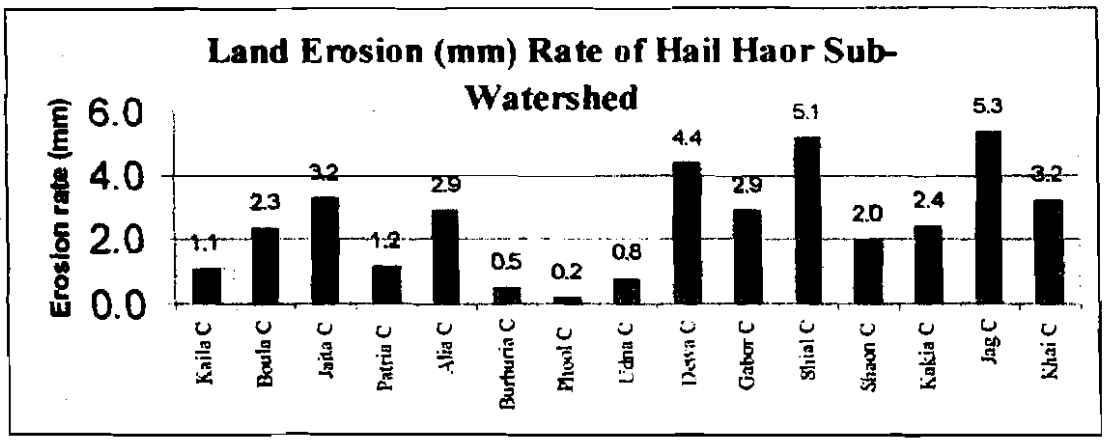


Figure 1.9 shows the rate of soil erosion of different chora sub-watershed. This is derived for different choras sub watershed from the total volume of suspended sediment contents in the monsoon of 2001 dividing by the corresponding chora sub watershed area. Erosion rate is expressed by mm for a sub-watershed. It doesn't mean that the entire watershed erodes uniformly. Some places are more vulnerable to soil erosion with small rainfall than others. Erosion rate also includes the bank erosion which is very common in most of the chora reach

Analysis shows that the Jag watershed is the most degraded watershed followed by Shial chora. Dewa, Shial, Jag and Khai are the eastern side choras of Hail Haor originating from the Balesera hills and show high soil erosion rate. Whereas among the western side chora of Hail Haor like Joita, Alia, and Boula show high rate of soil erosion.

1.3.2 DEPOSITED SEDIMENT

There are numerous formulas to calculate deposited sediment from the suspended sediment load. In a WDB report, used sediment-rating curve derived by Brune and a formula by Lane and Koelzer to determine trap efficiency ("Hydrology for Engineers" by Linsley, Kohler and Paulhus). They considered the Haor as a reservoir and computed the deposited sediment from the suspended sediment load theoretically. Because of the geology of the catchment and Haor vegetation conditions, using the theoretical definition alone was not considered adequate. Therefore, it was decided to measure real time deposition rates inside the Haor. The following five sites were selected inside the Haor. Outfall of 1. Bilashi C., 2. Joinka C., 3. Kakia C., 4.Jag C., and 5. Boula C. Two sediment traps at each site were placed approximately 100m apart before the monsoon. The sediment trap design is shown in figure 1.11. Traps of Bilashi, Boula and Joinka outfall were found at the end of the wet season. However, Traps from other Choras were not found at the end of the study period.

Figure 1.12 shows the deposited sediment depth of the outfall of Bilashi, Boula and Joinka Choras during the wet season. Deposition of sediment at the outfall of Bilashi is around 15 cm whereas at the outfall of Boula is around 11 cm. The outfall of Joinka is around 8cm. Local peoples opinion is that the Haor has filled by as much as 1.5m in 20 years, which means around 7.5 cm in a year. This studies real time observation shows a higher rate of deposition in the Haor. Soil classification of trapped soil is also shown in the figure 1.12. It shows that Bilashi has more silt and sand than clay whereas Boula has more clay than silt and sand. This is likely due to more agricultural land in the watershed of Boula. Deposited sediment of the Joinka is silt and clay. Deposition rate is low here because most of the sediment is deposited upstream, far from the measured point.

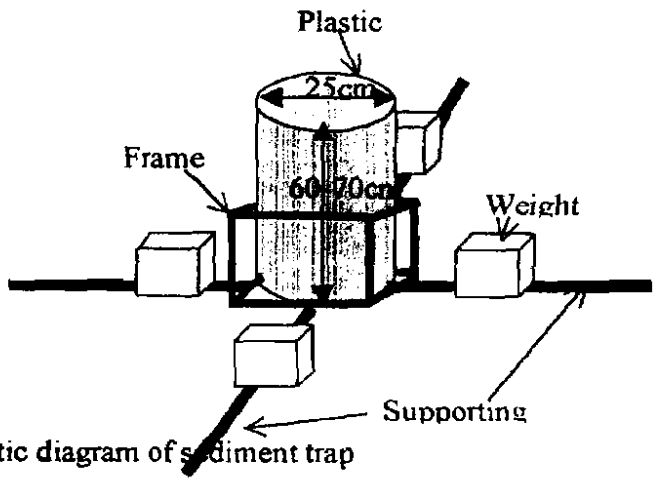


Figure 1.10: Schematic diagram of sediment trap

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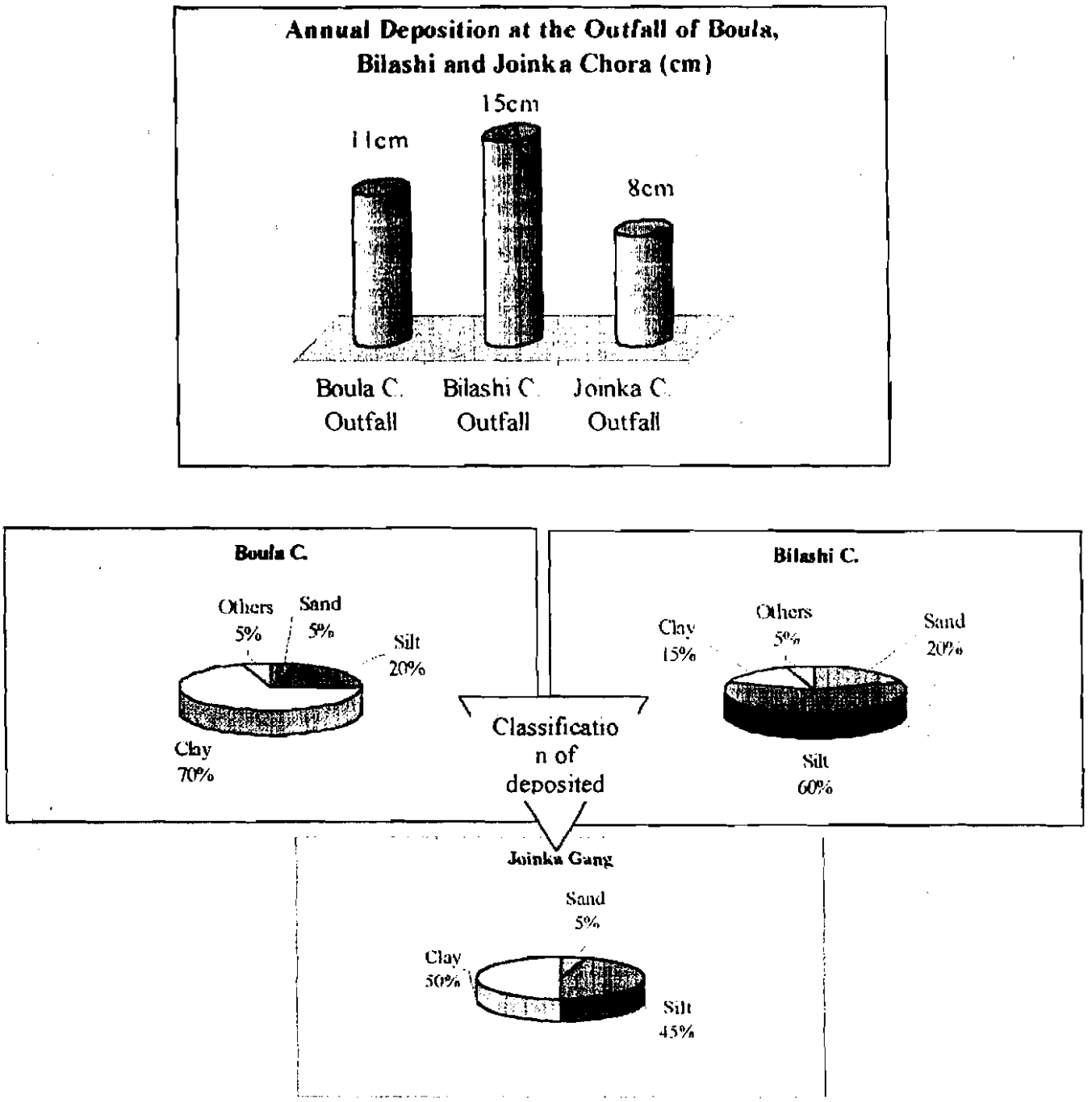

Figure 1.12: Deposited Sediment at the outfall of Bilashi, Boula and Joinka Gang (Trapped Sediment Observation)

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1.4 RECOMMENDATION

The identified two major problems of Hail Haor are the scarcity of water during the dry season and the sedimentation in the wet season. It is roughly estimated that if all streams are allowed to flow uninterruptedly to the Hail Haor, 60cm more depth of water might be available in the Haor during the dry season. Therefore, proper and effective management of water at the upper shed area may reduce the problem of dry season scarcity without any physical intervention. Since MACH is a community participatory project, people of the project site may be motivated to change their water use and cropping pattern for the sustainable development of the wet lands.

Sedimentation is a rapidly increasing problem, and it is mainly caused by the deforestation of the site. Aforestation on the upper watershed area may reduce the soil erosion however, it is a long process to come to effect. Therefore, project should take immediate action to prevent sediment flow to the Haor, and this may be possible by constructing some check dams on the major sediment carrying streams. It will increase the water retaining capacity at the upper shed and the retaining water will recharge ground water. Sediment will deposit at the dam site. The chora resource management organization may be formed to handle the deposited sand. Already talked to the local people of Joita chora reach and they showed keen interest in check dam. Preliminary, a site has been selected for the construction of check dam. Construction of check dams depends on the project approval.

From the sediment load analysis, it is understood that most of the choras are carrying high sediment load in the rainy season. This is due to the degraded watershed of the choras. Among the observed choras, Boula, Bilashi, Jag, Joita, etc. are originating from the most degraded watershed. The Hail Haor cannot be managed without managing the watershed. Therefore, it is essential to take chora restoration program on some watershed or Hail haor a whole.

Only two years of hydrological observation has been done so far in the Hail Haor site. Nothing can be concluded finally from this observation. At least five years of monitoring is needed for reliable and effective planning of the site. Therefore, long term monitoring is recommended here with.

SECTION 2: HYDROLOGY AND WATER RESOURCES OF TURAG-BANGSHI FLOODPLAIN

2.1 INTRODUCTION

2.1.1 TURAG-BANGSHI FLOODPLAIN

Turag-Bangshi river basin is in the North Central Region (NCR) of Bangladesh. This region is bounded by Jamuna, Padma, Old Brahmaputra and the Sitolakha river; Jamuna on the west, Old Brahmaputra on the north and northeast and Sitolakha on the east. Other important waterways are the Dhaleswari-Kaliganga River, which crosses the southwestern part of the region. Besides these main rivers, the region is drained by many rivers, such as Bangshi, Pungli, Banar etc (**figure 2.1**).

In the southeast of NCR, Turag and Balu rivers flow southwards. Their slope is low and their connection through Tongi Khal helps alleviate floods. Floods of Turag River are caused by rainfall on the western (through Bangshi river, a main tributary to Turag) and southern parts of Madhupur Tract, and by high levels of Padma and Meghna River, causing a backwater effect to Turag river through its lower reach known as Buriganga river. Upper Bangshi River drains an important part of the Madhupur Tract. It is subject to flash floods due to heavy rainfalls on its left bank.

2.1.2 GENERAL RELIEF

The overall elevation of the NCR varies between 18 and 4m + PWD (Public Works Datum) from north to south. The main physiographic unit in this region is the Madhupur Tract upland, which divides the NCR in the middle in the north-south direction.

Existing local differences are the result of

- Large extension of the old and active flood plains generally affected by the meandering or the shifting of the floodwater courses or natural rivers. For this reason the flood plains present a generally complieated network of channels, terraces and ridges of different levels.
- The patchwork pattern of paddy or other crops fields, which is a succession of small terraces built for water management.
- The artificially built dwelling mounds above floods, or homestead system, adopted by the farmers to manage their flood-prone homes. The corresponding earth-fills and their adjacent borrow pits are man-mad local disturbances of the natural flat relief found everywhere.

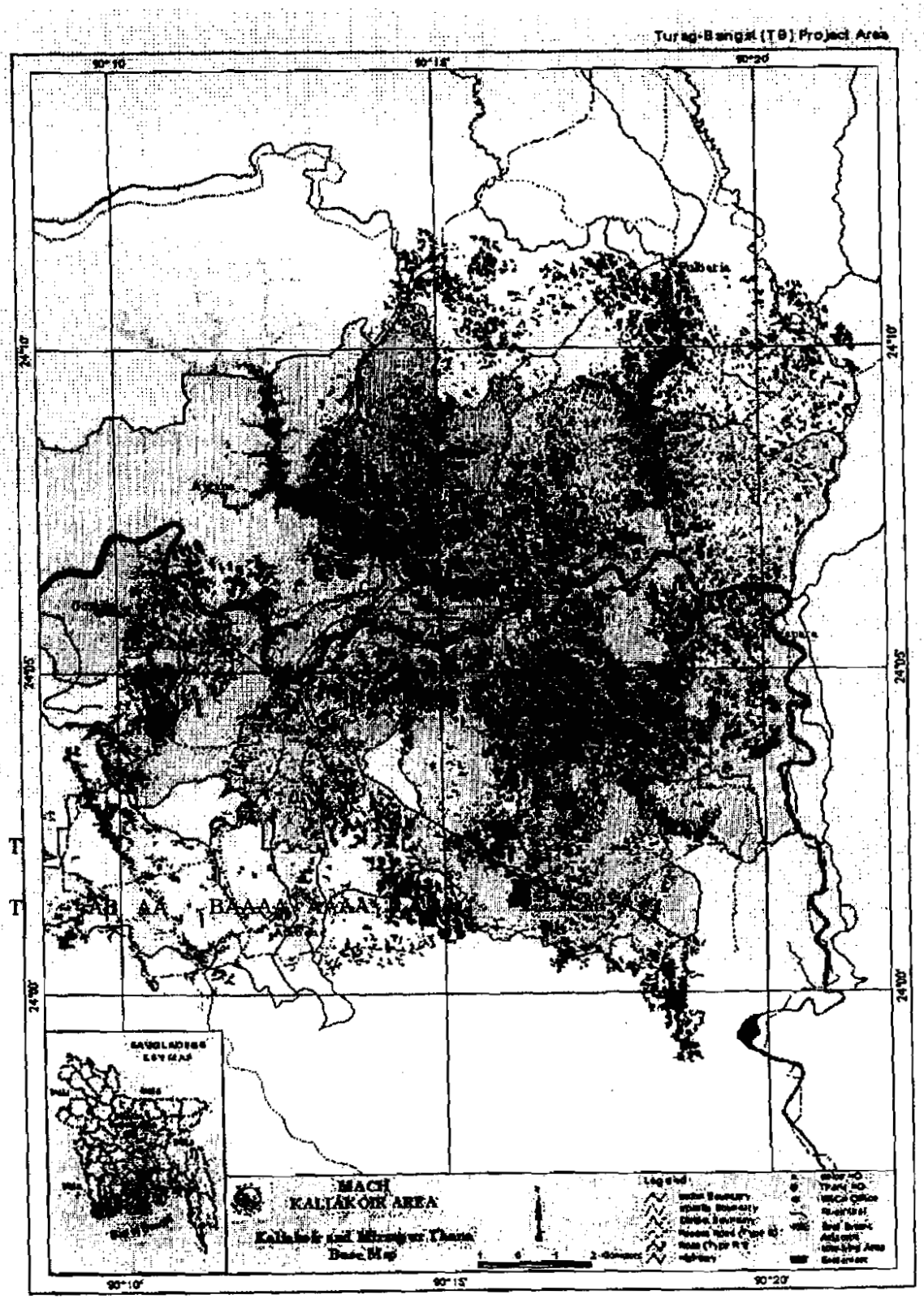

Figure 2.1: Base map of Turag-Bangshi River basin

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2.1.3 TURAG-BANGSHI MACH AREA

The project area of the site covers a part of Turag-Bangshi River and their adjacent wetlands of Mirzapur Thana of Tangail District and Kaliakoir Thana of Gazipur District. The two main beels of this site are Mokas and Aola Beel. The estimated catchment area is around 15,000 ha. This is a deeply flooded area in the low-red soils plateau of Modhupur tract. The floodplain increases in size as water overflows the banks of the Turag-Bongshi River in May-June. During monsoon the low areas becomes a connected sheet of water. By late November, most flood water recedes and "T-boro" or winter rice is planed in almost all low-lying areas.

Typical of most low-lying floodplains within Bangladesh the Turag-Bangshi River runs through the site with beels on either side of the river. At the beginning of the rainy season, as floodwaters enter the upstream portions of the Bangshi, water spills over the riverbanks through canals or khals that connect the river to those adjacent beels. Fish, for the most part, move from the rivers to the beel/floodplain areas for spawning or nursing and then into the deeper perennial portions of the beels or back into the river as water recede after the rains. Due to the dry season reductions in water levels caused by Farraka Dam in India, ground and surface water extraction for boro rice irrigation and reduced flows due to deforestation in local and upper-water shed areas dry season water levels in the local rivers and beels are much reduced. In drought years flows cease in the formerly perennial Turag with water and fish only remaining in river pools (called 'kum') and in the deepest portions of the beels (called 'doha'). Annual fish production is dependent in large part on the breeding populations remaining in those kum and dohas.

Within the Turag Site a total of 26 beels exist and have a water surface area of approximately 10,000 hectare at full flood, which is reduced to less than 700 ha at the end of the dry season. The Turag River runs for approximately 30 km and another 28km of khals exist within the site.

A brief description of some Beels of the Turag-Bangshi MACH area is given below.

Mokas Beel:
Mokas is a perennial Beel located to the south of the Turag River in Mouchak Union of Kaliakoir Thana. The catchment area of Mokas Beel is around 46 sq. kilometer. The beel is connected with Turag River by a *Saturia-Solahati* khal which is around 1km long. The Beel is surrounded by several villages namely Taltoli, Boroibari, Saturia-Solahati, Saturiachalla, Laskarchalla, Mazukhan, Ratanpur, Kouchakuri, Matikata, Sinabahao. The water of the Beel receives industrial waste from Ratanpur khal.

Aola Beel:
It is the biggest Beel in the Turag-Bangshi Project area. It is a perennial Beel and the catchment area of this Beel is around 96 sq. kilometer. At present, Nikni Khal connects the Beel with the river Turag. Farmers of the surrounding lands use water of this Beel intensively during the dry season to irrigate their Boro field. A submergible sluice gate was under construction at the inlet of the Beel, near the Medi-Asulia Bridge but stopped because of the local conflict over water sharing.

Kalidaha Beel:
Kalidaha Beel is a perennial type beel located on the northwest of Mokas Beel in Mouchak Union of Kaliakoir Thana. The villages of Taltoli and Bastoli are adjacent to the Beel. The Beel is also

connected with the Turag River by the Saturia-Solahati canal. Water cannot drain out fully from the Beel because of the closed inlet.

Kamlai Beel:

Kamlai is a perennial Beel. It is located in the Maddyapara Union of Kalialoir Thana. The village Gupinpur and Saturia Solahati are adjacent to the Beel. The Beel is connected with the Turag River by a small canal (Kamlai Beeler Khal) through Saturia-Solahati canal. The canal is 0.5 km long.

Khunai Beel:

Khunai is a seasonal Beel. It is located in the Madhapara Union of Kaliakoir Thana. The Beel is connected with the Turag River through Golachipa canal. The length of the canal is around 0.5 km.

Ujan Beel:

Ujan is a perennial Beel. It is located in the Boali Union of Kaliakoir Thana. The Beel is connected with the Turag River by Dakurail and Narandra/Boali canal. The length of the canal is around 2km. The villages of Dakurail, Goalia and Piprashit are adjacent to the Beel.

2.2 HYDROLOGY OF TURAG-BANGSHI FLOOD PLAIN

2.2.1 OVERVIEW

Hydrology at this site and in all of Bangladesh is determined in large part by the monsoon from May- October followed by a dry period from November-April. The availability of water determines fish production, the agriculture cycle and the lives of the people of the area. At the Turag Site MACH staff have studied rainfall, river and beel water regimes including tidal effects. Additionally the project has looked at water extraction from the Turag within the project area.

2.2.2 RAINFALL

Rainfall during the December to March period equals to 2 to 3% of the annual total. In the pre-monsoon period from March-May, 20-25% of the annual total occurs. Also during this period temperature rises to a maximum of over 40 °C. The south-west monsoon begins in the month of June and lasts until October and the rainfall during this period is convective. During this season heavy rainfall occurs over the whole region, relative humidity remains very high. Total annual rainfall shows a minimum value at 1400 mm around Tangail.

Bangladesh Water Development Board (BWDB) has a rain gauge station at Mirzapur and daily rainfall has been monitored since 1957. Historical monthly dry and wet season rainfall of Mirzapur is shown in figure 2.2a and 2.2b. It may be said from the figure 2.2a that there is virtually no rain in the month of January and February in the Mirzapur area. Rainfall increases in May and reaches a peak in August.

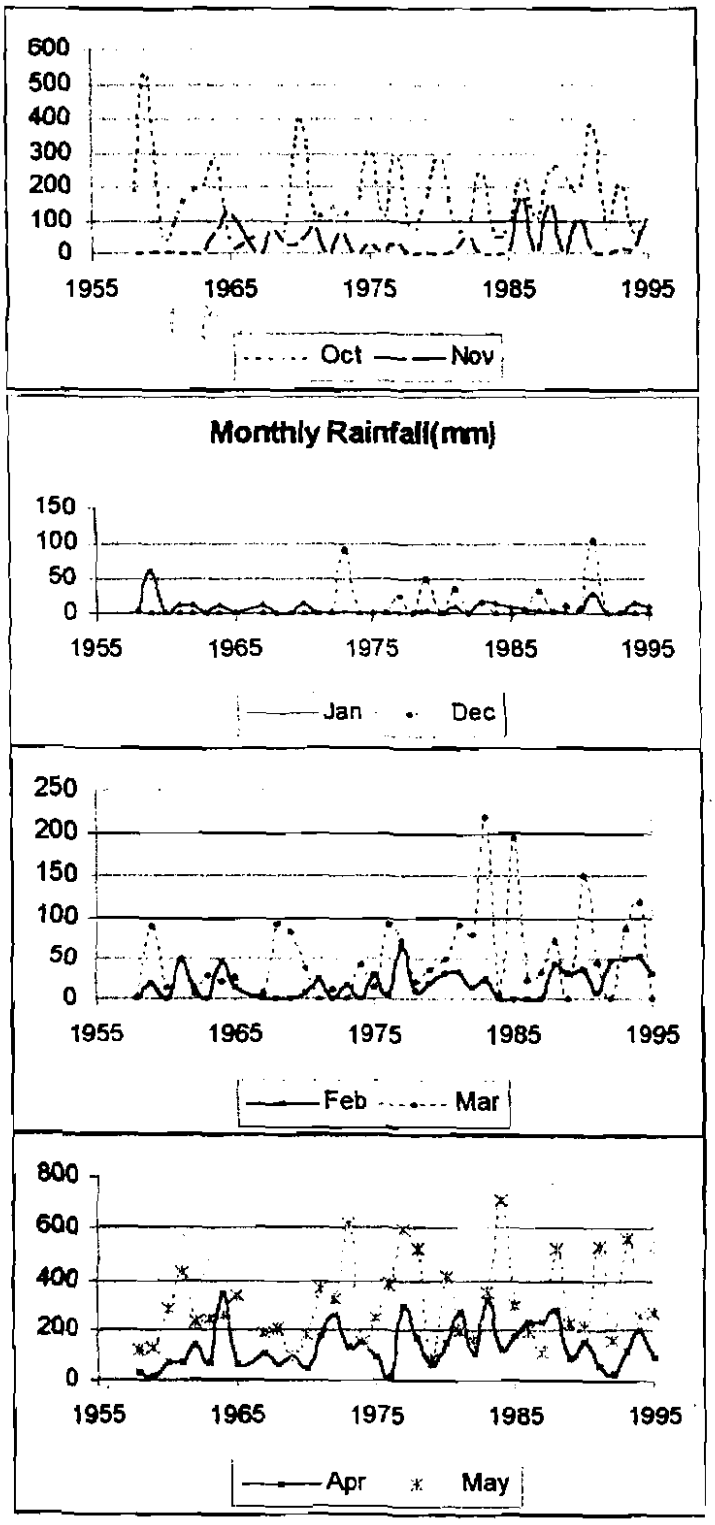

Figure 2.2b: Historical Monthly maximum Rainfall at Mirzapur Station (mm)

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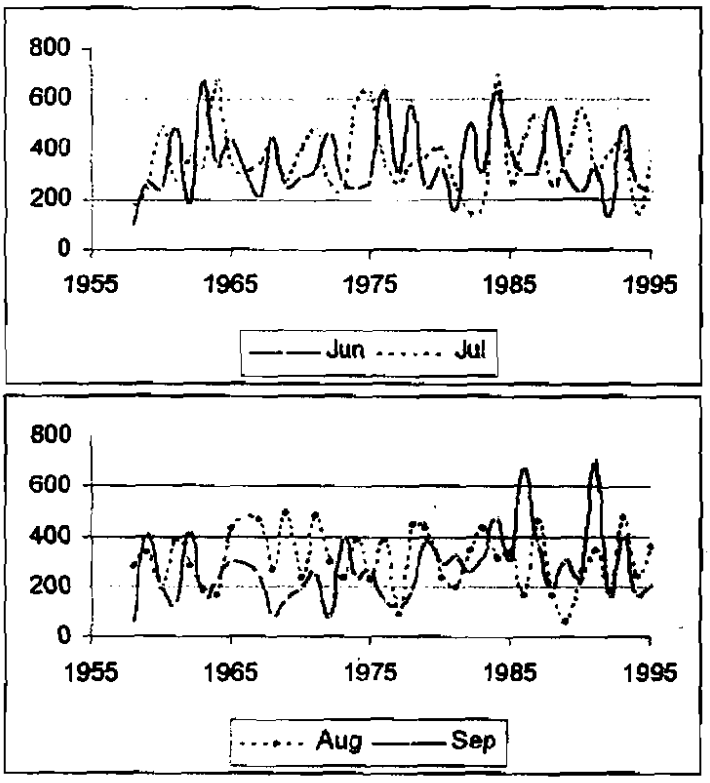

Figura 2.2a: Historical monthly maximum rainfall in Mirzapur during the Wet season

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2.3 RIVERS

2.3.1 HISTORICAL WATER LEVEL OF BANGSHI RIVER

Bangladesh Water Development Board (BWDB) has been monitoring the water level at Kaliakoir and Mirzapur thana on the Turag-Bangshi River. Average daily water level has been monitored since 1950 without considering the tidal effect in the river. But according to local communities the Turag at Kaliakoir Town has been experiencing greater tidal influences for the last two decades, particularly in the dry season. However, BWDB has tidal gauge stations on Tongi Khal and Buriganga River, downstream of the Turag River. They are monitoring daily maximum and minimum water levels.

River at Kaliakoir Town. Before 1970, dry season and wet season water levels shows a normal trend. However, after that year the yearly lowest flow are trending downward while the yearly high flow are trending upward. The lowering of flow in the dry season is mainly due to the Farakka barrage impact, deforestation at the upper reach, intensive Boro-rice irrigation, etc. The Farakka barrage has had a significant impact on the major and minor rivers of the region since the barrage began operating after 1970.

Withdrawal of water from the Ganges River by Farakka Barrage during the dry season has reduced the flow not only in the Ganges but also affects all the rivers that make up the Ganges-Brahmaputra-Meghna system. As the dry season Ganges flow decreased due to the influence of Farakka, other rivers in the catchment began down cutting to meet these lower flows. This has resulted in lowered channel flows and water tables throughout the region. Turag-Bangshi is not fed by the Ganges, but it is indirectly fed by the Jamuna / Brahmaputra River, and the decrease of dry season flow of the Ganges as well as ground water losses causes the decrease of water level of Jamuna, which is draining into the Ganges at Bahadurabad.

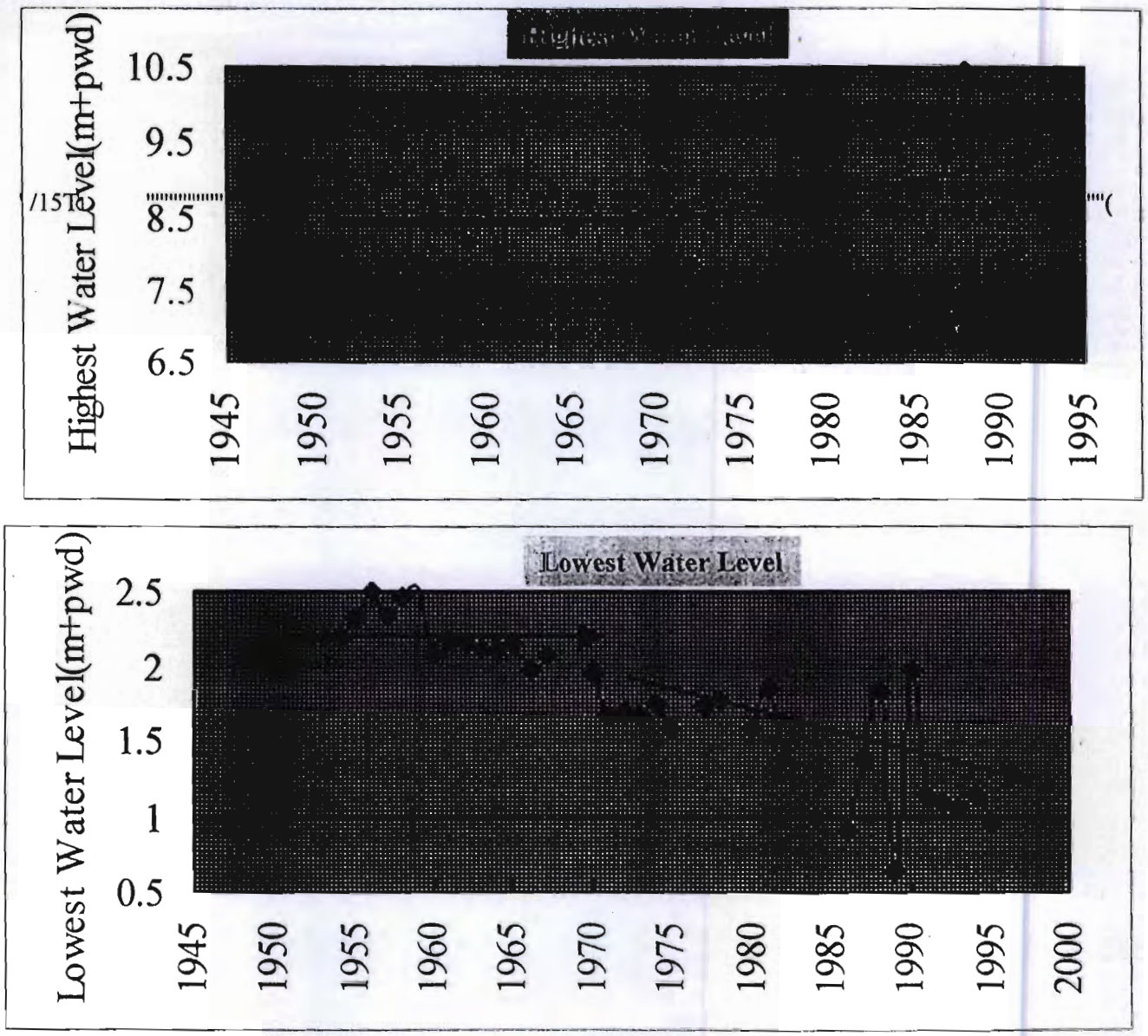

Figure 2.3 Historical maximum and minimum water level of Turag River

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2.3.2 TIDAL EFFECT IN THE TURAG RIVER

The Turag River has been more heavily influenced by the tide during the last two decades particularly during the dry season. This is due to the lowering of flow in the river during the dry season. Turag is connected with Meghna River through Tongi Khal and the Lakhya River and is also connected with Padma/Ganges through Buriganga. The river system is shown in figure 2.4.

BWDB data of water levels of Tongi khal and the Buriganga River has been analyzed. Daily maximum and minimum water levels of Tongi khal and the Buriganga are shown in figure 2.5. Tongi khal has an upward trend for its maximum water level after 1970 whereas Buriganga shows a stable trend. During the last 30 years, the tidal level of Tongi khal in the dry season has increased by approximately 40cm. Therefore, it can be concluded that the tidal effect in the Turag is likely to be caused by the Lakhya River, which is connected with Turag through Tongi Khal.

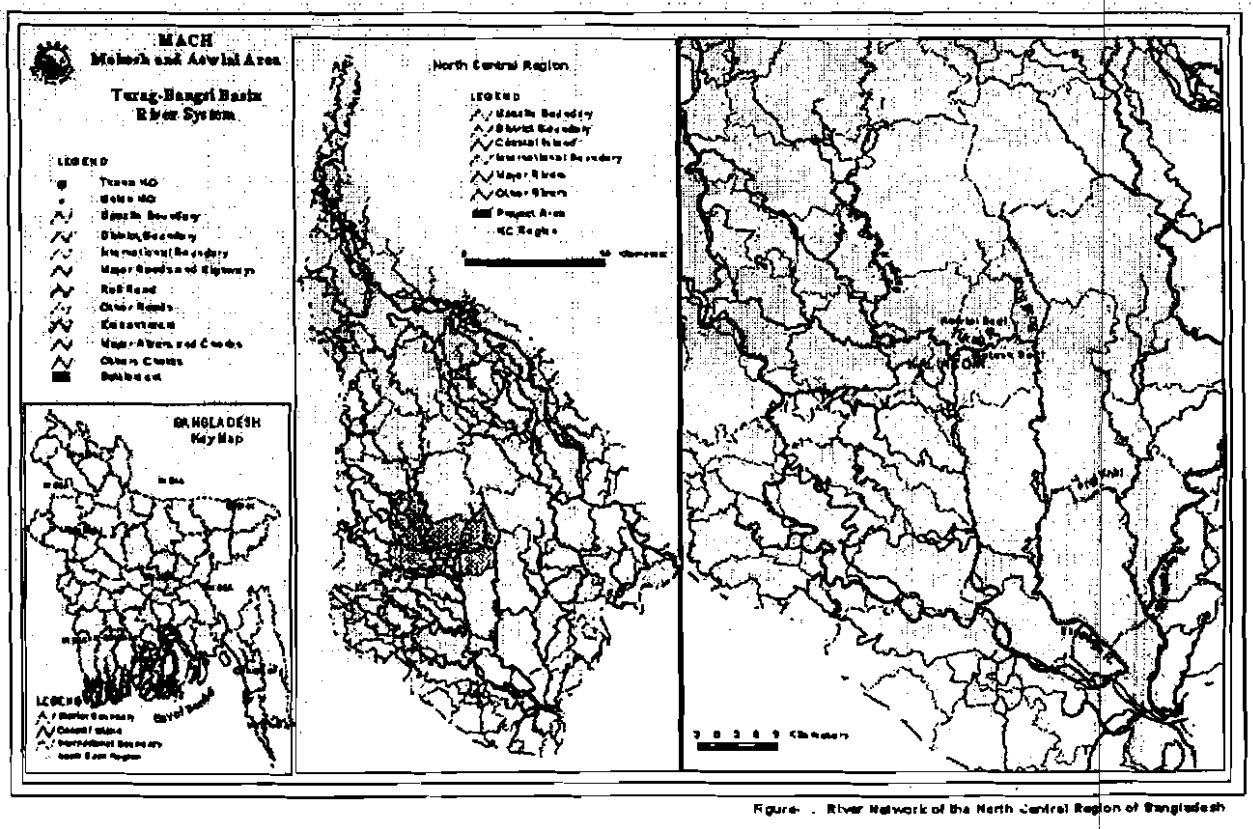

Figure 2.4: River network of the North-Central region of Bangladesh

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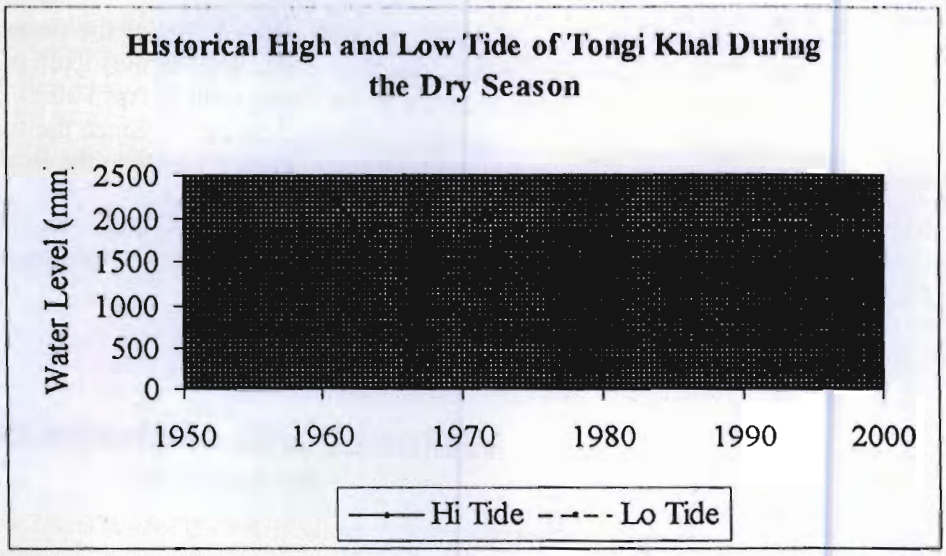

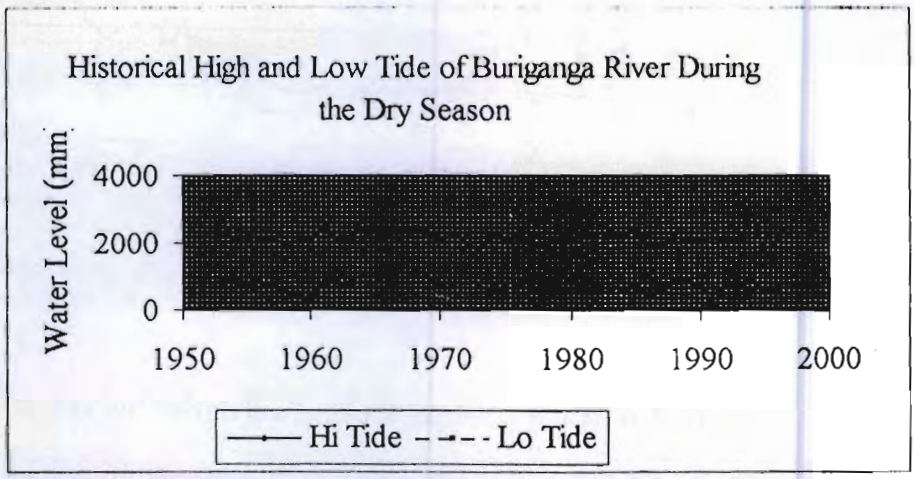

Figure 2.5: Historical High and Low Tide of Tongi Khal and Buriganga R. in the Dry Season

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2.4 BEELS & KHAL

2.4.1 WATER LEVEL VARIATION IN THE BEELS

Water levels were monitored in the two major Beels of the project, Aola Beel and the Mokas Beel. Two manual gauges were installed in the beels in the month of May 1999.
Another gauge has been installed in the Turag river in April 2000. Three local readers have been taking daily water level records since the installation. Since the two beels lose connection with the Turag in the dry season, no tidal fluctuation is visible in the Beel during this time.

Figure 2.6 shows the water level variation in Mokas and Aola Beel. The water level of Mokas Beel increased sharply from the end of June and begins to decrease from September. The gauges are tied up with a reference datum.

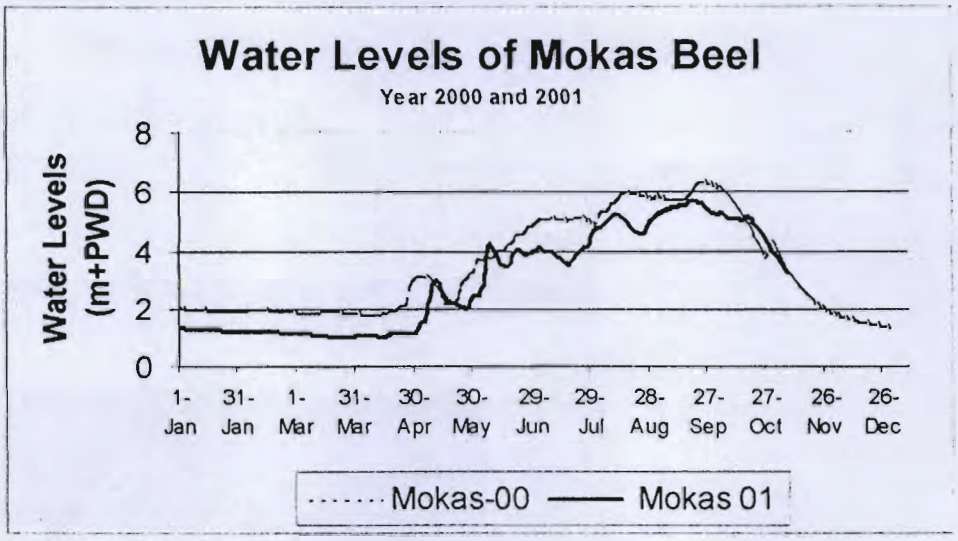

Figure 2.6: Water levels of Mokas Beel during the year 2000 and 2001

Figure 2.7 Shows the daily water levels of Turag river in the year 2000 and 2001. Turag has higher water levels in wet season of 2000 than the 2001. It is also observed from the graph that the river experiences tidal effect in the dry season, January to April. In the dry season, Turag virtually has no flow, and it dries to a series of pool, which have been used as dry season refuge of fish.

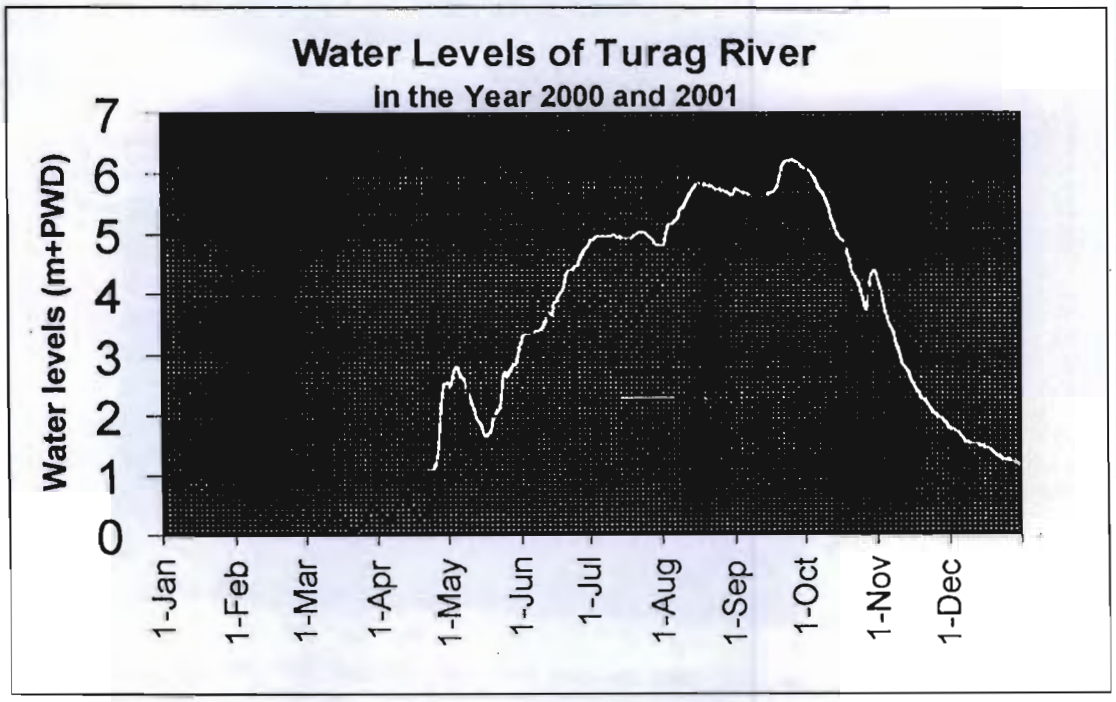

Figure 2.7: Water levels of Turag River during the year 2000 and 2001

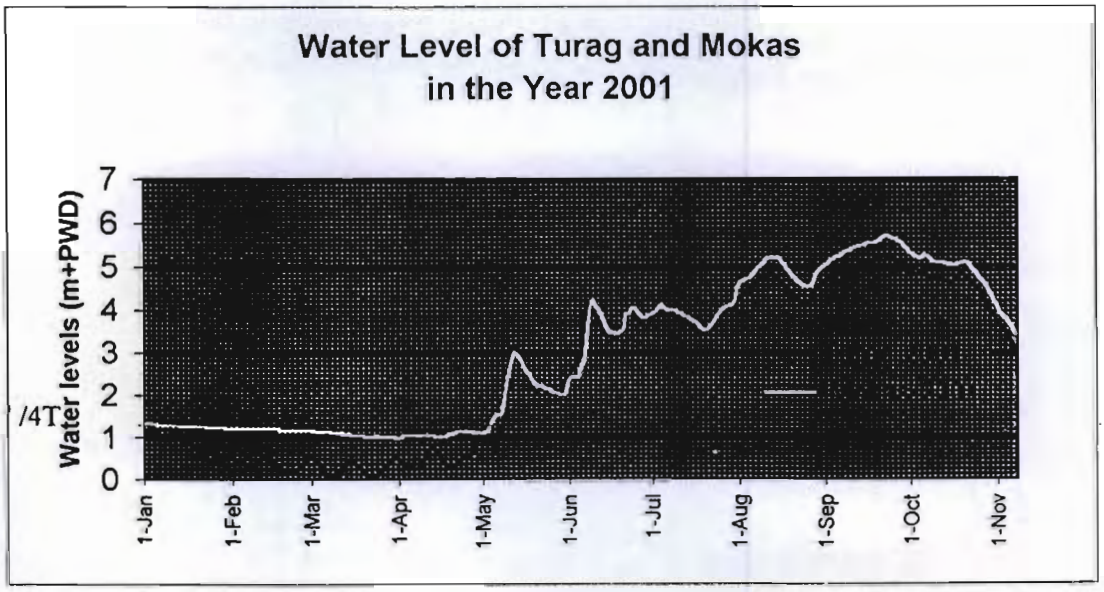

Figure 2.8: Comparison of water levels of Mokas with Turag river

Figure 2.8 shows the comparison of water levels of Turag river and Mokas beel in the year 2001. Mokas is connected with Turag river by a Khal. Mokas remains disconnected in the dry season. However, in the beginning of monsoon, early spring floods of Turag come into the Mokas through the khal. It helps in increasing the fish as well as biodiversity of the wetlands.

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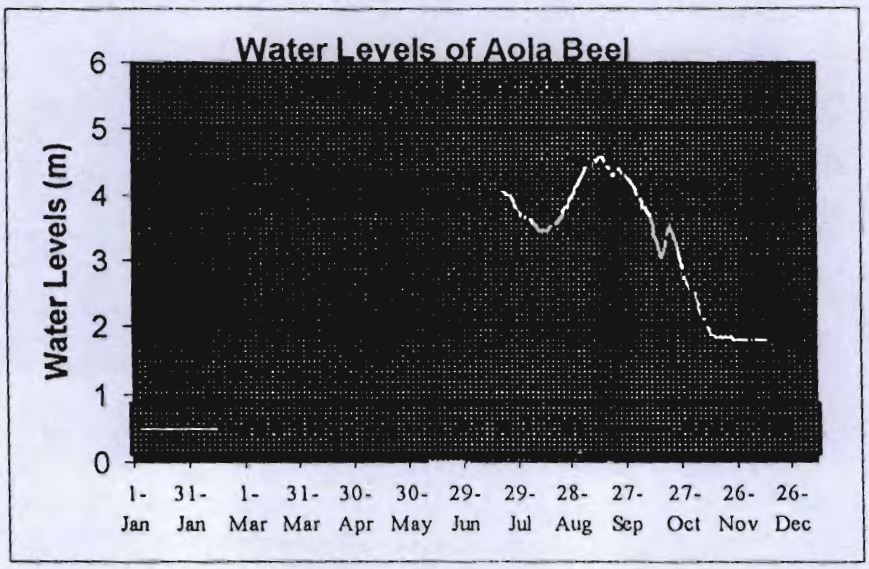

Figure 2.9: Water levels of Aola beel during the year 99, 00 and 2001

Figuer 2.9 shows the water levels of Aola beel. It resembles to the water levels of Mokas beel. Both Aola and Mokas experienced higher water levels in the year 2000.

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2.4.2 FLOW PATTERN IN THE BEELS

Aola Beel and the Mokas Beel are fed by the Turag River and rainfall runoff. Both beels drain to the Turag River by a connecting channel. Their flow pattern varies with season. Their seasonal fluctuation in flow patterns is described below.

Pre-monsoon:
The pre-monsoon period is considered to be from March-May. During this time, 20 to 35% of the annual total rainfall occurs. Water levels of the Turag remain low at this time. Since the elevation of catchment area of Aola Beel is high and the area is large, significant volume of surface runoff of the pre-monsoon rainfall drains to the Turag through the beel and connecting channel. Mokas Beel is at a lower elevation. Therefore, surface runoff of its catchment stored in the deepest part of the Beel and in May additional water comes to the Beel from the Turag through the connecting channel.

Monsoon:
During the monsoon period (June-September), water level of the Turag rises sharply and water from Turag enters the Aola and the Mokas Beel by the connecting channels. Usually, most of the period Mokas and Aola drain to Turag.

Post-Monsoon:
During this time, water level of Turag begins to drop and the stored water of both of the Beels begins to drain to the Turag. Since the elevation of the connecting channels is raised due to the siltation, at a certain stage, both beels loose their connection with the Turag.

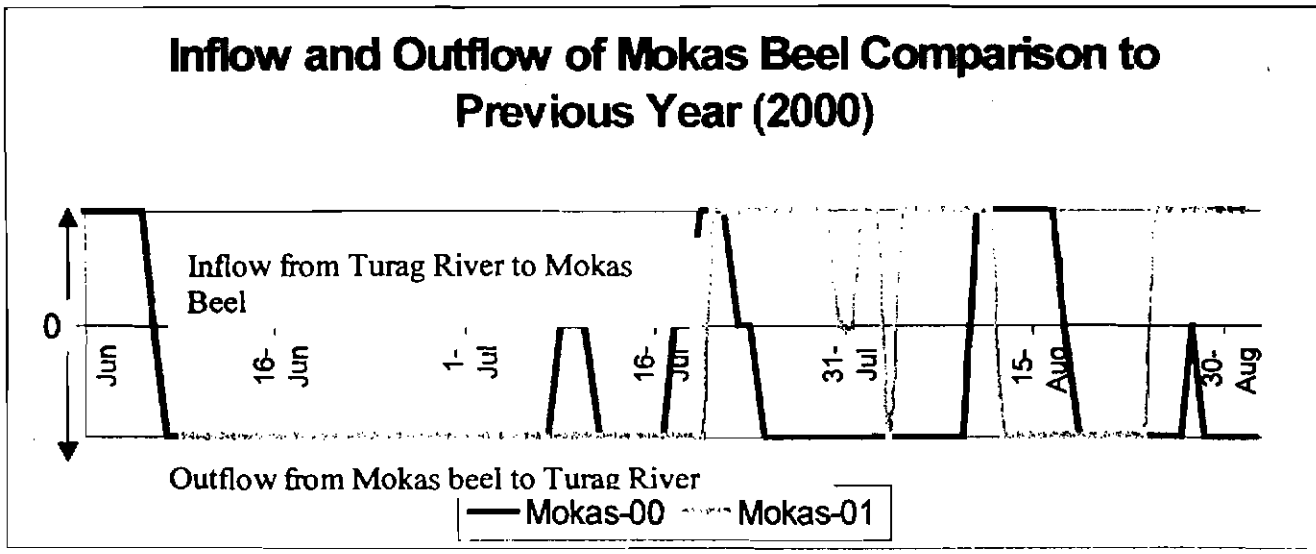

Figure 2.10: Comparison of inflow and outflow days of Mokas beel during the year 2000 and 2001.

2000 (Jun-Aug): Days of Inflow from Turag River to Mokas Beel were 15
2001 (Jun-Aug): Days of Inflow from Turag River to Mokas Beel were 31

Number of Inflow-days is higher in this year because of the higher water level in the Turag compared to Mokas beel and, the less intensity of local rainfall

Section 3:Hydrology and Water Resources of Upper Kongshow-Malijhee river basin

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3.1 BACKGROUND

The upper Kongshaw-Malijhee basin is partly situated on the Meghalaya Fan and on the Brahmaputra floodplain. Alluvial fans are generally found along the Meghalaya foothills which are located along the northern border of the basin. The Old Brahmaputra floodplain land consists of sediments that were laid prior to the Brahmaputra River's avulsion in the 18th century. The topography slopes from the northwest to the southwest with land elevations varying from 31.5m, PWD to 5.0 m, PWD.

The Sherpur project site is a flash flood prone area. The farmers of the site suffer repeated heavy damage of their crops by the flooding from Shomeswari, Malijhiee and Chellakhali Rivers. Flash flooding occurs in these rivers more than once per year and spills over a large portion of the project area.

Flash flood discourages the use of the intensive pond aquaculture in the area. Continued flood damage to the monsoon crop will force farmers to shift to dry season boro. The resulting increasing in abstraction of surface water and groundwater for irrigation will cause damage to wetlands and environment during the dry season.

3.2 RIVER NETWORK

The major rivers of the project site include the Shomeswary, Malijhiee, and Chellakhali rivers. All originate in small watersheds within the Garo or Meghalaya Hills of India. These rivers form part of the upper watershed of the Syhlet Basin. All flow into the Sherpur basin and then out to the Bugai, the Kangsa and eventually the Syhlet Basin and the Meghna River.

Malijhi River:
The Malijhi River originates in the Meghalaya Hills (Tura Range) and has a catchment of 160 km^2 within India. After entering Bangladesh the Malijhi continues southwards, it receives inflow from several channels and the Shomeswari River, which originates from Darong Hills virtually doubles the Malijhi flow. The river then passes through a series of beels to the north of Sherpur after which it receives Challakhali River flow and join the Bhogai at Danakusa below Nalitabari. Malijhi carries huge sediment during the monsoon.

Challakhali River
The Challakhali River also originates in the Tura Range of the Meghalaya Hills and has a catchment of 120 km^2 within India. Within Bangladesh, the Chellakhali continues southward and passes through a series of beels south of Nalitabari before flowing into the Malijhee River. This is one of the most sediment-carrying rivers in the project area.

Shomeswari River
Shomweswari River originates from Darong Hills of Meghalaya Hill and has a catchment of 175 km2. Actually Shomeswari is not a single river originating from Darong Hills, there are several channels of Darong Hills entering Bangladesh with different name like Shomeswari, Kalghosha nodi, Mora nodi etc but the combined flow known as Shomeswri River. The river passes through a series of beels to the north of Sherpur and then joins with Malijhi near Surihara north of Sherpur.

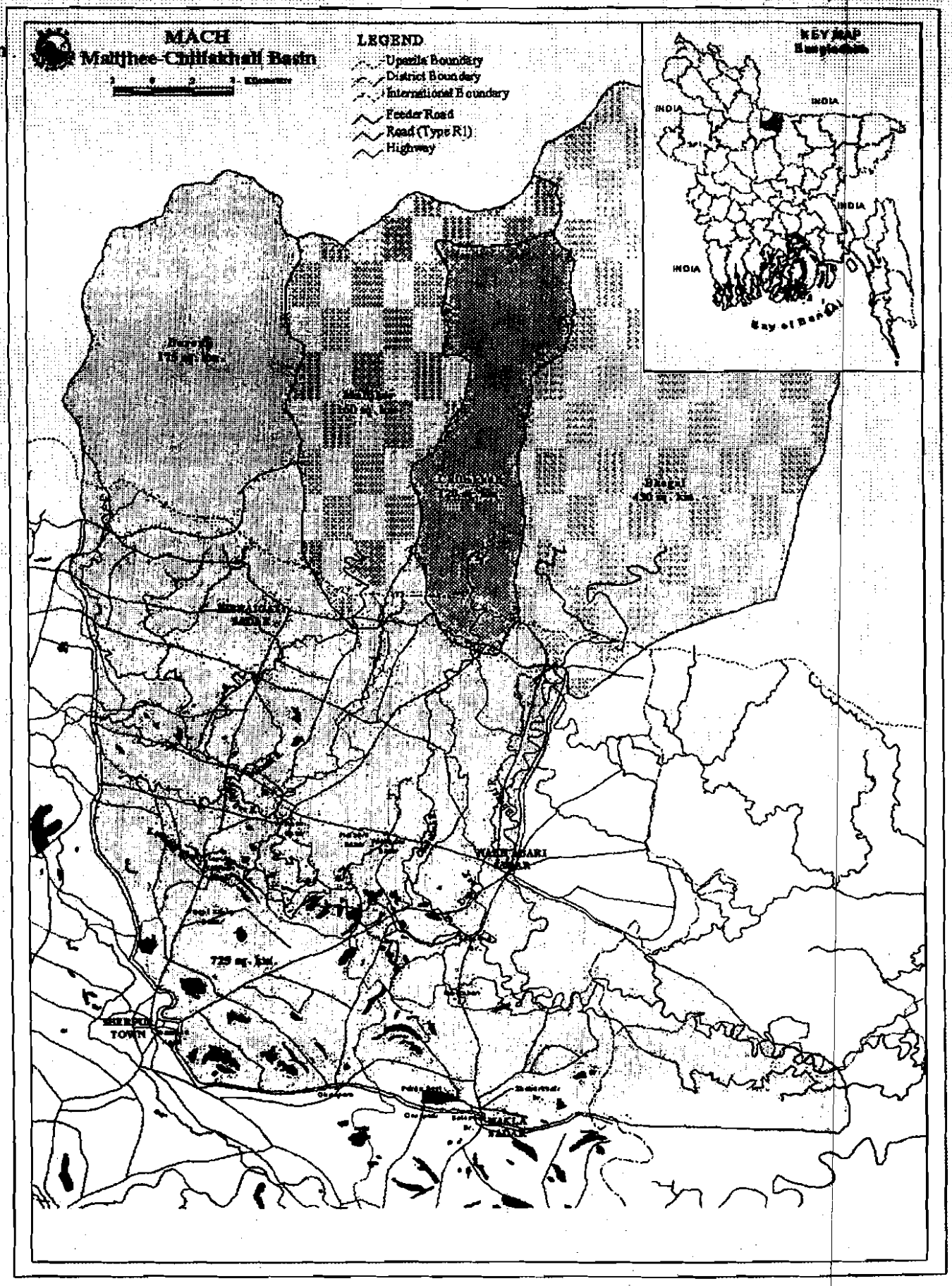

Figure 3.2: Catchment boundary of Malijhee river basin

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3.3 HYDROLOGY

Areas under study by the project include water levels at seven stations in the rivers and one rainfall gauge at Tinani Bazaar. The water level gauges are at 1. Dholi beel, 2. Malijhee River, 3. Chellakhali River, 4. Kapasia Bridge, 5. Baitkamari bridge, 6. Kewta beel and 7. Tenachura khal. The Kapasia and Baitkamari stations considered as the outlets of the river system. Once Kongsho-Malijhee basin fully drained to Shomeshowri river of Netrokona district but in recent history it changes its coarse. Shomeshowri River at Jhenaigati Thana is characterized as Pagla river (mad river) for its nature of changing coarse. It has already changed three courses and is flowing in a new channel. The river flows over several beels and meets with Malijhee river at Paglarmukh, a place on the Sherpur-Jhenaigati road. Around 6/7 years before it was the normal course of flow. However, due to the siltation at the Paglarmukh and re-excavation of Tenachura khal of Sreebordi Thana, Shomeshowri River diverted from Paglarmukh to Tenachura khal. A significant portion of the Shomeshowri River flows to Tenachura. Tenachura khal is connected with Mrigi River which is a tributary of Old Brahmaputra River.

Climate: There are no climatologically stations within the basin other than MACH rainfall station. Mymensingh climatological station, though located outside the basin, is the nearest relevant station. Maximum temperatures in the area vary from about 29°C to 30°C with the highest temperatures experienced during the period between March and October. Minimum temperatures range between 16° C and 20° C.

Evapotranspiration: Annual potential evapotranspiration as measured by BMD at Mymensingh is 1506mm with the lowest monthly amount in December (87mm) and the highest monthly amount in April (162mm).

3.3.1 WATER LEVELS IN THE RIVERS AND BEELS

Five water level gauges are in operation in Sherpur site from June 2000. These are, 1. Malijhi River at Tinani bazar, 2. Chellakhali River, 3. Kapashia Bridge, 4. Baitkamari bridge and Dholi beel of Jhenaigati union. Another two gauges are in operation at Kewta beel and Tenachura Bridge from May 2001. **Figure 3.3** shows the daily water levels of four locations.

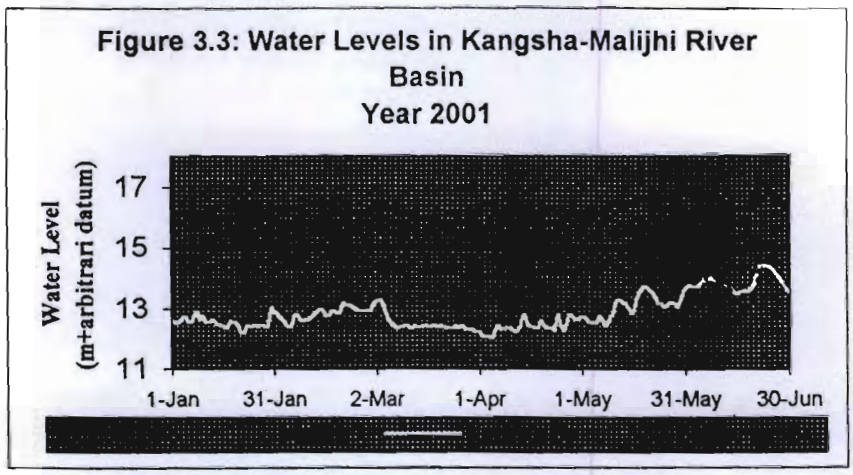

Figure 3.3: Daily water levels in the Upper-Kangsha Malijhi basin.

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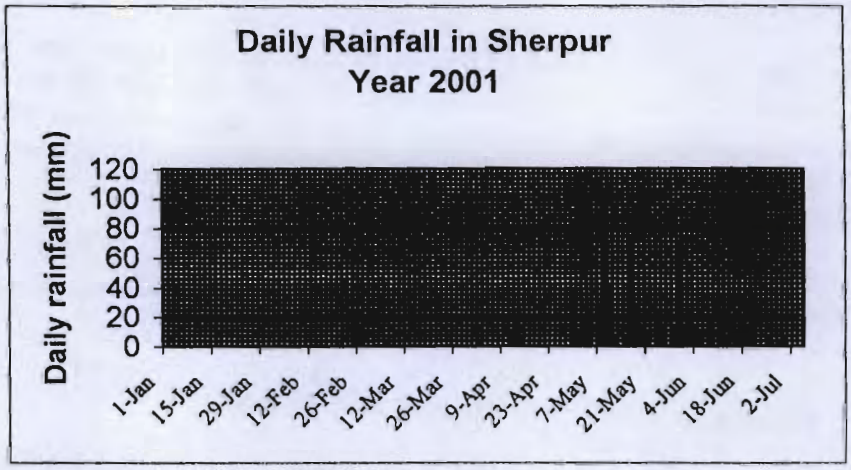
3.3.2 RAINFALL

There is an increasing trend of rainfall from south to north of the area. The mean annual rainfall varies from 2800mm to 4400mm. One rain gauge is placed at Tinani bazar in Jhenaigati union. The reader has been keeping daily rainfall records since September 2000. Virtually there was no rain in the dry season, from Jan-April 2001.



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3.4 PRIORITIZATION OF BEELS

Rapid sedimentation is a problem in Sherpur site. Siltation rate of some beels are very high and some are low. Therefore, in the beginning of Sherpur site activities, MACH decided to concentrate in those beels which have low siltation rate considering the sustainability and effective future management. To prioritize the beels of the system on the basis of siltation, a survey was conducted in September 2000. Beels were prioritize considering the chennel network, source of sediment and distance from the channel, deposited beels bad materials, etc. Also local peoples opinions were highly considered in this regard.

3.4.1 CRITERIA OF BEEL SELECTION

Priority 1: Excellent. No siltation, no future possibility of siltation.
Priority 2: Fair. Very Low siltation rate. Siltation by fine material. No direct connection with Channel. Far from sediment carrying channel. Low possibility of filling in future.
Priority 3: Good. Low siltation rate. Siltation by fine and medium coarse material. Not very far from sediment carrying channel. Low possibility of filling in future.
Priority 4: Bad. Relatively high siltation rate. Very close to or dircct connection with sediment carrying channel. Possibility of filling in far future.
Priority 5: Very Bad. Very high siltation rate, possibility of filling in near future.

Table 3.1 and **table 3.2** shows the list of beels and their priority index.

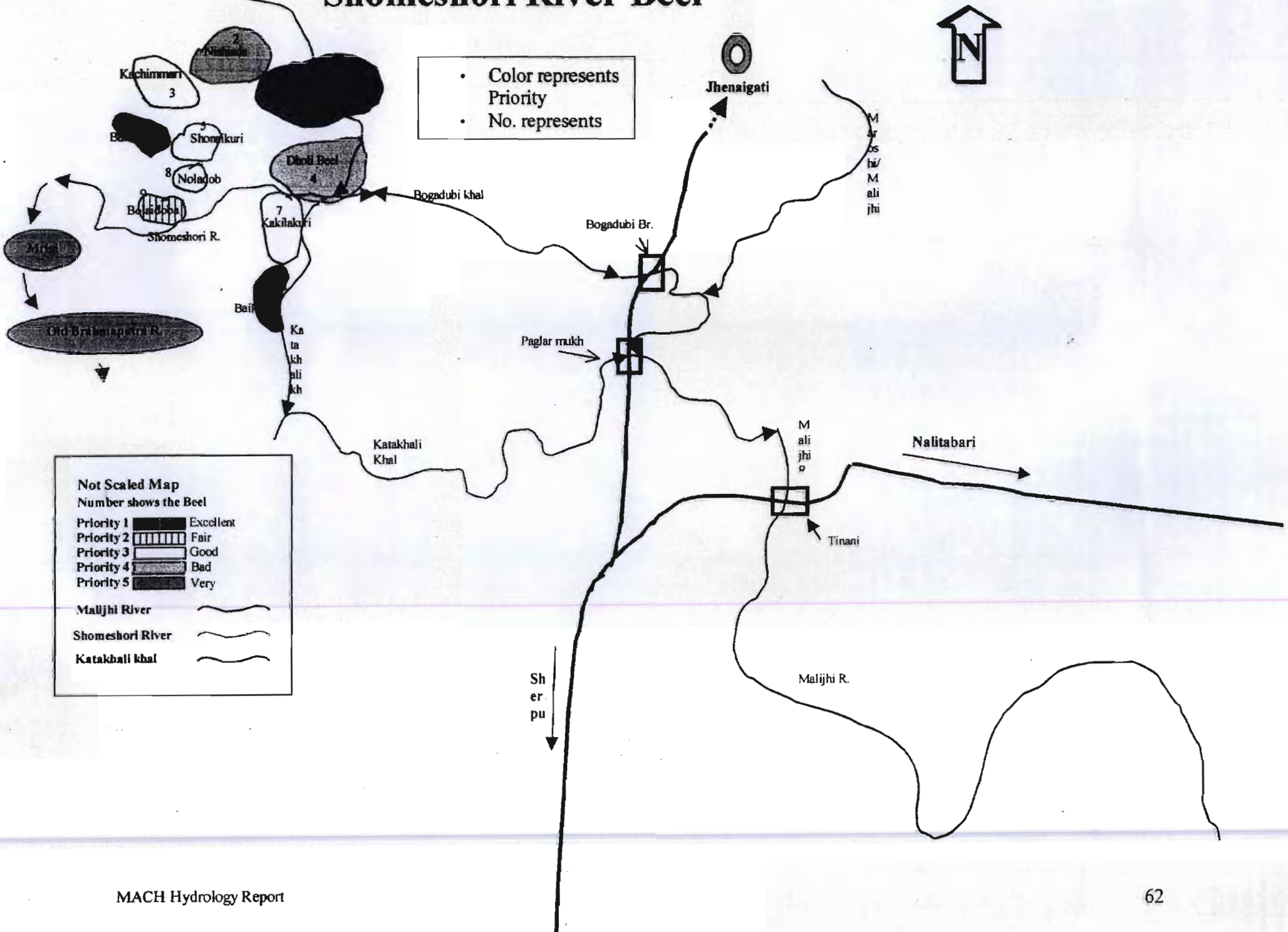
Table 3.1: Priority List of Beels of Shomeshori River Beel Complex
(See figure 3.3)

Beel Code	Beel name	Description	Priority
1	*Gozar mari beel*	Direct siltation by Shomeshori R.	5
2	*Nishinda beel*	Relatively low siltation than Gozarmari	4
3	*Kachimmari beel*	Low siltation rate, far from Shomeshori	3
4	*Dholi beel*	High siltation rate, connection with Shomeshori	4
5	*Sonaikuri*	Relatively low siltation	3
6	*Bailsha beel*	Low siltation	1
7	*Kakilakuri*	Lower siltation than Dholi beel	3
8	*Noladoba*	No direct connection with Shomeshori	3
9	*Bolai doba*	Low siltation rate	2
10	*Baila*		1

Table 3.2: Priority List of Beels of Malijhi-Chellakhali Beel Complex (See figure 3.4)

1. Beel Code	Beel name	Description	Priority
11	*Hashli*	Small size, low siltation rate, no direct connection with Malijhi	2
12	*Darabashia*	Very near to Malijhi, almost filledup	4
13	*Takimari*	Low siltation rate	2
14	*Fulpaira*	Canal connection with Malijhi, relatively high siltation rate, seasonal	4
15	*Roha*	Small size, low siltation rate, seasonal	3
16	*Boithavanga*	Siltedup near the Malijhi portion.	3
17	*Batiya b*	Low siltatin rate. Perinial	2
18	*Bamontali*	No siltation. Large water area even in the dry season. Suitable for fish sanctuary	1
19	*Beki*	Present siltation rate is low. No direct connection with Malijhi	1
20	*Paikka*	High siltation rate.	4
21	*Khaila*	Seasonal, small size, almost filled up	4
22	*Bhegi*	Seasonal, small size, almost filled up	
23	*Shonnashi*	Perinial, low siltation, small size	2
24	*Khuski*	Seasonal, low siltation, very small water area in the dry season, possibly one Kum	2
25	*Nerila*	Perinial, low siltation	2
26	*Rowmari*	Almost filled up	4
27	*Kasti*	Relatively high siltation rate	4
28	*Borobila*	Siltation by Challakhali	4
29	*Chuar*	Almost filled up	4
30	*Nizla*	Low siltation rate	3
31	*Boropukur*	Small size, relatively low siltation, small water area in the dry season	3
32	*Chinamari*	Silted up. Sediment intrusion from Balughat	5
33	*Digdari*	Relatively big size, almost silted up, no kum	4
34	*Haili*	Almost silted up	4
35	*Dublakuri*	Almost silted up	4
36	*Shoarkuri*	Small size, low siltation rate	3
37	*Boalmari*	Small size, low siltation rate	3
38	*Bouli*	Small size, low siltation rate	3
39	*Jugaina*	Filled up	5
40	*Golla*	High siltation rate	4
41	*Kawakuri*	Almost no siltation. No connection with Chellakhali	1
42	*Kaiyakuri*	Connection with sediment carrying channel	4

Shomeshori River Beel



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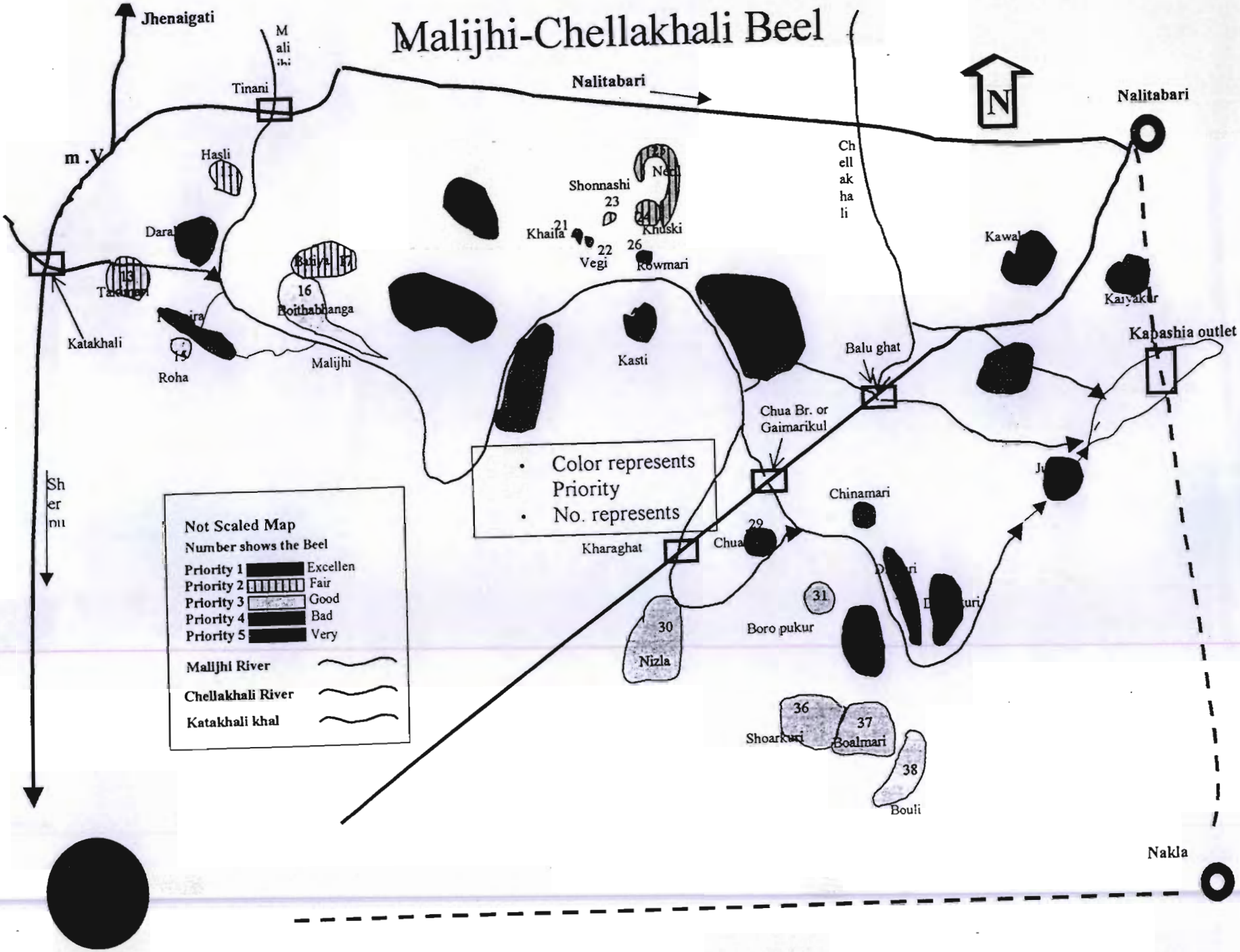
Malijhi-Chellakhali Beel



3.5 RECOMMENDATION

Major problems in the Kongshaw-Malijhee site are the flash flood and siltation. Naturally the area is flash flood prone area, however the situation has been aggravated due to unplanned local road network and the siltation of the channel. In a preliminary survey in the project site, it was seen that on the Sherpur-Nalitabari highway, 29 bridges/culverts were found in its 26 km distance. Average opening is 1.29 m per 100 m. Also insufficient openings were found on the Nalitabari-Nokla highway (2%). Due to the drainage congestion, the beels and khals are getting silted every year and causes biodiversity loss rapidly.

Shomeshowary and Malijhee carry huge sediment each year from its upper reach. Already some beels of Shomeshwori coarse has been filled up like Gozarmari beel and some are threatened to disappear. A survey was conducted at a place of Chellakhali River where commercial sand mining is practiced; it was found that around 1 lack tons of sand was being transported each year for the site. Other small river like Kalaghosha River carries huge sediment each year. Immediate measures should be taken to reduce the sediment intrusion into the beel areas. Riparian plantation and Uppershed plantation may reduce the sedimentation but it is a cross boundary problem, difficult to manage. Therefore, structural measures may improve the situation. Check dam is widely used in many countries to prevent sediment load at a place. On an experimental basis, a Check dam may be constructed on the Kalaghosha river of Jhenaigati Thana.

Sherpur is a new site in the MACH project. Therefore the existing monitored hydrology data is not sufficient to analyze hydrology of the site. Some more years monitoring need to be continued.

Special Study: Feasibility Study of Re-opening of Shaka Borak Channel

4.1 INTRODUCTION

MACH intends to increase natural production of fish and other aquatic biodiversity through ecological management of wetland habitats with active participation of local community. One of the objectives of MACH is to reestablish lost connectivity among the diverse wetland habitats for free movement of fish and other aquatic organisms. Once Hail haor was connected with Kushiyara river and it was rich in fish production specially riverine species of fish. However, fish production reduced substantially due to the loss of connection.
Therefore, MACH has taken initiative to study the feasibility of re-establishing connectivity between Hail Haor and Kushiyara River and thereby ensure increased fish production and biodiversity in Hail haor.

4.1.1 OVERVIEW OF HAIL HAOR IRRIGATION PROJECT 1964

The feasibility study of the Hail Haor Irrigation Project was conducted by Consulting Engineers (Pakistan) Ltd. (CEP), Dhaka with the assistance of Bergers Associates, Salt Lake City, USA, under an agreement with the erstwhile East Pakistan Water and Power Development Authority (EPWAPDA), in 1964.
Bangladesh National Consultants (BNC), Dhaka were invited by BWDB (1973) to take up the detailed design of the Hail Haor Irrigation Project. A draft Feasibility and definite Project Report on Hail Haor Irrigation Project was published in 1976, followed by a design Report and an Operation and Maintenance Manual in 1977.
In mid 1976 an agreement was signed between the BWDB and NEDECO. BWDB and NEDECO started to update the so called "Geoup A" projects, followed by "Group B" projects, the last covered in an extension of the first agreement between BWDB and NEDECO. One of the "Group B" projects is Hail Haor Irrigation Project and preliminary work started in February 1980.

4.1.2 BACKGROUND OF KAMARKHALI SLUICE GATE CONSTRUCTION

The Pakistan water development board had conducted a study on Hail haor and Boro haor during the year 1963 and 1964 aiming to protect the area from the early spring flood and facilitate the area with irrigation. It was concluded in the report as follows:
"1. Damage to harvestable Boro crops in the Hail haor, Boro haor and in the adjacent area, during early spring floods are primarily due to the backflow from Kushiyara through Shakabbarak.
2. For the present cropping pattern, the present drainage efficiency is adequate for post-monsoon drainage. During the spring floods, however, the drainage efficiency of the Gopla river is low due to the backflow from Kushiyara through Shakaborak and there is drainage congestion.
3. In order to save, damages due to spring floods, a control structure at the intake of shakabarak is necessary."

The drainage outlet of the Hail haor is the Gopla river which flows first northword, then swings south-west into the Gunjajuri haor and finally flows through the channel of Ratna river into the Dhaleswari river at a point above a mile upstream of Madna covering a total distance of about 50 miles. It drains not only Hail haor basin but also Gunjajuri haor and Bara haor. The drainage of the area was slow before the construction of sluice gate near Shakabarak offtake because the capacity of the river was not adequate to drain large volume of accumulation water of the two haors which are fed by number of streams from the surrounding hills and the backflow of Kushiyara.

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During monsoon all rivers maintain high stages leaving no scope for gravity drainage for the low lands of the area. In the normal years when early spring floods did not occur and the stage of river Kushiyara was not high, the runoff resulting from the small amount of rainfall on the Hail haor basin is completely drained into the Gopla river which ultimately drains into Surma-Meghna river near Madna.

4.2 FACTORS CONSIDERED IN THE STUDY

The connection of Kushiyara river with the Boro Haor was disrupted due to manmade intervention. Most of the closers were done under the plan of Water Development Board to enhance Boro cultivation in the area, and other channels were silted naturally. Therefore following factors should be considered before reopening the channel.

- Peoples opinion about the reopening of the channel whether they are against it or not
- Bed level of Shakaborak intake and the average bed levels of Boro and Aman lands in and around the Boro Haor to know the slope of the channel and thereby flooding of the Boro haor by Kushiyara river
- Aman and Boro plantation and harvesting period in the area and the occurrence of floods in the Kushiyara
- Historical highest water levels of Kushiyara during the Boro harvesting period

4.3 INFORMATION COLLECTION AND FINDINGS

Average altitude of Aman and boro lands in and around the Boro haor were determined by a DGPS survey. Two GIS experts of BCAS, Mr. Abdul Alim and Mr. Nazibur Rahman have conducted the survey. Altitudes of different locations were referenced with a known point near Moulvibazar town. Altitudes were taken at the inlet of Shakaborak, Aman transplanted land around the Boro haor periphery, Boro lands which was under water during the survey, Bizna Bridge section which is the common outlet of Hail and Boro Haor deepest point.

The estimated bed elevations are as follows:
Kushiara at Shakaborak offtake : 5 m
Bizna river bed at Bizna bridge section: 2.2m
Average Boro lands: 2.5m- 5m
Average Aman lands: Above 5m
Deepest point of Boro haor: 1.32 m
Figure 4B.1 shows the graphical representation of land elevation of Boro Haor.

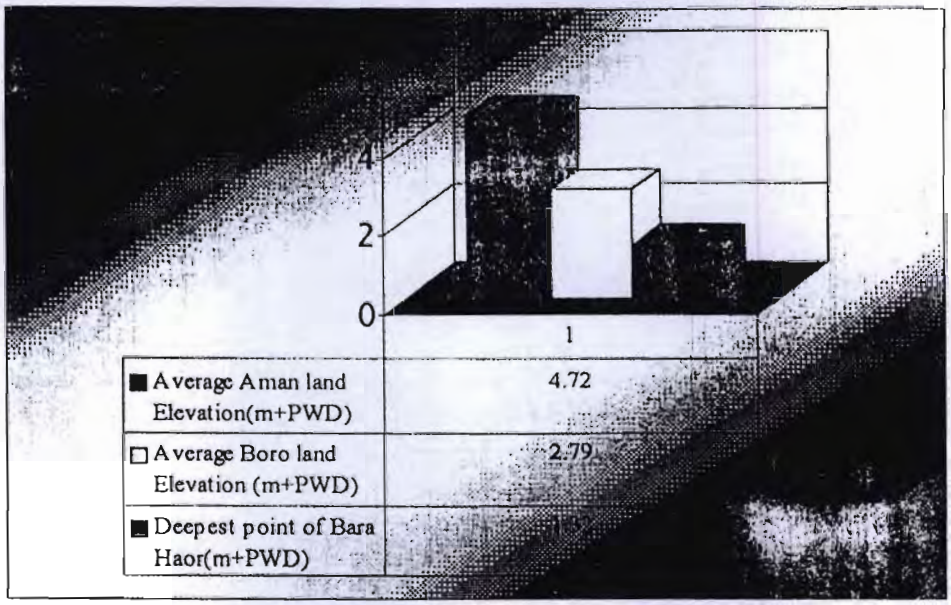

Figure 4B.1: Average elevation of Aman and Boro land in the Boro Haor.

4.4 HISTORICAL WATER LEVELS OF KUSHIYARA AT MONUMIKH:

Bangladesh Water Development Board (BWDB) has been keeping daily water levels record of Kushiara river at Monumukh, 2 km up from the Shakaborak offtake, from 1950. Data from 1950 to 1994 has been collected from WARPO database. A frequency analysis has been done to know the yearly variation of Kushiara water levels during the month of March, April and May, which are considered as the Boro harvesting month. The highest water levels in the month of March, April and May from 1959 to 1977 are presented in **table 4B.1**. The data has been plotted in **figure 4B.2**. It is seen from the **figure 4B.2** that the occurrence of flood heights during the month of April, harvesting time of Boro, remain always quite above the average Boro lands elevation.

The historical highest and lowest water levels are shown in **figure 4B.3**. The figure shows the trend of maximum and minimum water levels of Kushiyara over the last 50 years.

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Table 4B.1: Historical highest water levels (m,pwd) of Kushiara in the month of March, April and May

Year	March	April	May
1959	4.57	4.86	7.5
1960	2.56	2.13	4.89
1961	6.98	6.76	7.04
1962		5.01	5.84
1963	2.48	4.26	6.25
1964	3.09	7.71	10
1965	2.48	3.38	6.13
1966	2.29	3.03	6.52
1967	3.35	5.89	7.01
1968	2.91	4.97	7.39
1969	2.7	6.66	5.2
1970	3.47	4.89	6.78
1971	2.39	5.73	6.61
1972	2.44	5.86	7.26
1973	2.53	5.78	10
1974	3.53	6.59	7.32
1975	2.41	5.2	6.68
1976	5.47	5.64	6.51
1977	2.88	8.03	8.42

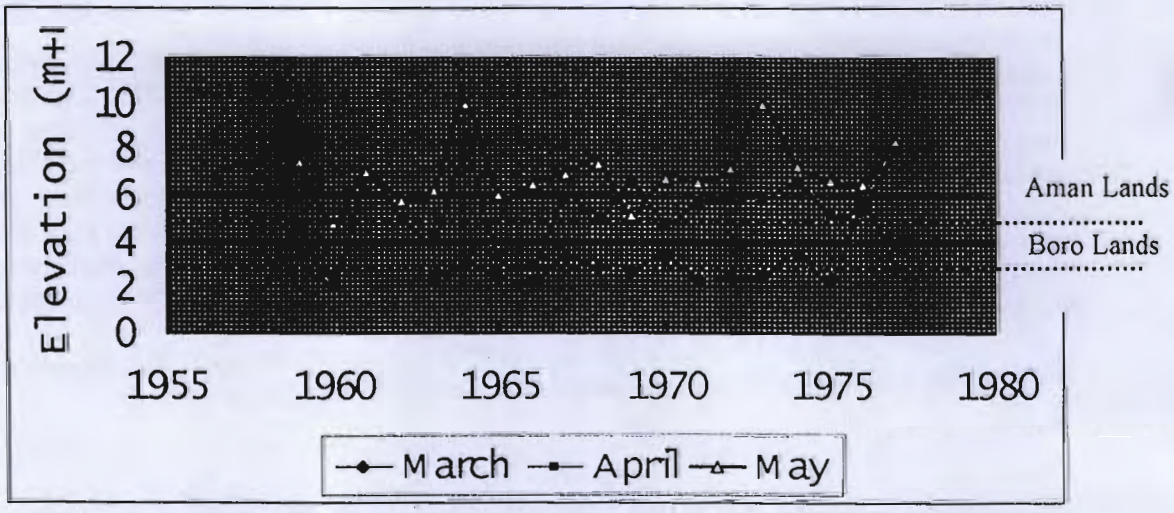

Figure 4B.2:Historical Water Levels Variation of Kushiara River near Monumukh during the Month of March, April and May

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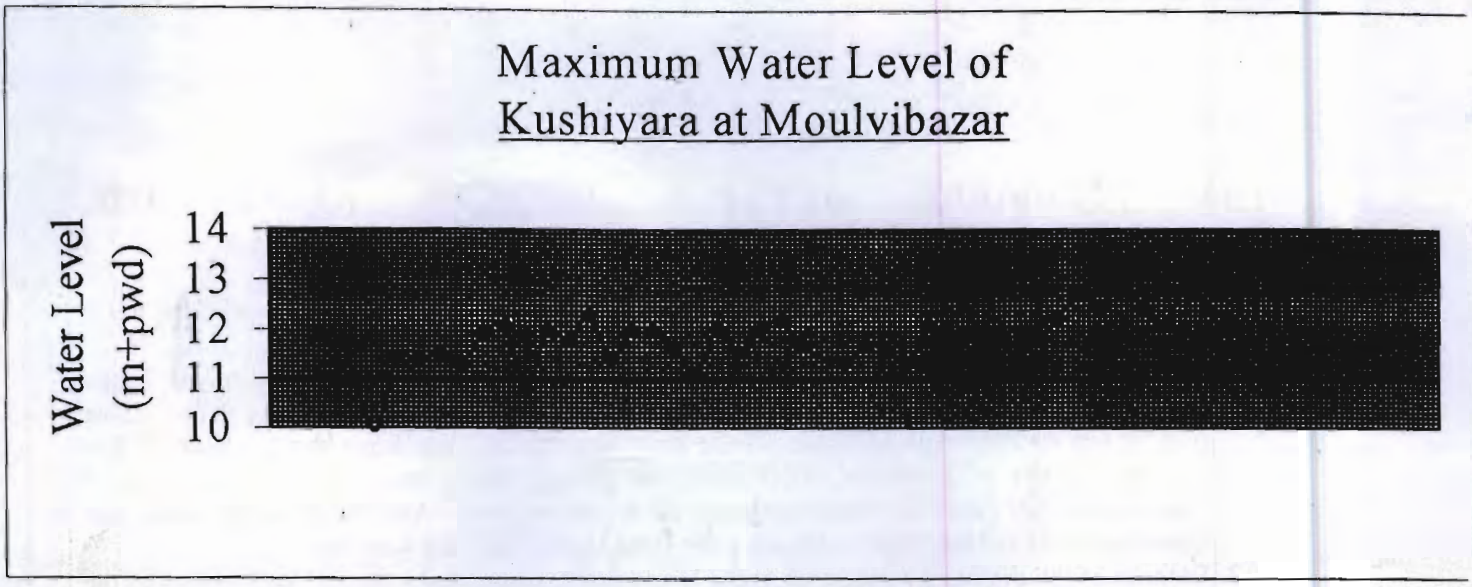

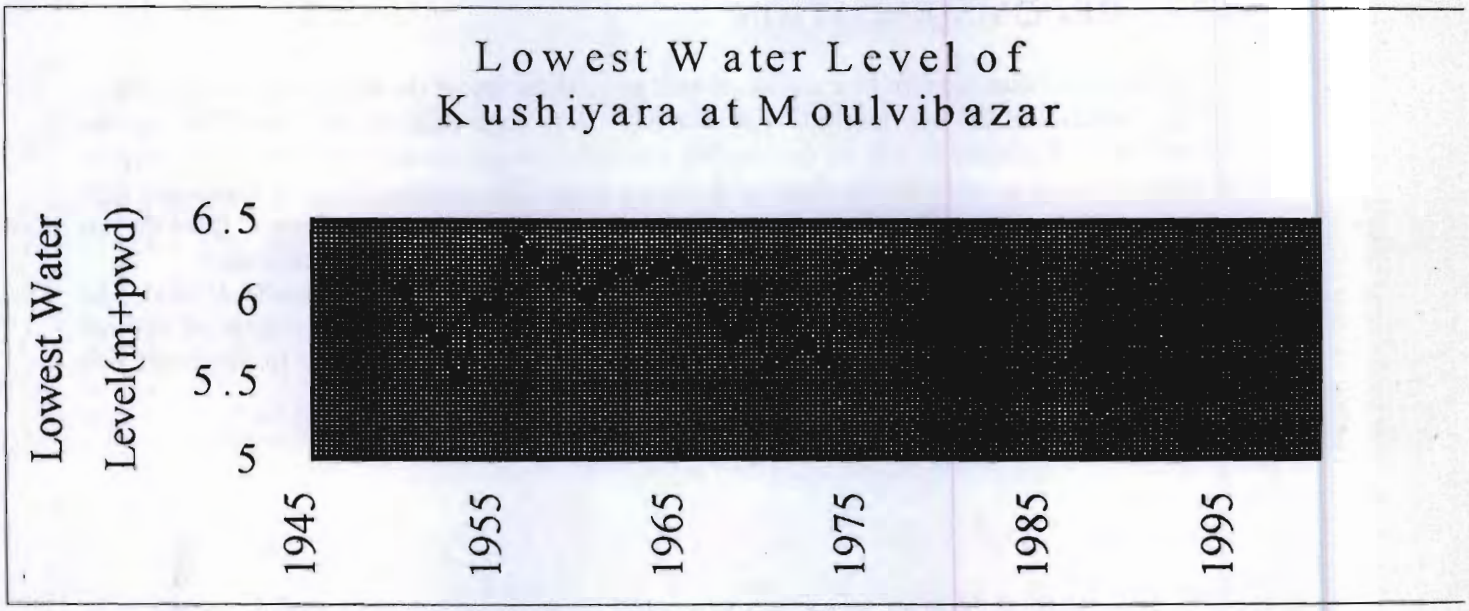

Figure 4B.3: Historical highest and lowest waterlevels of Kushiyara river at Monu Mukh

4.5 PEOPLES OPINIONS ABOUT THE SHAKABORAK RE-OPENING

Many peoples were interviewed from Shakaborak intake to Bizna outlet during our short survey. It was observed opinions varied with places. Peoples of the Kamarkhali and Shakaborak intake area were reluctant about the reopening of the river because they will neither be benefited nor be looser from the works.

Peoples of the North and North-east periphery of Boro Haor showed keen interest in the works because there lands are in relatively higher altitude and will not be affected from the flooding of Kushiyara river, on the contrary, there lands will come under irrigation facilities from the Shakaborak. Peoples of the western side of the Boro haor were very much against of re-opening of the Shakaborak because they would be directly affected from the early spring flood of Kushiyara after the reopening of Shakaborak. They are very influential and strong peoples compared to other side peoples, and operate the Kamarkhali sluice living around 20 km apart

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from it.

4.6 PROBABLE ADVERSE IMPACTS AFTER THE REOPENING OF SHAKABORAK:

1. Huge Boro lands of Boro Haor might be destroyed before harvesting because of the early spring floods in the month of March and April.
2. Drainage congestion may happen at the Bizna river point because Bizna is the only drainage outlet of Hail and Boro haor. Bizna also drains the Gunzajuri Haor of Hobigonj district. This river is not wide enough to drain off the rainwater of Hail and Boro haor watershed. The additional water of Kushiara which will pass through Boro haor after the reopening of Shakaborak may cause drainage congestion at the Bizna point. Also the Kushiara water will cause backflow to Hail haor and destroy the Boro land of the Hail haor too.
3. Because of the drainage congestion at the Bizna point, suspended sediment will deposit at the point and consequently river bed will be raised and a permanent water logging will take place.

4.7 RECOMMENDATION

It is of no doubt that the fish production as well as biodiversity of the Boro haor and Hail Haor will be increased if the lost connection is reestablished through Shakaborak river. However, the re-opening of Shakaborak will be devastating without putting a control structure on the river to prevent intrusion of early spring flood of Kushiara River. The construction of a traditional type under-shot sluice gate will not fulfill our purpose to migrate fish from Kushiara to Boro than to Hail Haor. A fish friendly spill type gate may be constructed to enhance fish migration.
The only active existing canal connecting Boro haor with Kushiara is Kamarkhali khal. The existing Kamarkhali sluice is not in favorable condition of fish migration because of its high velocity in the sluice. Therefore, construction of a fish-by-pass is necessary to accelerate fish movement

Section 5: Special study

Hail Haor Watershed study

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5.1 INTRODUCTION

Hail Haor watershed management plan, prepared by Centre for Natural Resources Studies (CNRS), envisages integrated development of Hail Haor basin and its watersheds spreading over the Satgaon, Foyzabad and Balishira hills ranges of the Sreemongal Upazila of Moulvibazar district. The goal and objectives of the plan is to demonstrate on a sub-watershed scale, improved land and water management practices that are conductive to improving the quantity and quality of water, reducing the sediment inflow into the haor basin, creating congenial habitat for forest-based resources production and long term sustainable utility of haor basin as productive fishery ground.

In order to achieve the goals and objectives of the program, regular monitoring would be required and conducted. Two types of hydrology monitoring have been conducted; 1. General hydrology monitoring comprising discharge, sediment load, rainfall monitoring at a lower frequency of the representative 20 Chhoras of the entire Hail haor system, and 2. Intensive hydrology monitoring of selected two Chhoras sub watershed, Joita and Jag, at a higher frequency to characterize rainfall-runoff and sediment loading relation of different land use pattern. This section will cover the intensive monitoring only. General monitoring is discussed in section 1.

5.2 STUDY AREA

Two Chhoras and its corresponding watershed were selected for intensive hydrology monitoring. These were Jag Chhora from the east side of the Haor and Joita Chhora from the west side. Jag Chhora and Joita Chhora originate from the Balesera hills and the Shatgaon hills respectively. Both are perennial in nature and carries huge sediment in the rainy season. The GIS division of BCAS delineated sub-watershed of these Chhoras from IRS image of Hail haor. Delineated watershed of the Joita Chhora is 667 ha whereas the Jag Chhora is 1004 ha. Length of the Joita Chhora is around 9km and the Jag Chhora is 14km. **Figure 5.1** and **figure 5.2** shows the study area.

5.2.1 SUB WATERSHED DELINEATION

For intensive hydrology monitoring, both the Chhoras were divided into three sub watersheds. The divisions were done mainly on the basis of land use. Overall land uses of the two watersheds are tea, lemon and pineapple, forest and other homestead agriculture.

The Joita watershed was divided into three sub-watersheds. Theses are defined as follows.

1. Lemon section or upper reaches: This is the hilly portion of the Joita watershed. The land comprises the tea and lemon-pincapple garden. Total area is 360 ha and 50% of it is Lemon garden.
2. Tea road section or middle reaches: Total land area is 212 ha and 80% of the land is tea garden
3. Metalled road section or lower reaches: Total land is 95 ha and mostly used for homestead garden

Also, Jag watershed was divided into three sub watershed. These were named as follows.

1. Lawa Hills section or upper reaches: This is the hilly portion of the Jag watershed. Total area is 676 ha. Mostly forest area and some portion (around 20%) of it is the tea estate.
2. Metalled road section or middle reaches: Total land area is 239 ha and 90% of it is tea
3. Haor section or lower reaches: Total are is very small, around 90 ha and all are agriculture land

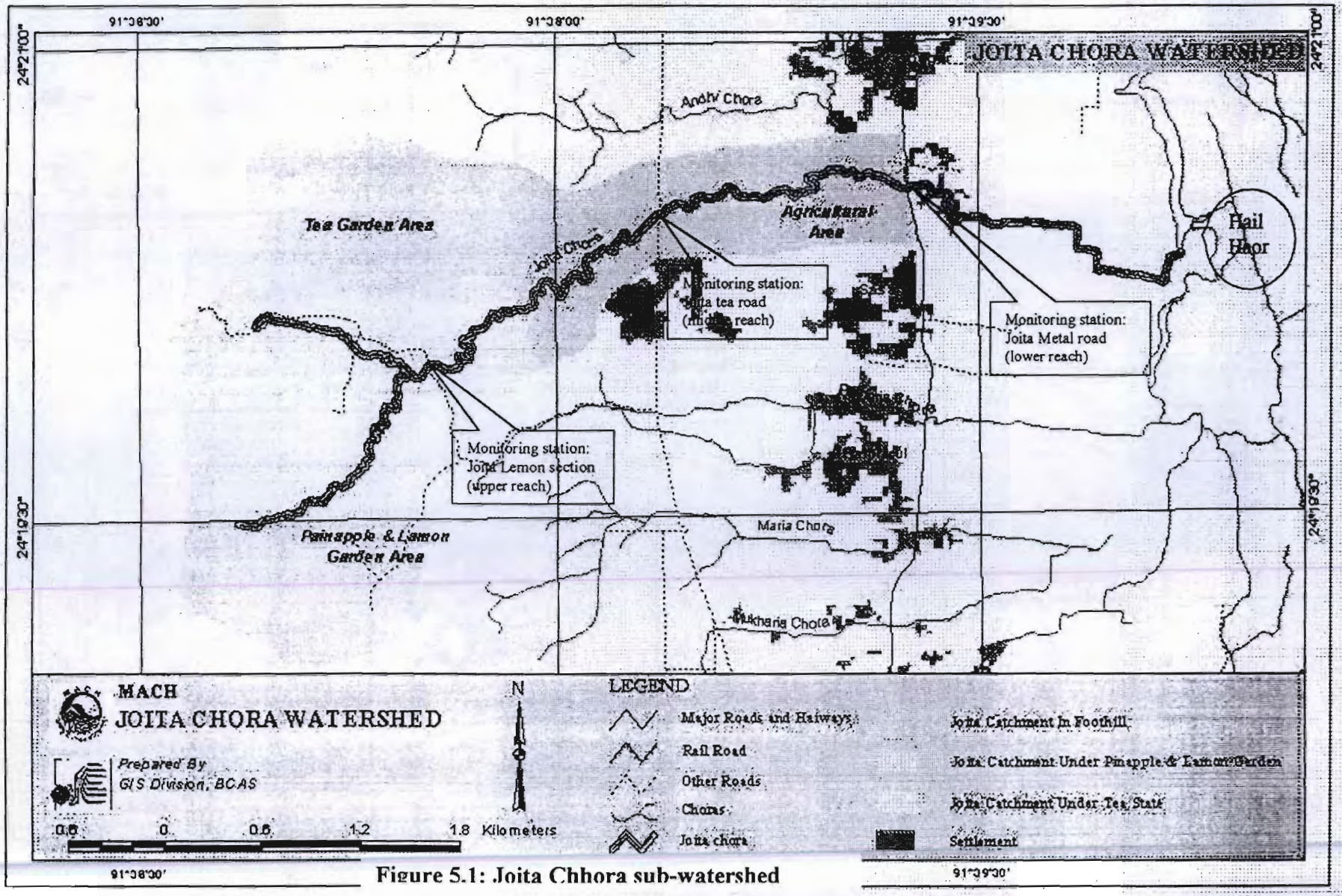

Figure 5.1: Joita Chhora sub-watershed

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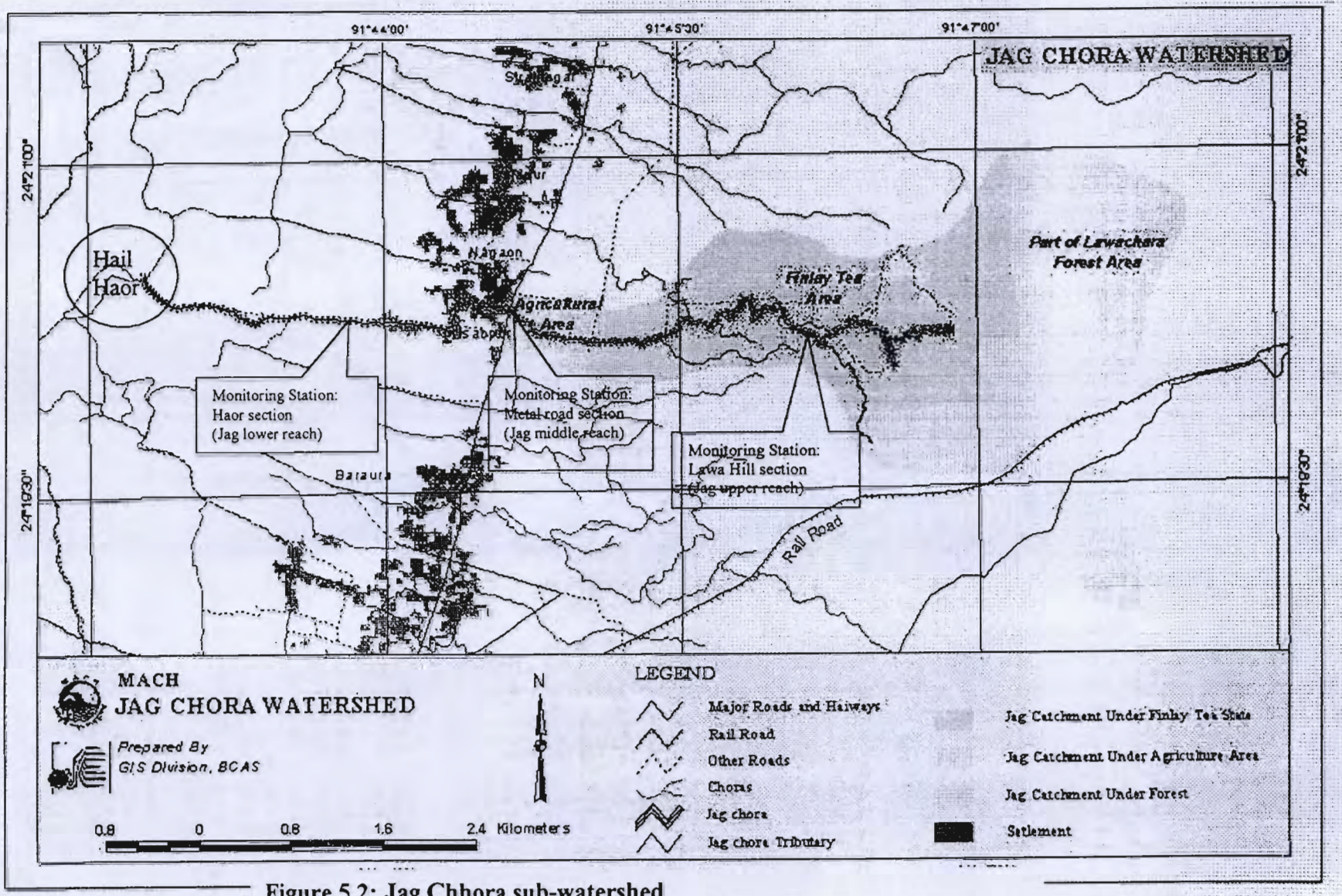

Figure 5.2: Jag Chhora sub-watershed

5.3 HYDROLOGY MONITORING

Three round of monitoring were carried out in the month of May, June and July of 2000. May is considered as the pre monsoon period and the June and July is considered as monsoon. In each round, monitoring continued for 7 days. Also in the 2001, three round of monitoring were conducted. These were in the month of June, July and August.

5.3.1 MONITORING & DATA COLLECTION FREQUENCY

Four types of measurement were carried out. These were:

1. Rainfall measurement: Two rain gauges were placed at the middle reaches of both of the Chhoras. Rainfalls reading were taken at three hours interval, from morning 6 to evening 6.

2. Water level measurement: six wooden gauges were placed at six sections of the Joita and Jag Chhora. Measurements were taken at three hours intervals, from morning 6 to evening 6.

3. Discharge measurement: Flow velocities were measured by using floats at the section of water level monitoring station. Measured flow velocities were frequently verified by Current meter reading. Measurements were taken at three hours intervals, from morning 6 to evening 6.

4. Sediment content measurement: Standard sediment sampler was used to collect sample during discharge measurement. Samples were taken at three hours intervals, from morning 6 to evening 6.
Suspended sediments were settled down by flocculating agent and measured volume of the contents. Also, water samples were filtered, dried and weighted by electronic balance to estimate the specific weight of the sediment.

5.4 RESULT AND ANALYSIS

5.4.1 RAINFALL

Rainfall variation over the Jag and Joita Chhora is presented in **figure 5.3**. The presence of two hills, Shatgaon and Balesera hills on the west and east side of the Hail haor influence the local rainfall pattern. The orographic effect on the Joita Chhora watershed causes more rainfall than the Jag Chhora watershed.

5.4.2 RAINFALL AND FLOW

Hilly streams are usually flashy in nature. Both Jag and Joita Chhora flash in a small rain. One-meter rise in water levels usually occur in a half an hour moderate rainfall. To catch this peak flow intensive monitoring of three hours interval was conducted. General monitoring doesn't catch this situation. **Figure 5.4** and **figure 5.5** present the response of Jag and Joita Chhora with rainfall. Discharge at all sections of Joita Chhora increased sharply with rainfall and dropped after the rain. However, in the Jag Chhora at the upper reach run-off doesn't occur quickly as the rainfall intensities. This is because of the dense forest cover of the Lowa hills of the upper reach of Jag Chhora.

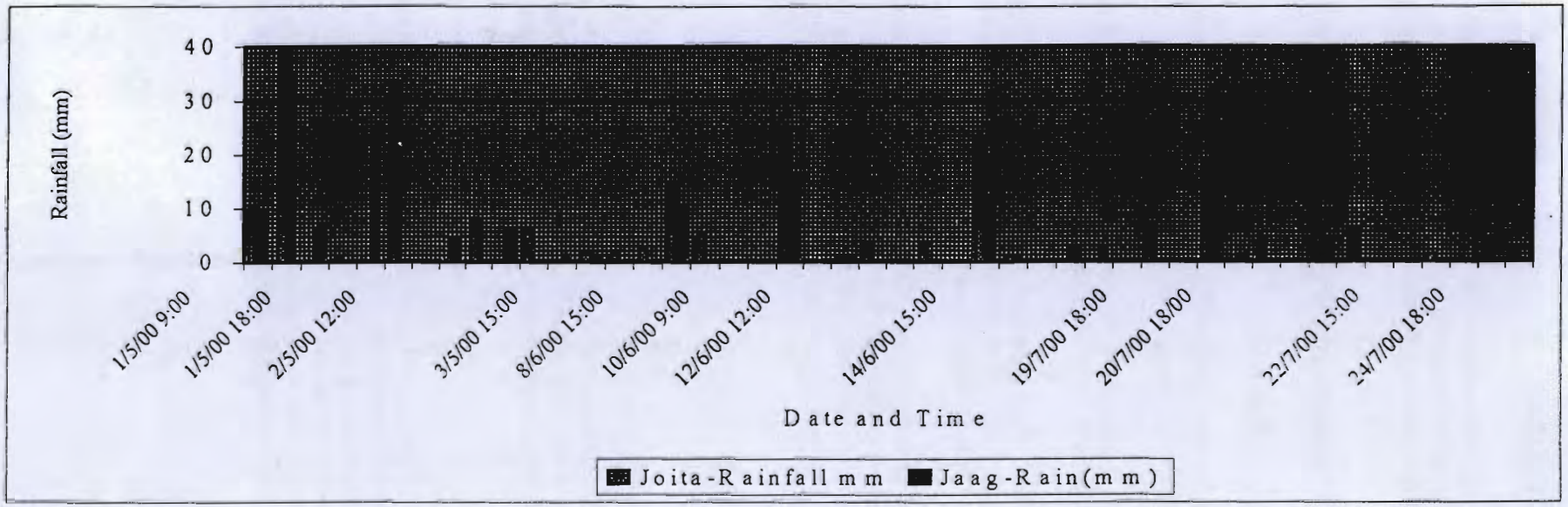

Figure 5.3: Rainfall Variation over Joita and Jag Catchment. Rainfall variation over the Jag and Joita Chhora is presented in this figure. The presence of two hills, Shatgaon and Balesera hills, on the West and East Side of the Hail haor influence the local rainfall pattern. The orographic effect on the Joita Chhora watershed causes more rainfall than the Jag Chhora watershed.

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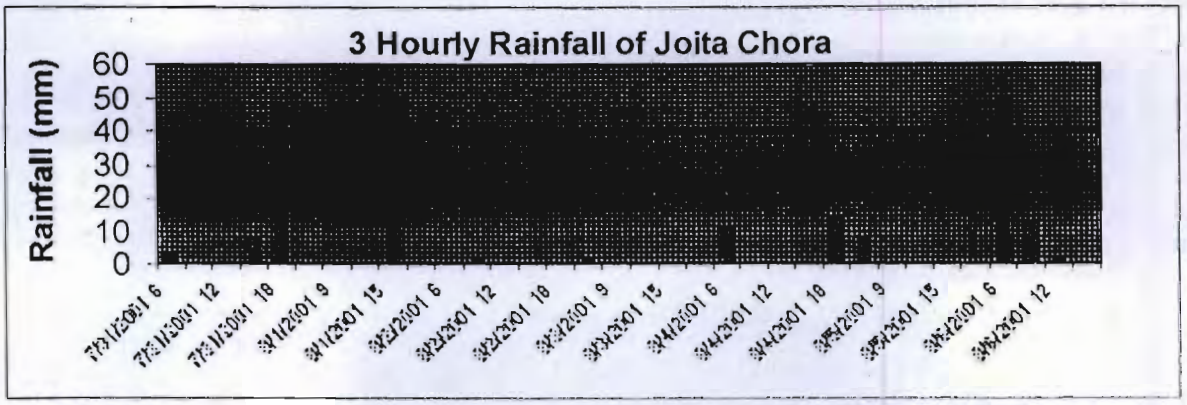

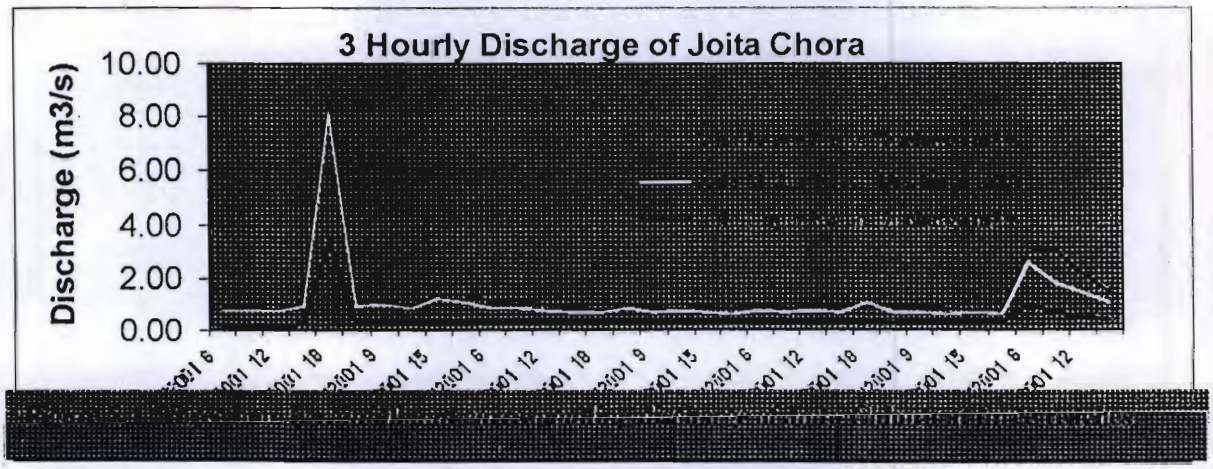

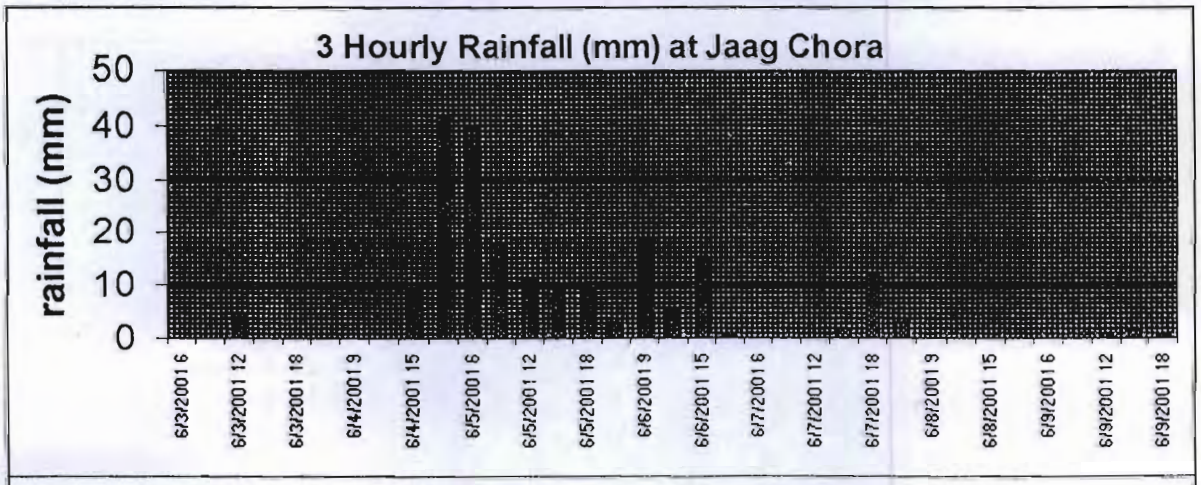

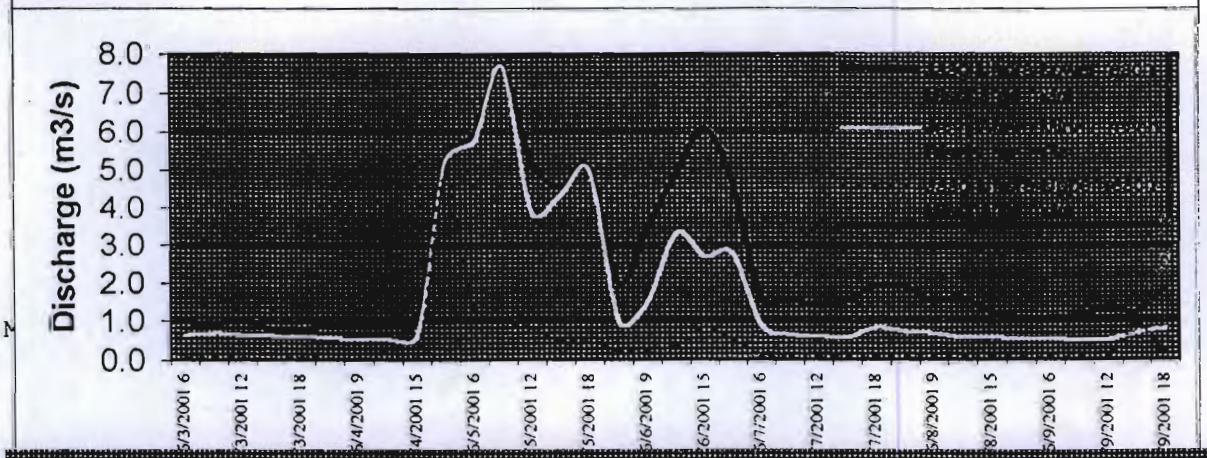

Figure 5.[illegible] Three hourly [illegible] rainfall and corresponding discharge at Joita Chora and Jaag Chora respectively

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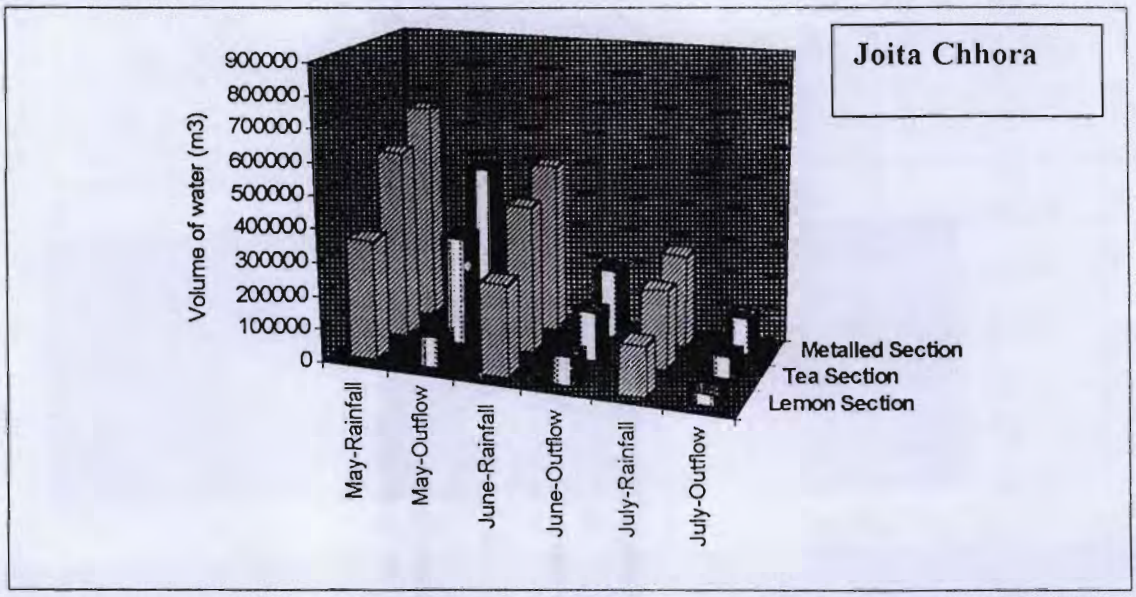
5.4.3 INFLOW AND OUTFLOW OF CHHORAS

Figure 5.6 is the isometric presentation of inflow (rainfall) and outflow at three sections of Jag and Joita Chhora. Only the rainfall events of the three round of monitoring and its corresponding discharge were considered. First round of inflow and discharge were presented as May Rainfall and May Outflow, second and third round of monitoring were presented as June and July respectively. In the first round of monitoring, 1st week of May, Rainfall intensity was higher than the other June and July monitoring. Comparatively, lower rate of runoff was seen in the Lawa section of Jag Chhora than the Lemon section of Joita section.



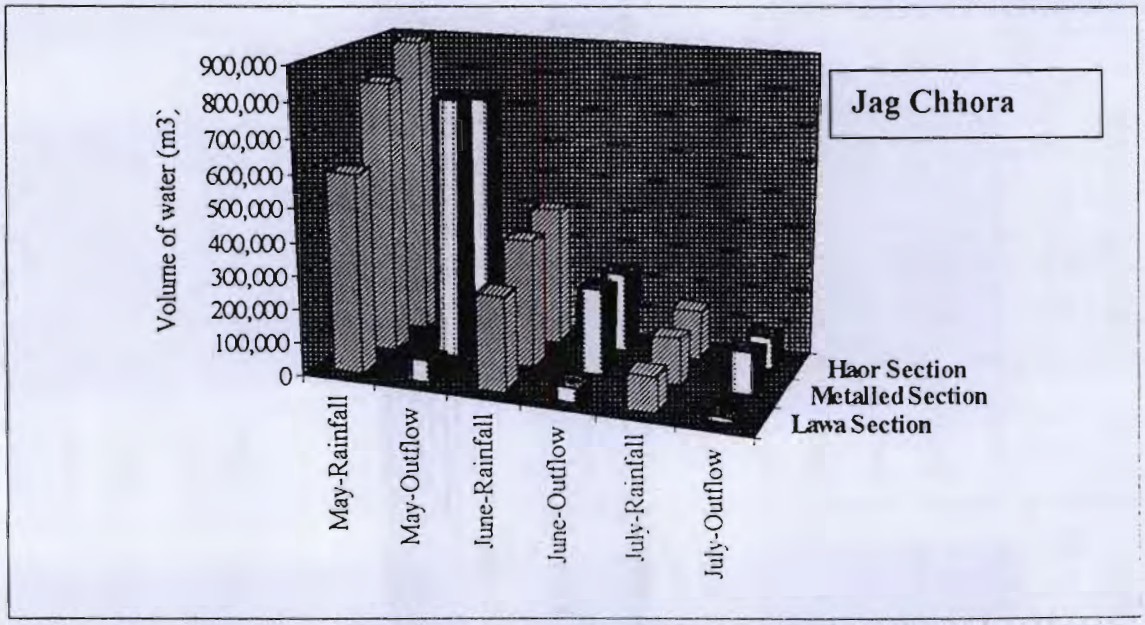


Figure 5.6: Inflow and outflow at three sections of Jag and Joita Chhora. Inflow means the rainfall volume of the corresponding period. Outflow means the volume of discharge of the same period.

5.4.4 SEDIMENT LOADING

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Joita Chhora: Silt content of flowing water was plotted against the time interval in **figure 5.7**. For better understanding, silt content per 1000 m3 of water was computed. Percentage of silt in the flowing water was almost same in the Tea road section (middle reaches) as well as Lemon garden section (upper reaches). Figure also shows the same tendency of increased silt contents with rainfall event. On the other hand, metal road section (lower reaches) varied with others. The change of silt content didn't follow the rain event always. Silt content was higher in this section compared to other sections mainly due to the land use of the surrounding area, bank erosion at many places along the channel reaches. General land use of the section is mainly homestead garden, potato and other vegetable garden. Soil erodes easily at this area with a small rainfall event. Also, huge volume of water passes through this section and this causes bank erosion at many places of the channel.

Jag Chhora: Percentage of silt content per 1000m3 of flowing water of Jag Chhora is relatively lower than the Joita Chhora (**figure 5.8**). Also the fluctuation of silt content was quite related with the rainfall intensity. This is because of presence of comparatively good vegetation cover in this watershed.

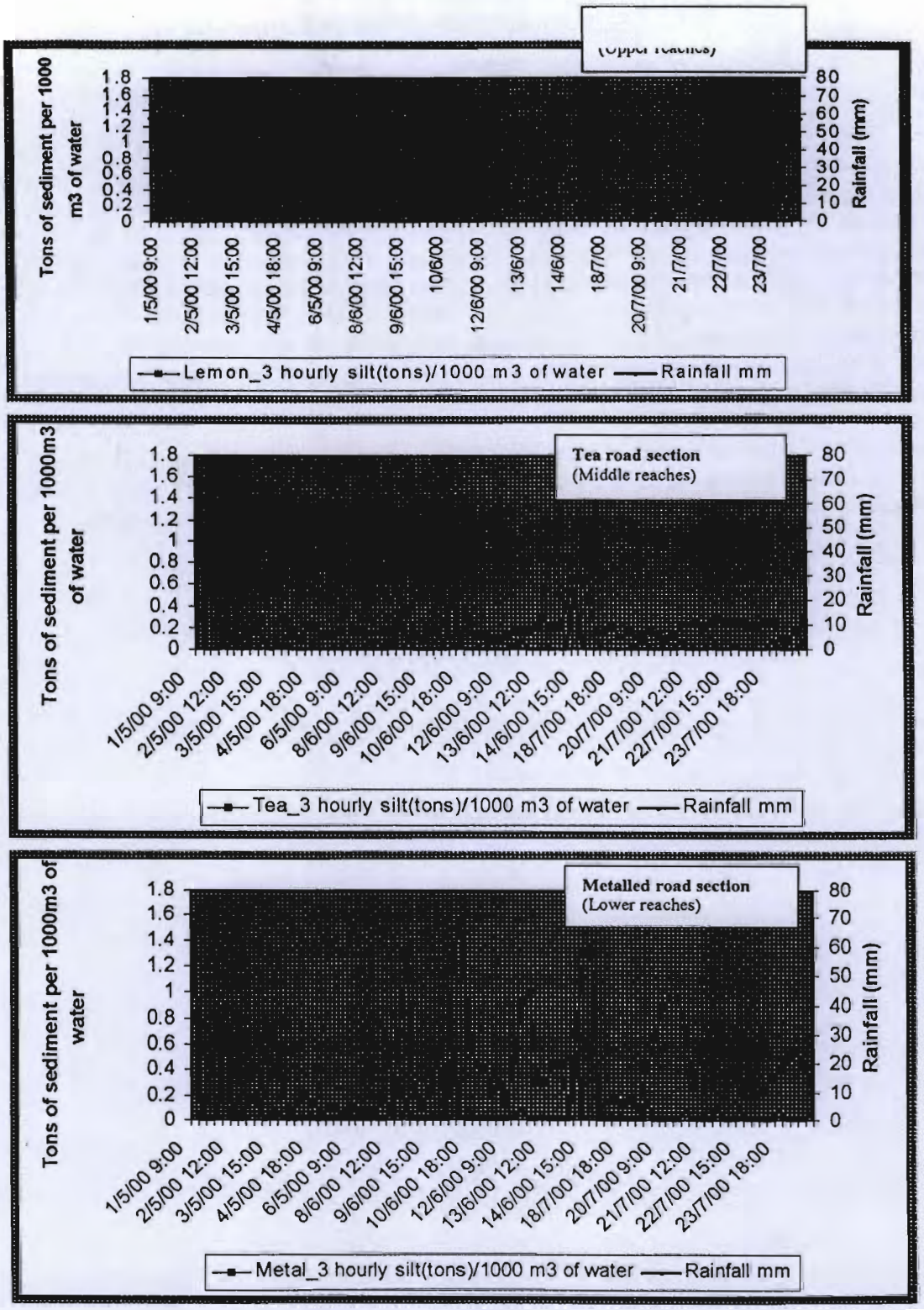

Figure 5.7: Joita Chhora: Variation of Sediment content with rainfall

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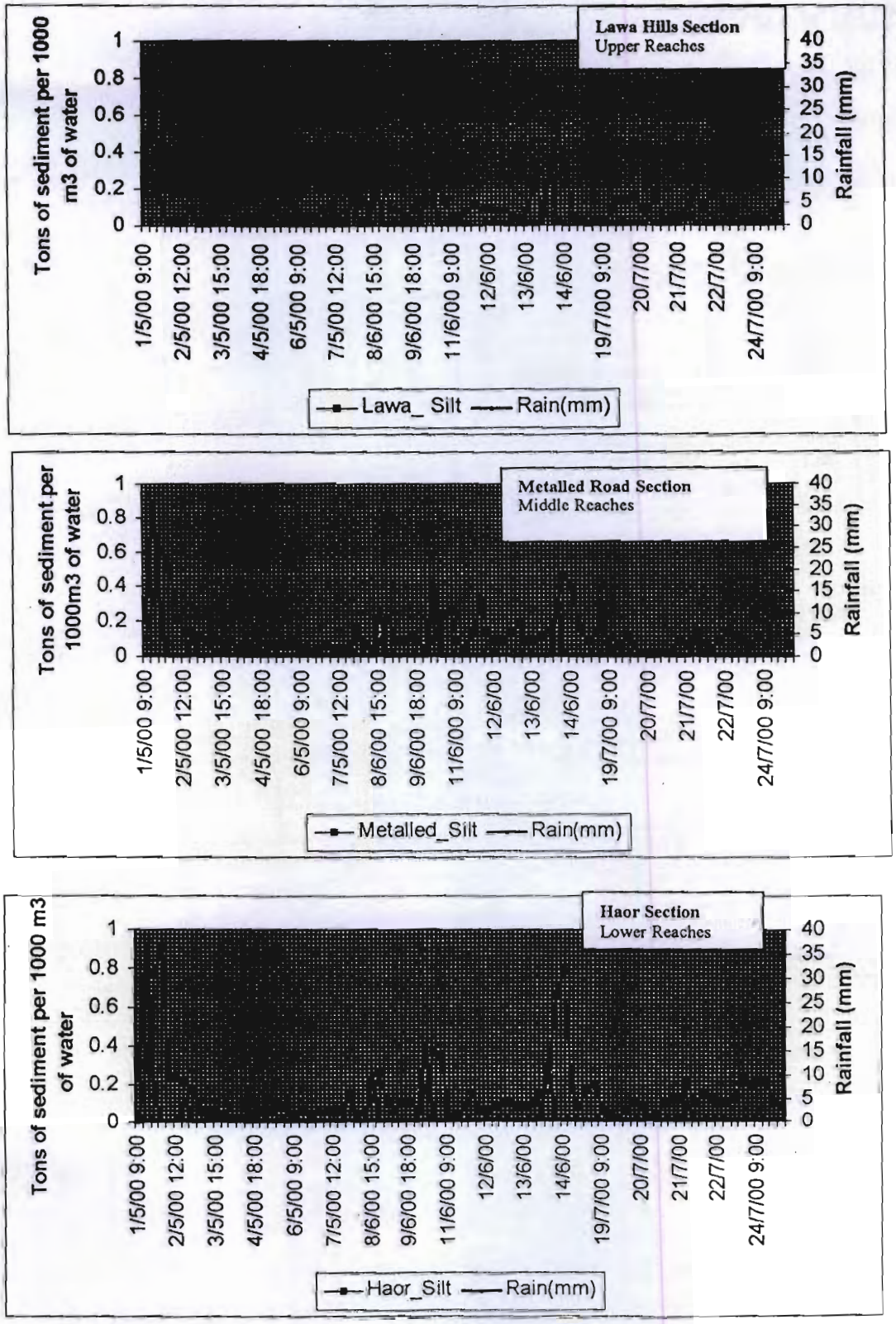

Figure 5.8: Jag Chhora: Variation of Sediment content with rainfall

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5.5 SUMMARY OF ANALYSES

Table 5A.1: Facts and finding of Joita Chhora

Joita Chhora

Sl. No.	Facts and Findings of Joita Chhora	Lemon Garden Section	Tea Road Section	Metalled Road Section
1	Sub catchment area within the section	360 ha	212 ha	95 ha
2	Land use	Tea garden: 184 ha Lemon and pineapple: 176 ha	Tea garden: 163 ha Lemon and pineapple: 49 ha	Tea garden: 17 ha Agriculture: 78 ha
3	Length of streams within the section	3.78 km	2.96 km	2.35 km
4	Drainage density, meter/ha	10.5 m/ha	13.96 m/ha	24.73 m/ha
5	Location (at bridge section)	24° 19'57.23N 91° 37'33.05E	24° 20'25.43N 91° 38'22.60E	24° 20' 29.94N 91° 39'15.38E
6	Elevation: Stream Bed	20.27m	11.39	6.64
7	Average channel gradient	1.215 %	0.3 %	0.2 %
8	Volume of rainfall over the sub-catchment in the monitoring period	793430 m3	469233 m3	209091 m3
9	Volume of Outflow at three storm events	221219 m3	549576 m3	819039 m3
10	Volume of Silt flow at three storm events	140 tons	297 tons	827 tons
11	Rate of land erosion from sub-catchment	0.39 ton/ha	0.73 5 ton/ha	5.58 ton/ha
12	Average silt contents in the flowing water	0.63kg/m3	0.54 kg/m3	1 kg/m3

Table 5A.2: Facts and finding of Jag Chhora

Jag Chhora

Sl. No.	Facts and Findings of Jag Chhora	Lawa Hills Section	Metalled Road Section	Haor Section
1	Sub catchment area within the section	676 ha	239 ha	90 ha
2	Land use	Forest: 465 ha Tea: 211 ha	Tea: 199 ha Agriculture: 40 ha	Agriculture: 90 ha
3	Length of streams within the section	4km	7km	3km
4	Drainage density, meter/ha	5.92	29.3	33.3
5	Location (at bridge section)	24° 20' 9.75695"N 91° 46' 52.9236"E	24° 20' 17.091"N 91° 44' 39.0" E	24° 20' 17.101"N 91° 43' 39.0" E
6	Elevation: Stream Bed	22.6	8.47	4
7	Average channel gradient	0.8 %	0.2 %	0.15 %
8	Volume of rainfall over the sub-catchment in the monitoring period	983182 m3	347449 m3	130383m3
9	Volume of Outflow at three storm events	119180 m3	1157517 m3	1071907m3
10	Volume of Silt flow at three storm events	35 tons	286 tons	407 tons
11	Rate of Land erosion from sub-catchment	0.052 ton/ha	1 ton/ha	1.34 ton/ha
12	Average silt contents in the flowing water	0.29 kg/m3	0.25kg/m3	0.38 kg/m3

5.6 RECOMMENDATION

Immediate Measures

One of the objectives of the study was to understand the status of sub-watershed in respect to soil degradation. Analyses of the two Chhoras, Joita and Jag, showed high siltation rate. The eroded sediments are carried by the streams and ultimately reaching to Haor, filling beels. If this process keeps continued for a decade several inches of sediment will be pilled up and many beels will lose their perennial nature and lose habitats. Therefore, sediment intrusion into the haor will be stopped immediately.

- **Check dam construction**: As immediate measures, Check Dams may be constructed on some sediment carrying streams to accumulate some portion of he carrying sediment at a specified location. Check dam concept is new in Bangladesh but widely used in many countries like Indonesia, Philippines, and India. This is also known as sediment storage dam, this artificial dam is usually designed to intercept and trap waterborne sediment. The dam has a principal spillway that allows water to slowly flow through, allowing the sediment to settle out. The spillway may be in the form of notch or box inlet. Already Chhora Resource Management Organization (CRMO) has been formed in the Joita Chhora reach. So, as an experimental basis, Check dams may be constructed on this Chhora. The CRMO can manage the chekdam, remove sediment each year from the site and earn money by selling the sand. Therefore, there are two-way benefits from the check dam, rapid sedimentation of beels will be slow down and the local CRMO will have a source of income.

- **Bank protection**: There are some places along the stream reach which are vulnerable to bank erosion. These skewed portion of the Chhoras need to be protected from erosion immediately.

Longterm Measures

Check dam and others are not the permanent solution of stopping rapid sedimentation. To reduce the soil erosion proper watershed management is must by the active participation of he community. The following measures should be taken.

- **Riparian plantation**

Riparian plantation along the Chhora reach will help in dissipate energy of the hilly streams by creating obstruction and thereby reduce the bank erosion.

- **Cropping pattern change**

Present cropping pattern of lemon and pineapple is a major cause of soil erosion. Vertical plantation of the pineapple will be changed to contour plantation. Already MACH has demonstrated a contour pineapple garden in Sreemongal, and MACH is receiving very positive response from the professional pineapple garden owner.

- **Uppershed plantation**

Uppershed plantation is necessary to develop the sub-watershed.

- **Controlling herbicides use in tea garden**

Study showed that tea estate has also great contribution to present sediment loading. Though the tea land is covered with trees, splashing of rain can't reach to the soil, however the soil is beard due to the use of herbicides which is extensively being used in the tea estate. The use of herbicides should be controlled.

- **Proper use of stream water**

Stream is the only source of irrigation water in Hail haor site. Earthen dams usually constructed across the stream to pile up water at a section and gravitational irrigation is done. Therefore, virtually stream flow can't reach upto haor causing water scarcity in the haor in the dry season. Most of the cases, diversion of water continued beyond the actual demand of water. Therefore, proper sharing of water is essential leaving a portion of water for haor.

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