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

FLOOD ACTION PLAN

NORTHEAST REGIONAL WATER MANAGEMENT PROJECT (FAP 6)

FISHERIES SPECIALIST STUDY

Volume 1:

MAIN REPORT

December 1994

SNC ♦ LAVALIN International
Northwest Hydraulic Consultants

in association with

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

Canadian International Development Agency

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

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
AFI	Ajmirigan Fish Industries Ltd
BFRSS	Bangladesh Fisheries Resources Survey System
BNP	Bernacsek-Nandi-Paul
BWDB	Bangladesh Water Development Board
CAS	Catch assessment survey
CBM	Community-based management
CIDA	Canadian International Development Agency
DFO	District Fisheries Officer
DOF	Department of Fisheries
DOFr	Department of Forestry
DOR	Department of Revenue
DRH	Department of Roads and Highways
EPC	Environment Pollution Control
FAD	Fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FAP	Flood Action Plan
FCD/I	Flood control, drainage and irrigation project (ie as used in this report, any water management project which contains one or more of these three elements)
FFPw	Full flood protection FCD/I project with pumped drainage and irrigation
FFPwo	Full flood protection FCD/I project without pumped drainage and irrigation
FRI	Fisheries Research Institute
FSMF	Fish Seed Multiplication Farm
GDP	Gross domestic product
GOB	Government of Bangladesh
GRP	Gross regional product
KCS	Kuliarchar Cold Storage Ltd
LLOP	Lowest level of plantation
MAF	Maximum area flooded
MFL	Ministry of Fisheries and Livestock
MIWDFC	Ministry of Irrigation, Water Development and Flood Control
MLGRDC	Ministry of Local Government, Rural Development and Co-operatives
MOC	Ministry of Communication
MOL	Ministry of Land
MSY	Maximum sustainable yield
NERP	Northeast Regional Project
NFA	National Fishermen Association
NFMP	New Fisheries Management Policy
PFP	Partial Flood Control FCD/I Project
PMP	Project Monitoring Program
RC	River channelization FCD/I project
RKX	River and khal re-excavation FCD/I project
UNDP	United Nations Development Programme
WFP	World Food Programme
WRS	Water retention structure FCD/I project

GLOSSARY OF TERMS

arat	Wholesale fish market
aratdar	Fish wholesaler
bana	Fish fence
beel	Floodplain lake, which may hold water permanently or dry up during the winter season
boromaach	Large fish species
chotomaach	Small fish species
crore	10 million unit of measurement
jal	Net
donga	Dugout canoe
duar or duba	Deep scour hole in river
fisheries management	control and regulation of fishing effort on fish stocks
gele	Fisherman
ghat	Fish landing or assembly place
goola	Earliest premonsoon flood water, usually rich in sediment and organic material
haor	Depression on the floodplain located between two or more rivers, which functions as a small internal drainage basin
hijal	A floodplain tree species (Barringtonia acutangula)
jalmohal	A beel, river section, khal or other water body which is registered for revenue collection purposes as a 'fishery'.
jalmohan	A wealthy middleman who leases jalmohals from the government and then subleases to fishermen.
jurinda	Unit of measure of hizal tree branches used for katha (equals quantity of branches piled 3-4 m high on two engine boats lashed together)
kandha	Higher elevation land in a haor
kaph	Scour pocket in river bank
katha	Brush park type fish production system., also known as pile fishery
kachuri pana	A floating aquatic plant, water hyacinth (Eichhornia crassipes)
khal	Drainage channel running across a haor, connecting a beel to a river.
khalashi	Hydraulic regulator operator
khas	Government owned land and water bodies.
kola	Temporary dry season fishing camp
koom	A synonym for duar
koroch	A floodplain tree species (Pongamia pinnata)
lentic	Stagnant water bodies such as beels and ponds
lotic	Flowing water bodies such as rivers, streams and khals
mohajan	Money lender, middleman and fish collector
mother fishery	An area of diverse high quality fishery habitats which controls fish abundance over a much larger area
paharadar	Fish guard
pile fishery	A katha fishery which is harvested only after three years
reserve fishery	A katha fishery which is harvested only after 5-7 years
shawla	Algae

shidal	Semi-fermented fish
shutki	Sun-dried fish
sisu	Gangetic dolphin (Platanista gangetica)

NERP DOCUMENTS

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

Northeast Regional Water Management Plan

- Main Report
- Appendix: Initial Environmental Evaluation

Specialist Studies

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

Public Participation Documentation

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

Pre-feasibility Studies

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

\13

14

Volume 2: APPENDICES

EXECUTIVE SUMMARY

The Fisheries Specialist Study was prepared as a technical annex to the Northeast Regional Water Management Plan. It describes the findings of the NERP Fisheries Team, which are based on analysis of existing reports and databases, short and longer term field studies of the impact of FCD/I projects, and consultation with fishing communities, government agencies, other projects and NGOs during the preparation of fisheries project proposals.

PROFILE OF THE REGION'S FISHERIES

Environment

The Upper Meghna River Floodplain has a total area of 21,710 km^2 in Bangladesh (and another 1,000 km^2 in India). The two main climatic seasons are the southwest monsoon rainy season from June to September, and the dry season from December to March (with cool winds from the northeast). Monsoon rainfall is up to 4100 mm in the region and in excess of 12000 mm in the catchment area in India. Air temperatures are maximum during the monsoon (33°C) and minimum during the dry season (8.5°C).

Flood depths of 5 metres occur in the deepest part of the Sylhet Depression. The main rivers are the Kushiyara, Surma, Kangsha, Baulai and Upper Meghna. The annual flood pattern consists of two phases: the pre-monsoon floods extending from early April to late June, followed by the deeply flooded phase which extends up to the end of the monsoon. River surface area during the dry season is 832 km^2. The lower reaches of the major rivers are affected by tidal flows and parts of the river beds are below sea level.

Haors are a distinct morphological feature of the region and consist of small circular internal drainage basins surrounded by rivers. Typically the lowest part of the haor contains one or more residual lakes (*beels*) during the dry season. Beels are connected to rivers by short channels called *khals*. There are as many as 6,149 beels in the region with a combined area of 635 km^2 (average size 10 ha); 58% of beels are permanent and 42% are seasonal.

FCD/I projects have significantly altered natural flooding processes in haors. Full flood protection embankments are designed to exclude all river flood waters from the haor so as to permit multiple cropping. Partial flood protection embankments are designed to prevent flooding of haors before about 15 May in order to allow harvesting of boro rice, following which controlled haor flooding and overtopping of submersible embankments takes place.

There are 200,000 ponds in the region, mostly in the form of borrow pits resulting from homestead and road construction.

Large quantities of silt, sand, gravel and stone are carried into the region from steep affluent streams and rivers in the Indian catchment area. Peat deposits also occur.

Water turbidity is high during the first phase of the monsoon but gradually clears, allowing aquatic macrophytes and algae to become abundant. Many smaller water bodies are infested with water hyacinth. Water buffalo and cattle dung contribute to water fertility. Pulp and paper mill effluent at Chhatak negatively affect water quality and fish stocks, as did the Fenchuganj Fertilizer Plant (now closed).

Once extensive wetland forests, consisting of *hizal* and *koroch*, have been almost entirely cleared, and only small patches and plantations remain.

Fish Biodiversity

130 native fish species and 8 exotic introductions occur in the region, popularly categorized as *boromaach* (large fish) and *chotomaach* (small fish). The ichthyofauna consists of:

- Major carps (*rui, catla, mrigel, kalibaus*),
- Large catfish (*boal, pangas, air, guizzar, air, baghair, rita*),
- Minor carps (*gonia, lasu*),
- Small catfish (*magur, singi, pabda, basa, ghaura, tengra*),
- Hilsa herring (*ilish*),
- Snakeheads (*shol, gajar, tila, taki, cheng*)
- Knifefish (*chital, foli*),
- Stingray (*Shakush*),
- Miscellaneous (*kaikka, punti, chela, mola, rani, gutum, phasa, kachki, chapila, baim, koi, bailla, bheda and chanda*),
- Prawns (*golda chingra, itcha*),
- Tilapia (2 introduced species: *niloticus, mossambicus*)
- Chinese carp (five introduced species: common, grass, bighead, silver, black)
- Thai barb (introduced)

Sisu (Gangetic dolphin) are common in the larger rivers especially in deeper scour holes.

Life Cycle

The annual succession of pre-monsoon floods, monsoon floods, flood recession and dry season largely controls the events in the life histories of the floodplain fish species. Spawning migrations usually take place during the pre-monsoon and early monsoon floods. Major carp, *chital, baghair, air, ilish* and some of the chotomaach species breed in the rivers. Other species (*boal, gonia*, and most chotomaach) breed on the floodplains. Fingerling grow rapidly during the full flood phase. During the flood recession and dry season large boromaach generally move back into the deeper parts of the rivers while chotomaach and juvenile boromaach overwinter in the larger beels.

Three species differ somewhat from the norms: 1) *pangas* spends its entire life in larger rivers and the coastal zone and does not appear to utilize the floodplain; 2) *ilish* spawns in rivers but juveniles drift downstream and mature in the sea; 3) *golda chingri* spawns in the sea and juveniles move into rivers to mature.

There is some evidence that suggests that major carp possess a 'homing' ability similar to salmon which causes them to return to particular locations during the dry season.

An important feature of rivers is the presence of duars, or scour holes usually situated in bends. Duars are stable structures, which provide a deep water refuge habitat for fish, especially boromaach broodstock, during the dry season. Some 325 duars were identified and mapped in the region. Because duars are more difficult to harvest completely than beels, they are regarded as critical fisheries overwintering habitat.

Major carp spawn in the upstream portions of large rivers and their tributaries. The principal carp breeding areas in the region are Tangua Haor, Pashuar Haor, Companiganj area, Erali Beel and Hakaluki Haor.

Mother fisheries are an important component of the region's fisheries environments and resources. These are well delimited areas consisting of dense concentration of high quality fisheries habitats, including deep river duars, large beels, sediment-free khals, clear water, wetland forest patches, reedbeds, native shrubs and grasses. Mother fisheries support a high abundance of fish, both resident and seasonal migrants, and act as dispersal centres for the surrounding areas of floodplain. Mother fisheries control fish abundance over larger areas of the floodplain. There currently exist four mother fisheries in the region: Tangua Haor, Hakaluki Haor, Kaliajuri area and Companiganj area. Kawadighi Haor was also a mother fishery of great importance in the past, but its productivity was damaged by the Manu River FCDI project.

Fishing Practices and Management

Most fishing boats in the region are plank vessels of <10m. Almost all are unmotorized and driven by paddling or by sail. Dugout canoes and rafts made of banana trunks are also used.

A great variety of artisanal fishing gears are in use in the region, and some 44 types were recorded by the team. *Ber jal* (large mesh beach seine), *borsi* (hooks), *chai* (basket traps), *current jal* (illegal small mesh gillnet), *thela jal* (push net), *jhaki jal* (cast net), *kona jal* (illegal fine mesh beach seine), *duri* (reed fish fence with basket traps), *uthar jal* (conical drop net), *polo* (plunge basket), *coach* (spear for large catfish) and *savar jal* (very fine mesh funnel trap net for carp spawn and fry) are the most common.

Katha is a widely.used highly cost-effective fishing method. It consists of setting piles of tree branches (*hizal, koroch*) into beels or quiet river stretches. Large numbers of fish are attracted into the katha, especially major carp and large catfish. The katha is harvested by surrounding it with a small mesh blocking net, removing the branches, and then closing up the blocking net and removing the fish. Traditionally, katha were harvested once every three years and these are called pile fisheries. In more recent years, katha are harvested annually (ie annual fisheries). Small katha set in rivers may be harvested every 2 or 3 months.

Other specialized fishing methods including *dakban* (complete beel dewatering), *donga* and *pagar* (excavating artificial refuge pits), *polo* (artificial ditches with pens and bamboo traps) and catching prawns by floating tufts or grass downstream.

Various fisheries management measures are used in the region. Reserve fisheries are pile fisheries which are harvested only once every 5-7 years so as to build up the fish stock. Fish sanctuaries are designated by the DOF or by local communities and consist of either a single beel, duar or river reach, or an aggregate of key localities. Currently the following areas are designated fish sanctuaries: Updakhali River, Luba River, Surma River near Sunamganj, and Khali River.

Fish Production

Nominal fish production statistics have been collected by the BFRSS from 1983-84 to 1988/89. Overall nominal production during this period increased from 95,895 to 114,273 tons. Miscellaneous chotomaach became more abundant while carp, catfish and *golda chingri* production decreased. Production by habitat in 1988/89 was: rivers (31.6%), beels (29.3%), subsistence fishing on flood lands (23.3%), and pond culture (15.8%).

Contrary to the production trend suggested by nominal BFRSS statistics, most fishermen and other individuals interviewed in the field maintain that production has declined significantly over the last 10-15 years due to siltation, overexploitation from using the fine mesh nets, annual fishing, deforestation, industrial water pollution, use of poisons to catch fish, fish disease and the barrier to fish migration caused by FCD/I projects.

The widely used Welcomme empirical equation for estimating floodplain fish catch predicts a MSY of 45 kg/ha/yr. The nominal yield of the Upper Meghna River floodplain in Bangladesh ranges form 37 to 45 kg/ha/yr, suggesting that the floodplain is fully exploited. The actual yield may however be higher as there is evidence that the subsistence fishery yield is underestimated.

A correlation analysis was carried out between river discharge time series data of the Upper Meghna River at Bhairab Bazar and various sets of BFRSS and private sector fish production data. A strong correlation was found between flood discharge (June to October) and finfish exports from the Ajmiriganj area (the sum of production in the same year plus the following year).

Floodplain fish production in the region was found to be significantly impacted by at least seven factors of direct or indirect anthropomorphic origin: sewage, fertilizers, pesticides, FCD/I projects, sedimentation, industrial effluent and fish disease. In most cases, several of these factors operated simultaneously. It was not possible to easily separate FCD/I impacts from non-FCD/I impacts.

Economic data collected for two beel fisheries (Medhol and Rui Beels) showed a rate of return of 193%.

Boromaach price per unit weight increases as fish weight increases. In theory this should be an incentive for fishermen to let fish grow to larger sizes before harvesting, and thus promote greater resource conservation. A simulation model of a rui katha fishery revealed that the economic discount rate and natural mortality strongly affected the age at which net present value is maximized. High discount rates (as would exist in stressed economies) — alone or in combination with high natural mortality (as would exist in aquatic environments stressed by FCD/I projects and other negative factors) — promote harvesting at biologically unsustainable ages of 3 years or less [rui reaches first maturity at age 3].

Postharvest Sector

Ninety percent of fish production from the region is utilized in fresh or live form. There is limited use of ice. Sundried fish (*shutki*) and fermented fish (*shidal*) are the main processed fish products. Fish marketing is well organized. *Nikari* traders buy directly from the fishermen. *Aratadars* are wholesalers who operate from sheds at major landing stations. High value fish are transported to Dhaka markets by rail and road. The BFDC has constructed a large fish marketing centre at Dabor, but the facility has proved to be not viable. Market supply is highest from November to March (during the harvesting of beels), medium from June to November (during the monsoon flood) and lean from April to May (during the pre-monsoon).

The most important fish festival (Machher Mela) in Bangladesh has been held for over 100 years at Manumuk in January. Numerous fishermen and traders come from the region and beyond to sell large fish at the Mela. *Shauk* is an annual fishing festival held in Netrokona during the winter.

Ajmiriganj Fish Industries Ltd. is a fish processing plant which exports prawns (160 t in 1991) and finfish (168 t in 1992) sourced mainly from the Kaliajuri mother fishery area to Europe and North America. Finfish prices on the local market however have in recent years exceeded world market prices making it uneconomical to continue exporting them. Kuliarchar Cold Storage is another prawn and finfish exporter in the region.

Consumption of fish in the region is estimated to be about 6 kg/caput/annum. Consumption has probably declined over the last three decades.

Employment, Income and Welfare

Koibarta and *Maimol* are professional ('genuine' or traditional) fishing castes. Many economically marginalized rural people have entered the fishing industry in recent years as 'non-traditional' fishermen. The role of women in fisheries is limited to net weaving/repair, processing, pond feeding and occasional subsistence harvesting. Women do not work as fish traders or market vendors.

Many fishermen work as fisheries labourers during the dry season to harvest fish from katha and beels on behalf of leaseholders. Direct employment in the fisheries sector (production and post harvest) is estimated as between 345,000 and 460,000. Several million people carry out subsistence fishing.

Mean annual per caput income from fishing is estimated at Tk 10,400. There is probably a severe inequality of income distribution with jalmohal leaseholders, money lenders and government capturing large shares of total income.

Living standards in fishing communities are extremely poor, and illiteracy is high. Most fishermen are landless.

Institutions, Policy and Projects

The Department of Fisheries has a staff of 4,300, of which 28% are professionals. DOF suffers from shortcomings in planning, project implementation, design of extension activities, and inter-agency coordination.

The Fisheries Research Institute has 59 scientific staff and 105 support staff. It operates four field stations, including a riverine fisheries station at Chandpur and an aquaculture station at Mymensingh.

The Bangladesh Fisheries Development Corporation is a parastatal company with a poor financial performance record. Its attempt to enter into fish marketing in the region has been unsuccessful.

A large number of other government agencies and NGOs are involved in various capacities in the fisheries sector.

Current government development policy for floodplain fisheries (as outlined in the Fourth Five Year Plan) focuses on biological management of stocks, large-scale stocking of floodplains, community-based integrated development approach, and defining a land-water policy to protect the aquatic environment.

The 2nd Aquaculture Development Project (with Asian Development Bank Finance) is carrying out stocking floodplains. This includes rotenoning 1600 ha of selected beels and converting them into nurseries for carp fingerlings sourced from hatcheries. The project has been criticized for poisoning chotomaach on which local people depend for subsistence fishing.

Several other smaller projects are being executed in the region.

FISHERIES ENVIRONMENT ISSUES AND PROBLEMS

Fisheries without FCD/I Projects

Case studies were carried out of several fisheries in the region not directly affected by FCD/I projects in order to allow comparison with fisheries in FCD/I projects. These included the mother fisheries of Hakaluki Haor, Tangua Haor, the Kaliajuri area, and the Companiganj area. Most fisheries have suffered declining production over the last two decades. The most common reasons are over-fishing (from use of illegal gear such as current jal), fish disease, siltation, industrial effluent (pulp mill, urea fertilizer plant), de-watering, annual fishing and deforestation. Typically, most non-FCD/I fisheries are being impacted by several factors simultaneously. Remote effects from nearby and distant FCD/I projects also impact areas without FCD/I projects,including destruction of carp stocks and channelization of migrating broodstock.

Monitoring Programmes at Shanir Haor FCD Project and Manu River FCDI Project

Fisheries were monitored for two years at Shanir Haor and Manu River FCD/I projects in order to gather detailed information on impacts. This work was carried out as part of the Project Monitoring Programme which also included monitoring of hydrology, river morphology sedimentology, sociology, agriculture and livestock, forestry and natural resources, and navigation.

Shanir Haor is a partial flood protection project situated in the northern part of the Sylhet Depression. Fish production was higher in year 2 (+15.6% in the floodplain fishery, and +35.1% in the beel fishery) compared to year 1 due to greater flood intensity (+22.9%). Larger numbers of migratory fish were caught in year 2 compared to only a few in year 1 when inundation of the beel was delayed by one month. Delay of flooding also reduces the length of the growing season for fish.

Manu River is a high capital investment full flood protection project with pumped drainage and irrigation in the south eastern part of the region on the Kushiyara floodplain. Due to major breaching of the embankment in year 2, fish production increased substantially (+82.7% in the floodplain fishery, and +882.1% in the beel fishery). The project area contains Kawadighi Haor, which was a mother fishery whose productivity was destroyed following construction of the FCDI project. The embankment breach in a year 2 indicated that productivity could be rapidly rehabilitated if broodstock in the Kushiyara River could regain access to the haor. Stagnation of beel water during the dry season resulted in a severe disease outbreak and massive fish mortality.

Case Studies of Other FCD/I Projects
Case studies were made of the impacts on fisheries of most of the other FCD/I projects in the region. Although it was difficult to separate the effects of FCD/I projects on fish production from non-FCD/I factors such as sedimentation and fish disease, a general picture of impacts emerged from the studies.

Partial flood protection projects tend to have positive or no impacts more frequently than negative impacts. Benefits are associated with (1) higher water levels which improve pile fisheries, and (2) prevention of sedimentation. Reduced production is associated with obstruction of fish migrations.

Full flood protection projects have negative impacts (due to reduction in flooded area and obstruction of fish migration), or no impacts (if the area was initially not fish producing).

River channelization projects have mixed impacts. Benefits are due to greater habitat depth, better flow regime and improved connection with rivers and beels for migrating stocks.

Water retention projects have no impacts (probably because the few existing projects in the region do not perform well).

In summary, negative impacts of FCD/I projects centre on interference with fish migration/reproduction and general reduction/disruption of aquatic quality and area. Impacts in the region do not appear to be as severe as elsewhere in Bangladesh due to the relatively larger proportion of projects being partial flood protection projects (rather than full flood protection projects).

Project failure include too early overtopping of submersible embankments, breaching of embankments by floods or public cuts, inoperable drainage and irrigation structures and river channel siltation. Overall declining maintenance of FCD/I projects lessens the negative impacts on fisheries.

Conflicts Between Fisheries and Agriculture
Conflicts between farmers and fishermen centre on reclamation of beel area for paddy cultivation. Other sources of conflict are: mid-dry season beel draining to carry out total fish harvests (while farmers want to retain water for irrigation), end of dry season haor flooding(which farmers resist in order to harvest more rice) and harvesting of the fish resource during the monsoon flood (jalmohal leaseholders claim ownership of all fish in the haor and try to prevent farmers from carrying on subsistence fishing).

FCD/I Project Impact Modelling
Based on the results of case studies, an empirical model approach to predicting impacts of FCD/I projects on fish production was developed. Changes in fish production inside different types of FCD/I projects were determined on a very preliminary basis as: 50% decline inside partial flood control projects, 90% decline inside full flood protection projects, 25% decline for river channelization project areas, nil impact for river and khal re-excavation projects (in the sense of

restoration of pre-project conditions) and nil impact of water retention structures (although theoretically they have a potential for positive impacts).

A loss of 10.1% of Upper Meghna River floodplain fish production was estimated to be due to the existing 65+ FCD/I projects in the region. This figure does not take into account remote FCD/I impacts and losses induced by non-FCD/I factors.

Water Pollution
The Chhatak Pulp Mill discharges bleach kraft effluent into the Surma River after 7-8 days of residence in sedimentation ponds. Impacts on the river include increased suspended solids, COD and BOD. The darkly coloured effluent plume sinks to the bottom of the river channel. Impacts on fisheries include tainting of fish flesh at least as far downstream as Sunamganj, and reduced prices of fish caught downstream of the mill. During the dry season effluent dilution is minimal. Fish production declines sharply downstream of the mill and the river water cannot be used for domestic purposes.

The Fenchuganj Fertilizer Plant on the Kushiyara River (closed in 1992) previously discharged sulphuric acid, ammonia and caustic soda into the river. Fish production downstream declined by 70-80% after plant construction. Pulse discharges of effluent caused massive fish mortalities as far downstream as Markuli and Ajmiriganj during the dry season. The flesh of fish is also tainted.

Agrochemicals
The use of pesticides and fertilizers in the region is increasing. The impacts of pesticide are probably at sublethal level. Runoff water carrying excess fertilizer has negative impacts on beels during the dry season due to eutrophication inducing excessive aquatic macrophyte growth.

Deforestation
Massive cutting of floodplain forests (over 80%) in the region has resulted in widespread loss of the environmental and economic functions served by flood tolerant trees. Fish production is higher in inundated tree patches. A shortage of branches for katha has increased the cost of fish production.

Sedimentation
The northern part of the Sylhet Depression and lower part of the Kushiyara River are suffering from severe sedimentation. Infilling of beels and river duars reduces the available area of these important habitats

FISHERIES MANAGEMENT ISSUES AND PROBLEMS

Decreasing Stock Abundance
Stocks of many fish species are decreasing in abundance in the region, particularly major carps, some large catfish, large prawn and some smaller cyprinids. Declines are attributed to FCD/I impacts, overfishing, sedimentation, deforestation, industrial pollution, pesticides, fertilizers, and fish disease.

The ADB-financed stocking program is attempting to rebuild major carp populations and introduce exotic carp species. It is not clear if the programme is sustainable or if its goals can be met without a simultaneous improvement in fisheries management.

Decreasing Biodiversity

Two major carp (*Nanid* and *Angrot*) and *Koral* appear to have become extinct in the region. Populations of pangas, mohasol and sarputi have been seriously reduced. Several species are going extinct at the local level: *bedha, taki, gagla, batch* and *chital*.

Fish Disease

Epizootic ulcerative disease is a serious problem in the region, reducing fish populations which affects subsistence consumption and fishermen's incomes. Disease outbreaks resulting in massive mortalities (in many cases over 50% fish loss) occur almost entirely in beels and haors, and rarely in rivers. Annually, external lesions become visible during the late monsoon, and increase to epidemic proportions during the dry season. Stagnant water bodies close to intensively farmed agricultural plots are most susceptible. This suggests that fertilizers and/or pesticides along with other deteriorations in water quality under stagnant conditions (rotting plant matter, decrease in pH) reduce the resistance of fish to disease outbreak. Diseased fish are not found during the premonsoon and early monsoon flood. Heavy rain and flash floods greatly reduce disease incidence, by up to 90%. Years with high flood intensity have less disease outbreaks than years with low flood intensity.

Jalmohal leasing System

The leasing of jalmohals [water bodies (beels, khals) and river stretches] for fishing purposes is a source of revenue for government. Ownership of jalmohals is with the MOL, and district government administers the auctioning of jalmohal leases. Typically leaseholders are highly capitalized businessmen pursuing investment interests. Ordinary fishermen can rarely afford to win leases at open auction.

Fish are harvested from a jalmohal by one of two principal arrangements: (1) the leaseholder issues a contract to a fishing team to harvest the resource on his behalf, or (2) the leaseholder issues as many fishing permits to individual fishermen as possible in order to recover the lease fee and realize a profit.

The leasing system is generally destructive of resources as in either of these two harvesting methods there is a clear economic incentive to harvest the maximum number of fish. Added to this is the belief generally among leaseholders that the lease bestows total ownership of all fish stocks in the jalmohal, and therefore the right to harvest all fish. The shortening of lease periods induces further resource mining. General overharvesting of jalmohals in the region has resulted in failure to auction off expired leases due to the perceived paucity of fish resources.

New Fisheries Management Policy

In 1986, the government initiated a new system of fisheries access and tenure which was to allow only genuine fishermen to hold fishing licences for jalmohals. The intent of the New Fisheries Management Policy (or *Nitimala*) was to eventually eliminate jalmohal leasing and direct more benefits to genuine fishermen. Licence fees were to be equal to the previous lease fee in order that there would be no loss in revenue to government.

NFMP met with mixed success. Only a fraction of the intended jalmohals were transferred from the leasing system to NFMP. Those genuine fishermen who did go under NFMP had problems in accessing the promised bank loans. Some disenfranchised leaseholders exerted their influence on NFMP coops and gradually took over control by using the fishermen as a front.

In order to evaluate various options for fisheries tenure and credit, the economic impacts of four modalities were simulated:

- **Jalmohal leasing** generates high profit for leaseholders (15% return on investment). Fishermen incomes (and thus local consumer demand) are minimal and exceeded by government revenue.

- **Conventional NFMP licensing** (full licence fee, no credit) generates fishermen incomes which exceed government revenue. However the price of the licence fee is increased by 300% due to the need to raise the fee from local moneylenders (who are often ex-leaseholders).

- **NFMP with reduced licence fee** (but no credit) generates much higher incomes for fishermen, due to savings on both the licence fee principal and the interest on the informal loan market required to pay the fee.

- **NFMP with reduced licence fee and credit** generates the highest level of fishermen income (and local consumer demand). Fishing costs are minimized.

A fully liberalized NFMP with nominal licence fees and bank credit would result in the highest rate of local economic growth.

The focus of government revenue collection should re-orient towards the value added in the post harvest sector, rather than undermine the economics of the production sector.

Community-based Management
A number of examples of community-based fisheries management (*mohalshamil jalkar*) exist in the region. The capacity of the local community to enforce rules aimed at rationally managing fish resources varies depending on different factors.

Fish Sanctuaries
Although government has established a number of fish sanctuaries and protected areas (such as the Luba River), the resources that would be required to make the programme successful have not yet been allocated.

Subsistence Fishing
Subsistence fishing on the floodplain and in small jalmohals is of great importance for the nutritional health of the rural population, as about 76% of households in greater Sylhet District and 57% in greater Mymensingh carry out subsistence fishing.

Illegal Fishing
Apart from using illegal nets such as current jals, the use of poisonous plants and dynamite is a small but growing threat along the Indian border zone. Violent clashes resulting in death between

competing interests over fishery resources is a not infrequent occurrence and can affect lucrative mother fisheries such as Tangua haor.

STRATEGY FOR FISHERIES REHABILITATION AND SUSTAINABLE DEVELOPMENT

Driving forces

International driving forces impacting the fisheries of the region include: global warming, decreasing world market prices for the region's finfish, increasing world market prices for prawns, increasing deforestation in the Indian catchment, and increasing foreign assistance for FCD/I projects.

Driving forces at national level are: increasing consumer demand for fish in urban markets, government focus on revenue collection from all economic sectors, and MOL ownership of jalmohals.

Regional level driving forces are: increasing landlessness, leasing of jalmohals by district administrations, resistance of leaseholders to NFMP, increased planting of HYV rice, and increasing population.

Project Design

Virtually all FCD/I projects constructed in Bangladesh and in the region are designed to enhance agriculture or protect infrastructure. It is suggested the FCD/I project concepts should also include enhancement of fisheries, either as unipurpose or as multipourpose projects. All existing FCD/I projects should be developed further to bring them up to multipurpose specifications.

Various structural approaches to fisheries development and mitigation are discussed.

Beel Bypass

Under this FCD/I scheme, embankments would be routed to bypass beel clusters. This would leave beels freely connected by khals to rivers and allow unimpeded spawning migrations of fish.

Beel Embankment

Under this FCD/I scheme, embankments or bunds would be constructed around key beels to prevent sedimentation and increase dry season water levels. Such schemes have already proved successful in at least four beels in the region. Planting of hizal tree fences along the embankment and *nolkhagra* reed beds along the beel margin would further increase benefits.

Haor Zoning

Under this FCD/I scheme, embankments would be constructed both along the periphery of a project area and inside the project area in order to subdivide the project area into zones for agriculture and fisheries.

Compartmental Bunds

This FCD/I scheme is designed to enhance agriculture by constructing low bunds inside the project area to form separate compartments with the aim of protecting individual compartments against inundation. Because the scheme tends to increase hectare-months of inundation of those compartments which become water-logged for one reason or another, some increase in fish production is realized.

Fishpasses
Under this FCD/I mitigation scheme, fishpasses would be constructed to allow migrating fish to cross over embankments. The vertical slot design is considered to be the most appropriate for FCD/I projects as it operates over a wide range of head and tail water elevations without adjustments. Hydraulic regulators, navigation gates and public embankment cuts also function to varying degrees as "fish bypass structures".

Artificial Duars
The important river duar habitat is under threat from siltation and loop cutting by river channelization projects. A mitigative scheme would be to construct spur dikes to act as flow deflectors at strategic points along river channels. The spur dike induces the formation of a scour hole (artificial duar) downstream which would be utilised by boromaach broodstock for overwintering.

Fish sanctuaries
Fishermen in many areas advocate setting up fish sanctuaries in river duars, beels and carp spawning grounds in order to protect broodstock. Various structural and management options to make fish sanctuaries effective are discussed

Stocking
Stocking programmes need to become more comprehensive in design if they are to have a lasting impact. Particularly important is identifying and protecting critical habitat and localities. The use of rotenone should be terminated, and the introducing of exotic species re-examined. Attention should be given to rebuilding stocks of *mohashol, nandina, sarputi, angrot, mrigel* and *pangas*.

*Community-based New Fisheries Management **Policy***
Community-based management systems have a potentially beneficial role to play in improving NFMP. This would include full ownership of the fishery resources by fishing communities, reducing licence fees to a nominal level and accelerating the transfer of jalmohals from leasing to NFMP. Government should establish real targets for employment creation, income growth and improved living standards, and actualize these through provision of credit, training and human resource development, social services and investment in better technology to improve productivity. NGOs should be involved in assisting fishing communities to organize effectively. The role of the government should be a supportive rather than a controlling one.

Afforestation
The economic and environmental benefits to be realized through floodplain afforestation are substantial. Hizal plantation areas should be offered under a 25 year stewardship system. Because katha fishing is capital intensive but also highly productive, fishing communities that grow hizal for katha would be able to increase their fishing capacity and their catches at relatively low cost.

Effluent Treatment
A tertiary treatment system should be installed at the Chhatak Pulp Mill. A possible replacement plant for the Fenchuganj Fertilizer plant should use modern environmentally friendly technology to minimize pollution at source. Sewage treatment in the region should be improved.

Postharvest Sector
Possibilities for development in the postharvest sector include: (1) increasing the role of women by upgrading processing techniques and assisting women to enter the fish marketing business, and (2) increasing imports of cheap frozen small pelagics from South America to supplement supplies for domestic consumption by reducing the import tariff.

Aquaculture
Increasing fish production from ponds in the region is feasible in marginally flooded and flood-free uplands if the supply of seed is improved. Possibilities also exist for progressively transforming pile fisheries from a simple fish aggregating system to a fish production enhancement system.

PROJECT PROPOSALS

Fisheries Engineering
Proposed initiatives include: (1) adopting a multipurpose approach to FCD/I project planning, (2) implementing pilot projects in beel bypass, beel embankment, haor zoning, vertical slot fishpass, navigation gates and artificial duars, and 3) assessing the efficacy of compartmental bunds.

Fish Sanctuaries
Proposed elements for a fish sanctuary programme should include river duar sanctuaries, creation of chotomaach beel sanctuaries, and carp breeding ground sanctuaries. Tentative locations for sanctuaries in the region are listed.

Fish Biodiversity
Rebuilding of threatened and depleted fish stocks in the region should be done by creating protected areas and enhanced habitats for threatened species, and artificial propagation and stocking of protected areas with threatened boromaach and chotomaach.

Fisheries Management
A new fisheries tenure and management regime should be introduced with the following elements: (1) upgrading NFMP to include CBM approach (investing resource tenure and management authority rights with fishing communities), (2) reducing the licence fee to nominal amounts, (3) defining the role of government as mainly supportive of local community initiatives, (4) accelerate the timetable of transfer of jalmohals from the leasing system to NFMP, and (5) formulation of a job creation and human resources development program.

Fisheries Postharvest Sector
Proposed projects are: (1) women fish trader project (to improve fish processing and develop business and marketing skills for women), and (2) importation and marketing of frozen small pelagics to augment supplies for domestic consumption.

Public Fisheries Institutions

Implementing the proposed projects will require structural and program changes in fisheries and related institutions, specifically:

- NFA: Strengthen capabilities to carry out mandate.
- DOF: Establish now units to support fisheries engineering and CBM-NFMP projects; improved staff training and incentives.
- BFDC: Divestment of Dabor Fish Marketing facility.
- FRI: Increased research on floodplain fisheries.
- BWDB: Establish a fisheries engineering unit.
- DOFr: Establish a floodplain afforestation unit.

Initiatives in Districts

Problems, initiatives, tentative locations, project actions and possible impacts are listed on a district basis.

1. PROLOGUE

This report is comprehensive in its coverage of fisheries findings in the region. The focus is on openwater floodplain capture fisheries and FCD/I impacts. The intent is to provide a substantive benchmark from which future interventions in the fisheries subsector can be planned.

Much use has been made of the following key source documents (although citations and quotations are not always specified): Ali (1991), Azadi (1985), BCAS (1989), CIDA (1989,1990), Chong et al (1991), Rahman (1989), Tsai and Ali (1985), World Bank (1991).

This report is based on the work of the following individuals:

- Garry M Bernacsek, Fisheries Team Leader
- Shibabrata Nandi, Fisheries Specialist
- Nirmal C Paul, Fisheries Field Specialist
- Tareque Akber, Fisheries Field Assistant

This document consists of a Main Report as Volume 1 and Appendices as Volume 2. It is a technical annex of the Northeast Regional Water Management Plan but it has been structured so that it can be used as a free-standing document within the fisheries sector.

Within the context of the regional water management planning process, fisheries related activities included:

- review of existing reports and studies
- analysis of BFRSS statistical database
- acquisition and analysis of nominal fisheries statistics from non-BFRSS sources
- case history field studies of impacts of FCD/I projects
- case history field studies of areas without FCD/I projects
- long term monitoring of fisheries at a partial flood protection project (Shanir Haor) and a full flood protection project with pumped drainage and irrigation (Manu River FCDI Project)
- prefeasibility study of two fisheries initiatives (Fisheries Management Programme and Fisheries Engineering Measures)
- liaison with DOF and other fisheries project personnel

2. PROFILE OF THE REGION'S FISHERIES

2.1 Fisheries Environments

2.1.1 Physiography

The topography of the region consists of a large central depression (Sylhet Depression) flanked by lowland floodplains, then gently sloping piedmont floodplains, and bordered distally by alluvial fans, terraces and uplands extending into India. Approximately 25% of the total region area of 24,180 sq km lies below 5 m elevation and 50% lies below 8 m elevation. Areas of the six dominant landforms of the region are shown in Table 2.1.

Table 2.1: Regional Landforms

LANDFORM	AREA (sq km)	% of TOTAL
Sylhet Depression	6000	25
Lowland floodplains	13260	55
Piedmont floodplains	960	4
Alluvial fans	1490	6
Terraces	500	2
Uplands	1970	8
TOTALS	24180	100

Source: NERP

There are four landforms in the Upper Meghna River floodplain (<u>senso lato</u>). The Sylhet Depression is a bowl-shaped basin. Almost all land in this unit is below 8 m (PWD datum). The depression is deeply flooded during the monsoon to depths of 5 m. The Lowland Floodplains are the deposition and erosion arenas of the major rivers of the region. Land elevations range between 9 and 16 m on the Surma/Kushiyara floodplain, 9 and 22 m on the Old Brahmaputra floodplain and less than 7 m on the Meghna floodplain. The Piedmont Floodplains are found along tributary streams in the southeastern part of the region. Land elevations range between 9 and 24 m. Alluvial fans are found along the foot of the Meghalaya Plateau in the northern part of the region. Land elevations range from 12 to 16 m in the west and from 9 to 11 m in the east.

Non-inundatable terraces occur along the western edge of the region and confine portions of the Old Brahmaputra River. Land elevations range between 8 and 10 m. Uplands occur as outliers from the Tripura Hills in the eastern part of the region. Elevations reach 30 m.

2.1.2 Climate

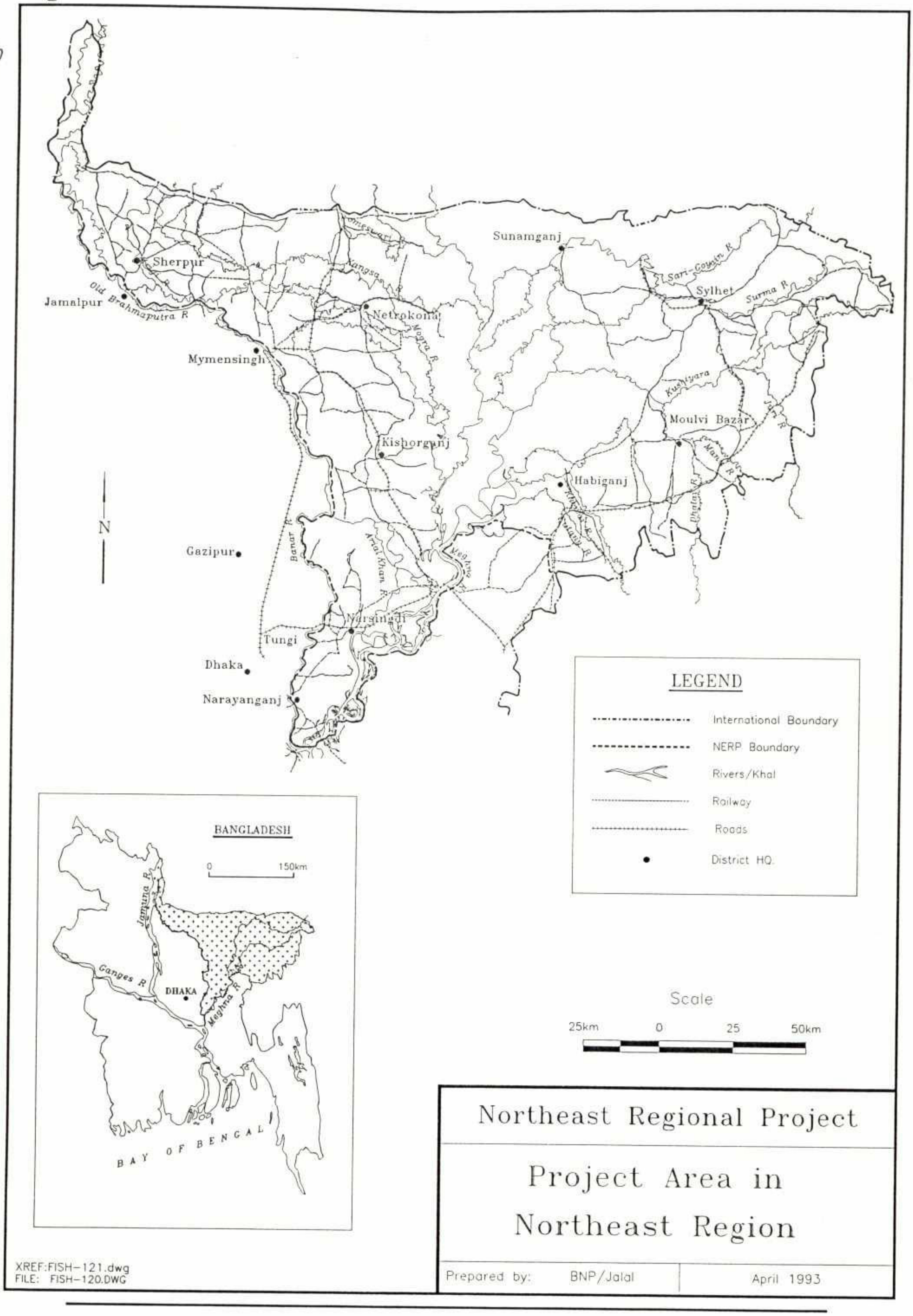
Two monsoon air movements govern the climate of the region:

- The <u>wet southwest monsoon</u> extends from June to September. It originates over the Indian Ocean and carries warm, moisture laden, connectively unstable air. It provides most of the annual rainfall. This rainy season is conventionally referred to as "the monsoon".

- The <u>dry northeast monsoon</u> extends from December to March. It originates over snow and ice-covered land masses, and carries dry, cool air during the winter months.

Reversals of monsoon air flows occur in the spring (April-May) and in the autumn (October-November).

Figure 1


Sherpur
Jamalpur
Old Brahmaputra R
Mymensingh
Netrokona
Mogra R
Kangsa
Sunamganj
Sari-Goyain R
Sylhet
Surma R
Kushiyara
Moulvi Bazar
Juri R
Manu R
Dhalai R
Kishorganj
Habiganj
N
Gazipur
Banar R
Arial Khan R
Meghna
Narsingdi
Tungi
Dhaka
Narayanganj
LEGEND
International Boundary
NERP Boundary
Rivers/Khal
Railway
Roads
District HQ.
BANGLADESH
0
150km
Jamuna R
Ganges R
DHAKA
Meghna R
BAY OF BENGAL
Scale
25km
0
25
50km
Northeast Regional Project
Project Area in
Northeast Region
XREF:FISH-121.dwg
FILE: FISH-120.DWG
Prepared by:
BNP/Jalal
April 1993

39

Land Classification System

Legend	Dominant Landform	Physiographic Unit
	Uplands	6A Susang Hills 6B Sylhet Hills
	Terrace	5 Madhupur Tract
	Alluvial Fan	4 Meghalaya Fans
	Piedmont Floodplain	3 Tripura Piedmont
	Lowland Floodplain	2A Surma/Kushiyara Floodplain 2B Old Brahmaputra Floodplain 2C Meghna Floodplain 2D Jamuna Floodplain
	Haor & Flood Basin	1A Central Basin 1B Meghalaya Basin 1C Sylhet Lowland

FILE: FISH-112.DWG

Northeast Regional Project

Land Classification

Prepared by: DMc/Jalal — April 1993

During the monsoon, the abundant rainfall across the region ranges from 1400 mm in the southwest to 4100 mm in the northeast. Rainfall in the Meghalaya catchment area in India can exceed 12000 mm (Cherrapunji is one of the wettest places on earth). Within the region, 65-69% of total annual rain falls during the summer monsoon. The winter monsoon delivers only 4% and the region experiences relative drought. The spring reversal yields 21-23% of annual rainfall and is responsible for the so-called "pre-monsoon floods". The autumn reversal yields 6-8% of annual rainfall. Over the last 30 years there has occurred a trend of increasing annual precipitation in the region — this may be due to global warming.

Maximum monthly mean air temperatures at Sylhet range from 30.9 to 33.4 C^0 during the wet season to 25.8 to 29.0 C^0 during the dry season, while the minimum monthly means are 21.0-24.5 C^0 and 8.5-16.6 C^0, respectively. Mean relative humidity varies between 83% in the wet season and 64% in the dry season. Annual evapotranspiration is about 1,200 mm, and peaks during March, April and May. Evaporation exceeds rainfall during the dry season.

2.1.3 River systems and hydrology

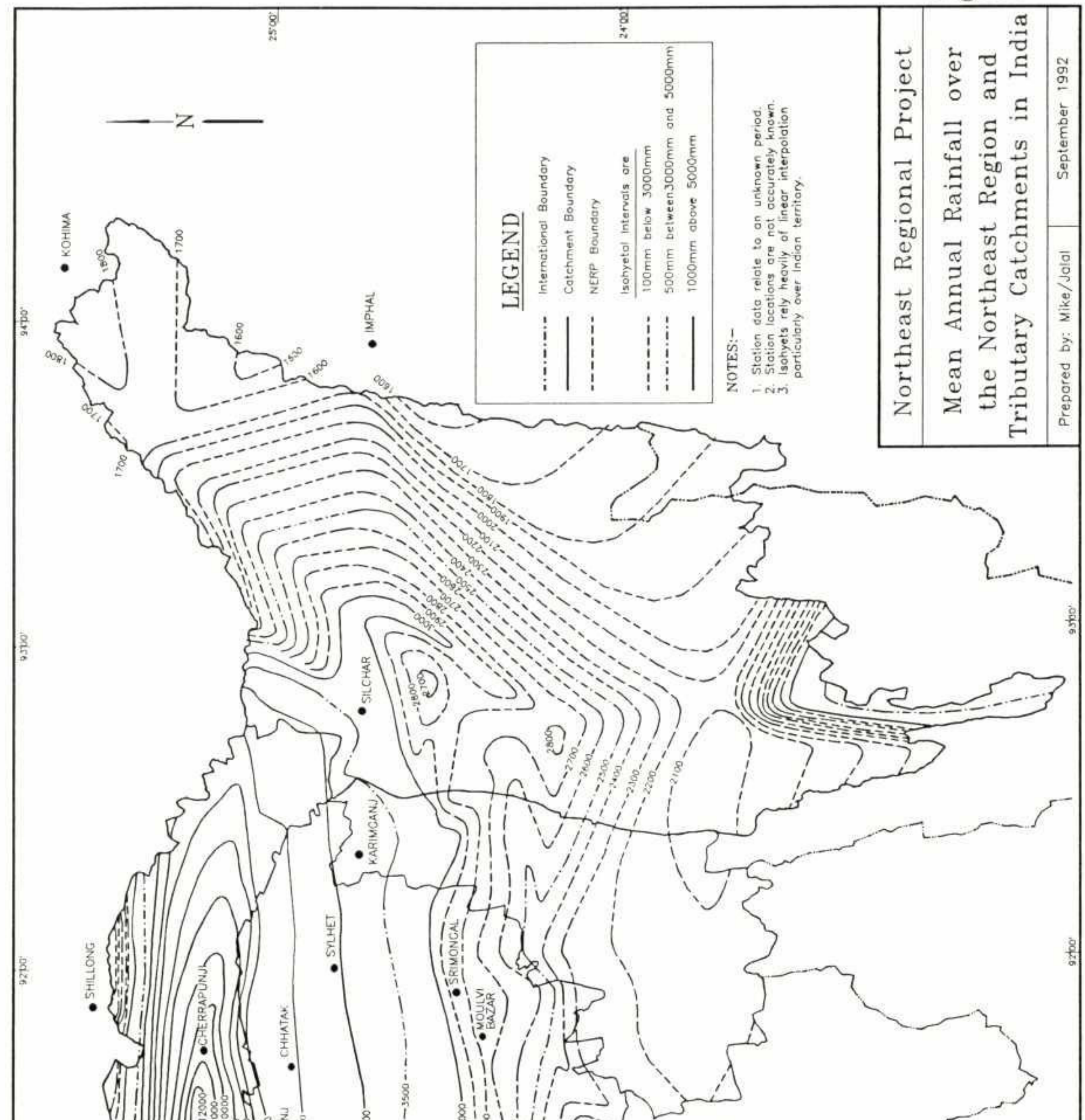
The region is "water-rich". Because of its special topographical and hydrological conditions it can be regarded as "unique" in Bangladesh. Most of the region is a self-contained drainage basin (with catchment extending into India) separate and distinct from the other large river systems of Bangladesh (Jamuna, Padma). The region is drained by a single major river channel in the southwest: the Upper Meghna River. This river receives inflow from two large tributaries, the Baulai River coming from the north, and the Kushiyara River from the northeast. The Baulai itself is formed by the confluence of the Kangsha River (which flows from west to east) and the Surma river (which flows east to west). The Surma and Kushiyara share a common origin at the bifurcation of the Barak River which flow into Bangladesh from India at the extreme eastern part of the region at Amalshid. The Kangsha, Surma and Kushiyara receive lower order tributary inflows from numerous small rivers and streams draining the Meghalaya and Tripura Hills, such as the Luba, Jhalukhali, Manu and Khowai Rivers. The western boundary of the region is defined by the Old Brahmaputra channel, which no longer conducts major discharge volumes due to siltation at its origin. The current meagre bank overspill of the Old Brahmaputra has reduced the water supply of rivers to the east (such as the Mogra) which discharge into the Sylhet Depression. The region is crisscrossed by numerous khals and silted up old river beds which conduct drainage flows rather than mainstream discharges.

The annual flood pattern has two distinct phases in the region:

- The <u>early flood (pre-monsoon) phase</u> occurs during the early monsoon season when river and beel water levels are relatively low. It can begin as early as April and extend as late as June. Flash floods occurring in the piedmont rivers flowing from India spill water into haors through khals and as river overbank spill. Unembanked haors thus act to attenuate flood conditions in rivers (conversely, embanking of haors accentuates flooding further downstream). When the flood recedes water stored in the haors drains back into the rivers.

- The <u>deeply flooded (monsoon) phase</u> begins when backwater from the Meghna system causes deep flooding throughout the Sylhet depression and extends into the haor areas of the Surma-Kushiyara floodplain. The haor areas remain as a large deeply flooded "lake" until the Meghna levels recede at the end of the monsoon season.

Figure 3

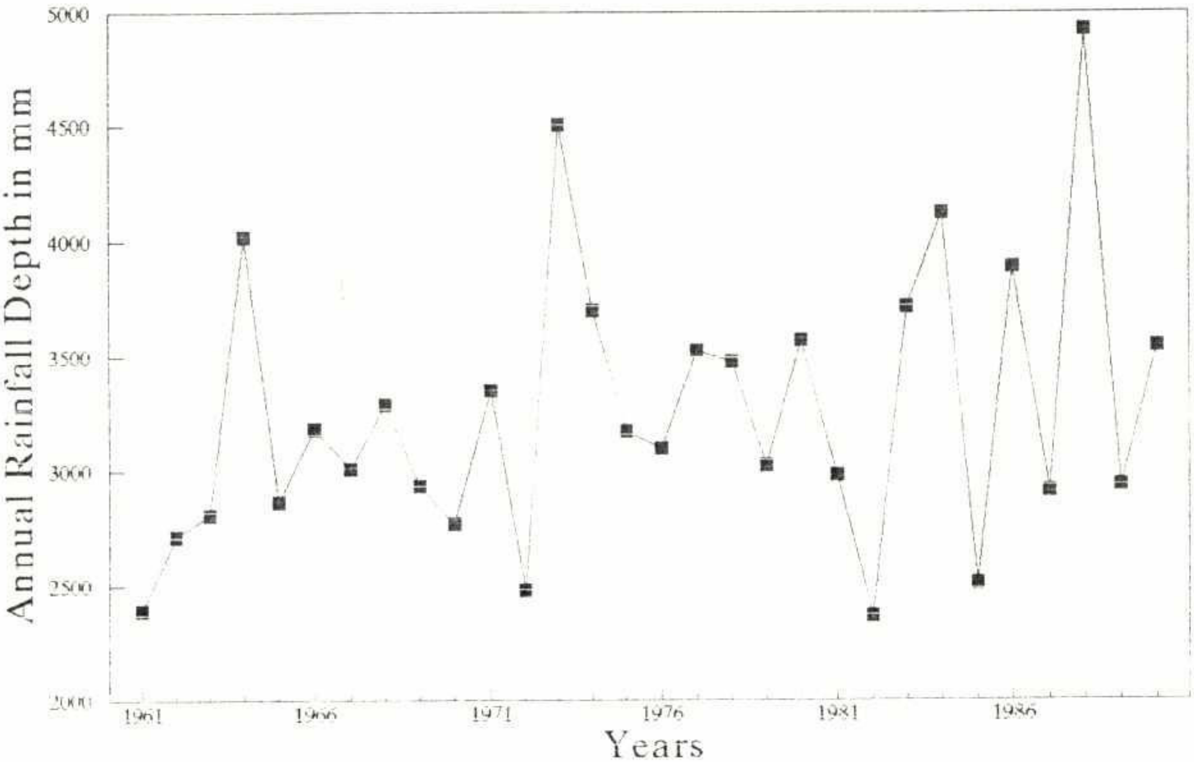


Northeast Regional Project
Mean Annual Rainfall over the Northeast Region and Tributary Catchments in India
Prepared by: Mike/Jalal
September 1992
LEGEND
International Boundary
Catchment Boundary
NERP Boundary
Isohyetal Intervals are
100mm below 3000mm
500mm between 3000mm and 5000mm
1000mm above 5000mm
NOTES:-
1. Station data relate to an unknown period.
2. Station locations are not accurately known.
3. Isohyets rely heavily of linear interpolation particularly over Indian territory.
N
Scale
1:650,000
KOHIMA
IMPHAL
SILCHAR
KARIMGANJ
SHILLONG
CHERRAPUNJI
CHHATAK
SYLHET
SRIMONGAL
MOULVI BAZAR
SUNAMGANJ
HABIGANJ
AGARTALA
BRAHMAN-BARIA
COMILLA
BHAIRAB BAZAR
NETRAKONA
MYMENSINGH
DHAKA
NARAYANGANJ
TURA
JAMALPUR

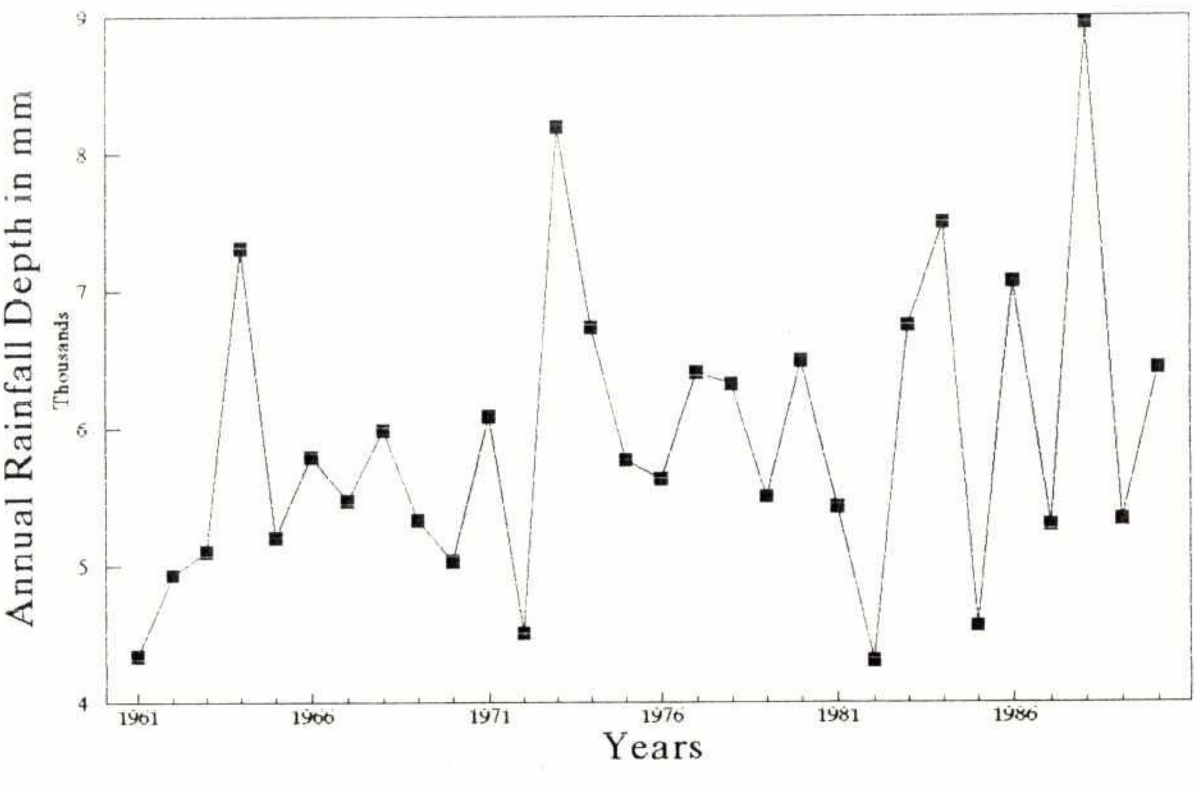
Figure 4

HISTORICAL ANNUAL RAINFALL

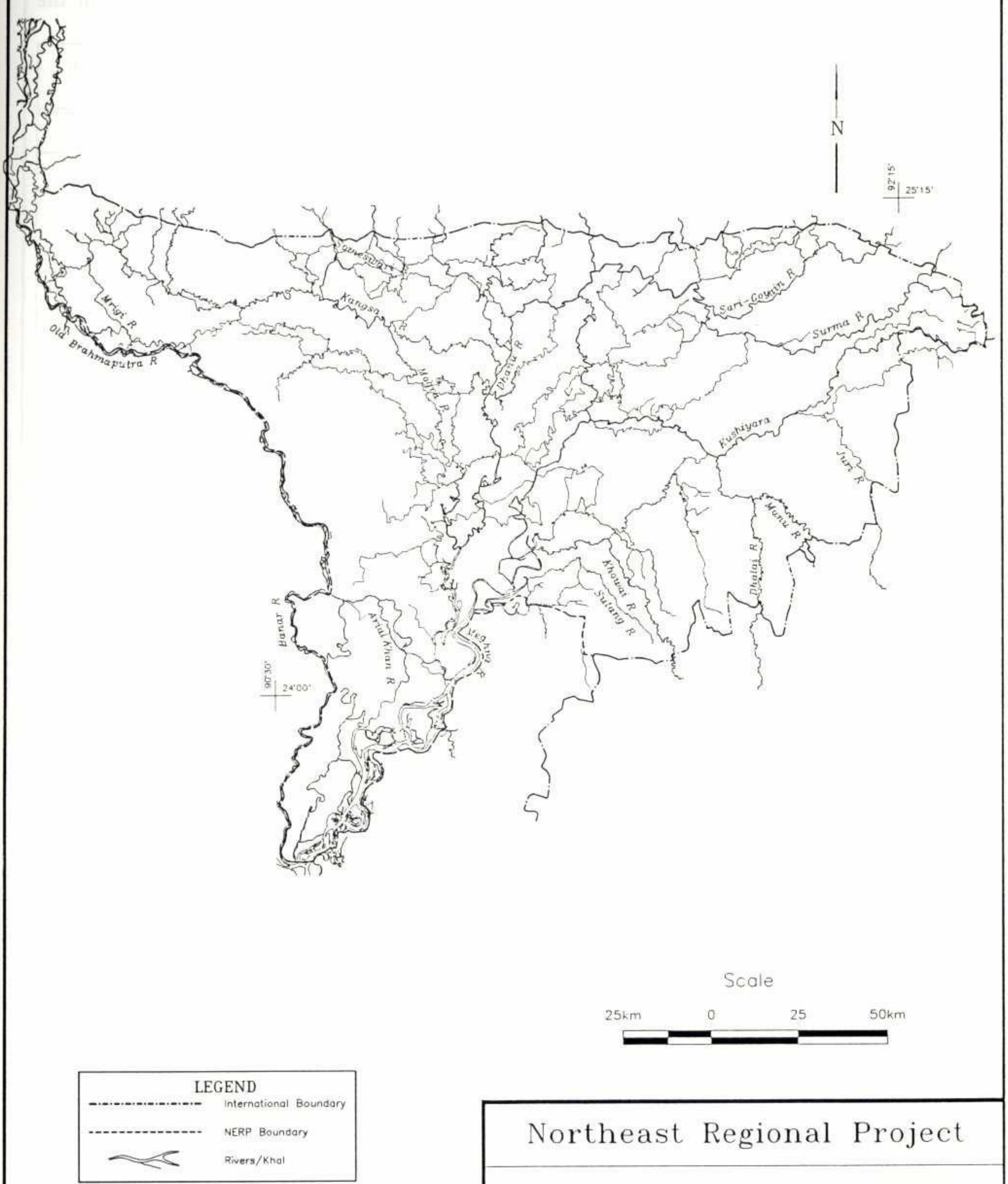
MOULVIBAZAR



SUNAMGANJ



38



Northeast Regional Project

Rivers of the Northeast Region

Prepared by: BNP/Jalal | April 1993

XREF: NERP-075.Dwg
FILE: NERP-072.DWG

39

All external streamflow into the region comes from 21 catchments that extend into India. They fall into three groups:

- Meghalaya river catchments which discharge southward into the Kangsha and Surma. Their drainage area is 13,466 km^2.
- Barak River basin which discharges westward into the Surma and Kushiyara at Amalshid on the Indo-Bangladesh border. Drainage area is 25,263 km^2.
- Tripura river catchments which discharge northward into the Kushiyara. Their drainage area is 6,845 km^2.

These Indian catchments produce about 60.5% of the total water supply of the region, mostly in the form of flash floods from April to September. The flash floods of the Meghalaya are particularly ferocious. Mean monthly streamflow entering from India varies from over 7,000 m^3/sec in July to a low of about 220 m^3/sec in February. Streamflow generated directly within the region from rainfall and groundwater discharge constitutes a significant part of total streamflow (between 30% and 80% of the inflow from India during the February to April dry season months).

The total surface area of water in river channels during the dry season is 832 km^2. The Upper Meghna River surface area is 336 km^2 and other rivers in greater Sylhet and Mymensingh Districts cover 496 km^2.

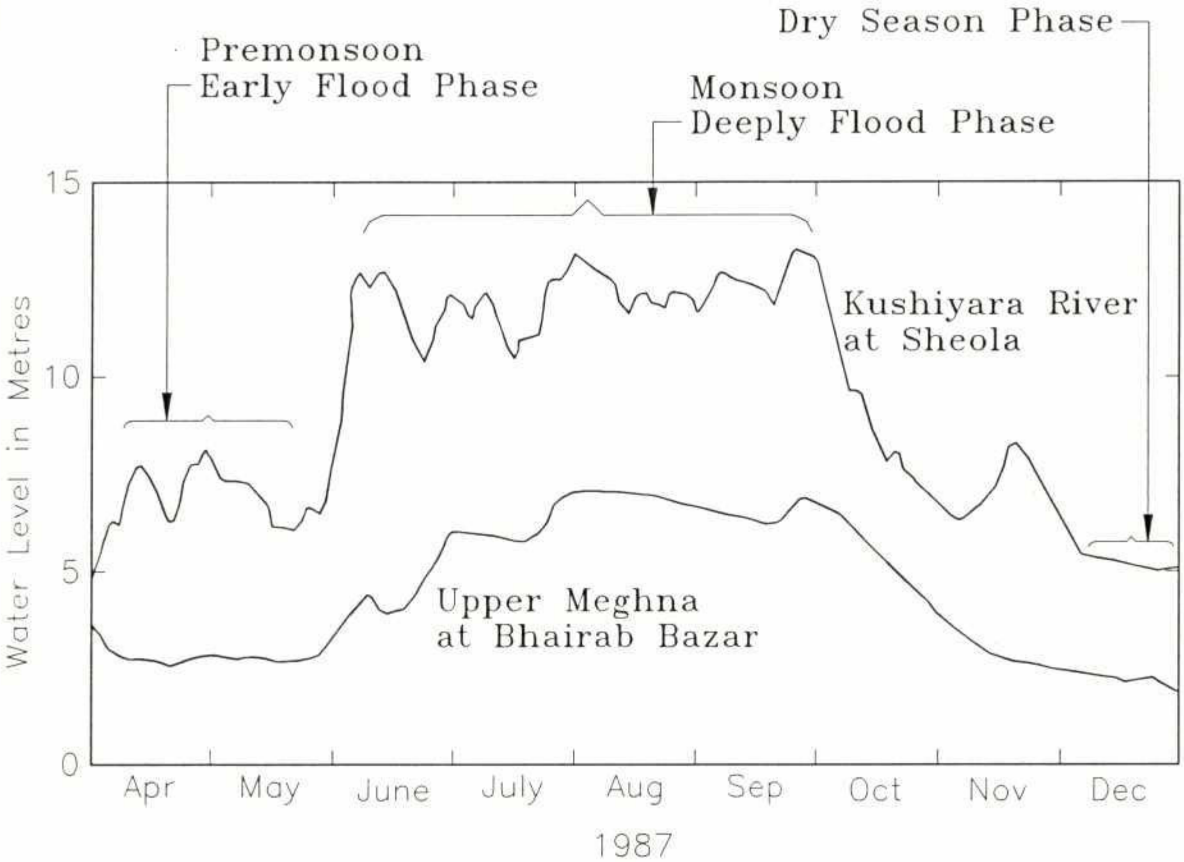
During the rainy season, all rivers overflow on to the lateral floodplain, except for those portions of the Surma, Kushiyara, Khowai, Manu and Kangsha which have full flood embankments. Low order affluent tributaries flowing into Bangladesh from the Indian hills, such as the Luba River, become spate streams, and attract spawning migrations of carp and other species.

Table 2.2: Length of Main Rivers in the Region

River	Length (km)
Meghna	110
Kushiyara/Kalni	235
Surma/Baulai	385
Dhaleswari	37
Juri	62
Manu	80
Dhalai	59
Lungla/Ratna	116
Karangi	49
Khowai/Barak	87
Sutang	77
Sari-Goyain	83
Dauki	11
Piyain	51
Dhalaigang	15
Sonai	11
Chalti	12
Jadukata/Baulai	63
Someswari	82
Mogra/Dhanu	170
Chillikhali	22
Malijhee	47
Nitai	36
Shibganj Dhalai/Upper Someswari	23
Bhogai/Kangsha	227
Total Length of Channels	**2,150**

Source: NERP

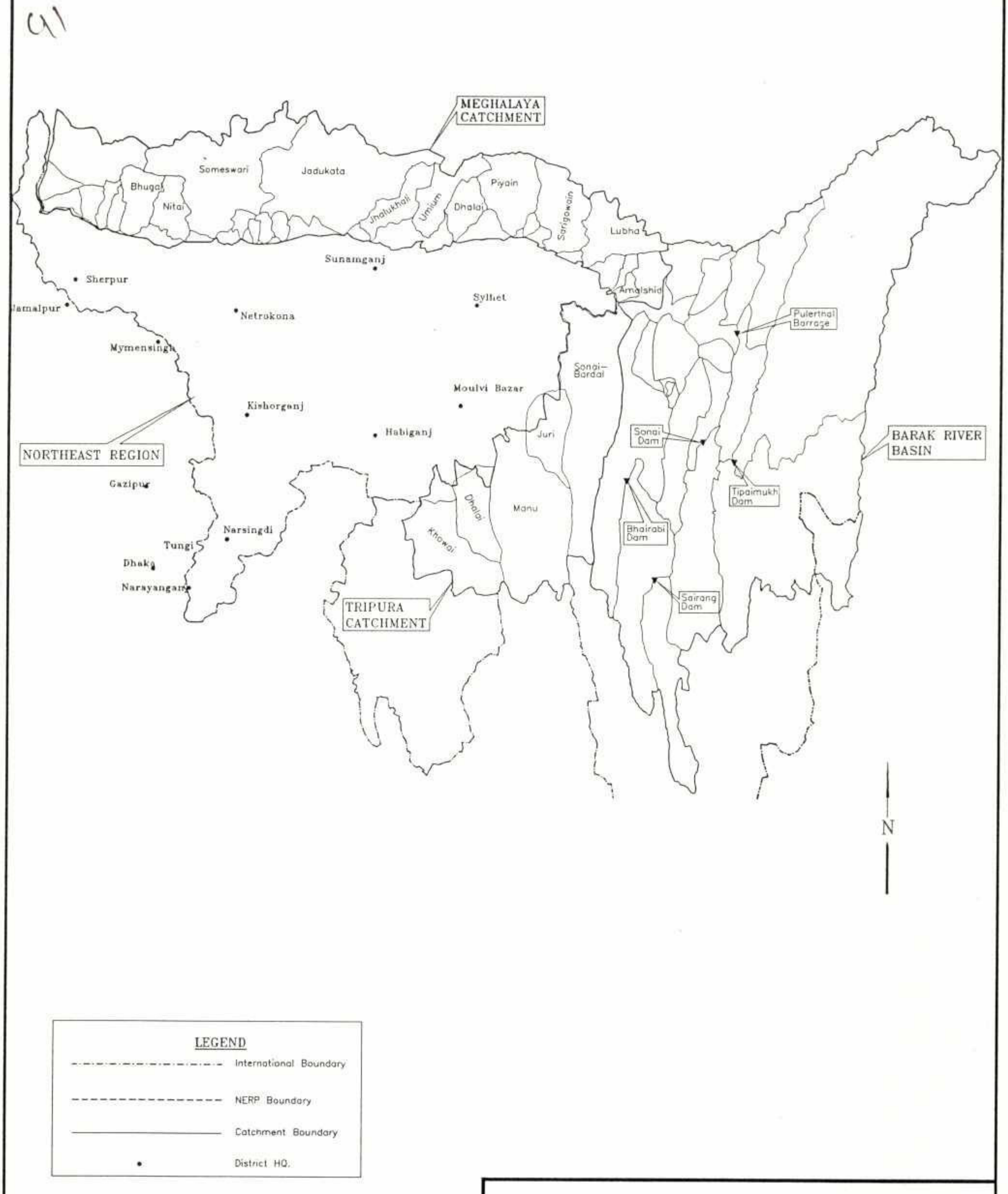
40



Northeast Regional Project	
Hydrographs of Water Levels for the Kushiyara and Upper Meghna River	
Prepared by: BNP/Jalal	April 1993

FILE: FISH-138.DWG

Figure 7



Northeast Regional Project

Catchment Areas of the Northeast Region

Prepared by: BNP/Jalal | April 1993

FILE: FISH-115.DWG

During the dry season the upper parts of the Surma (upstream from Chhatak), Kushiyara and Kangsha conduct little discharge and can be navigated only by country boats as the water level is very low (< 1.0 m in many places). However the Upper Meghna River, the Baulai, the Surma as far as Chhatak and portions of the Kushiyara have good water levels (although discharge is minimal) and are used by large metal hulled transport boats which come up from Bhairab Bazar. This is due to tidal backing-up of the Upper Meghna. The good water levels in these rivers during the dry season and the existence of deep scour holes (*duars*), make them important dry season overwintering refuge habitats for the brood stock of some commercially important species, particularly major carps and large catfish. It is therefore important to distinguish between tidally-influenced and non-tidally-influenced section of major rivers. Parts of the former's river beds are below sea level, especially the *duars,* and can be thought of as arms of the sea. Preliminary computer simulations indicate that over one-third of the region is inundated annually due to tidal backing-up of the Upper Meghna into the Sylhet Depression. This has major implications for the long term economic prospects of the region - particularly, that it may never be possible to achieve a cereal-based rural economy throughout the region, and that fish (ie protein) production would appear to have an assured and substantial role in the region's long term economic production endowments and possibilities. Furthermore, it seems unlikely that flood control works will produce substantial flood control benefits to the region given its water rich nature and lack of ready storage areas. Flood protection works such as embankments (and possibly flood relief channels) are more likely to yield substantial benefits to the non-fisheries sectors of the regional economy.

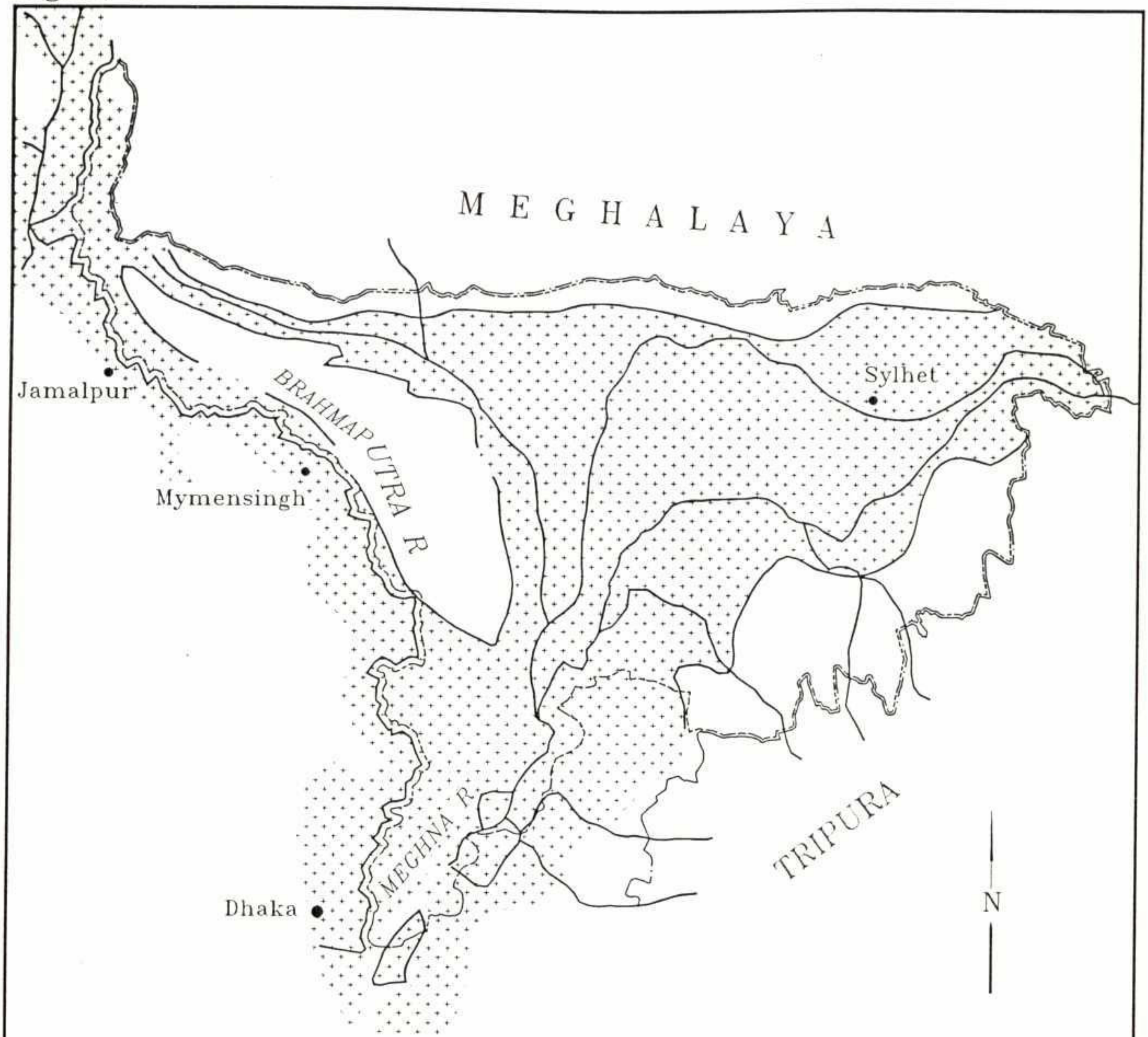
2.1.4 Floodplains, haors, beels, khals and FCD/I projects

Of the total surface area of the region of 24,180 sq km, approximately 90% (21,710 sq km) is occupied by the four landform units which are subject to annual flooding (Sylhet Depression, lowland floodplains, piedmont floodplains, alluvial fans). Together these form the larger floodplain of the Upper Meghna River. The extent and duration of flooding varies from year to year depending on flood intensity (the result of rainfall and river discharges).

Flood land elevation variations are typically very small, and the very flat river gradients have led to the formation of a dominant morphological feature in the region called *haors*. Essentially, a haor is a small internal drainage basin located on low-lying land between two or more rivers. Haors form as a result of sediment-laden water spilling over the river banks and building up natural levees which eventually enclose the land. Characteristically, there is one or more small lakes *(beels),* at the centre of the haor. The beels are usually connected to the rivers surrounding the haor by one or more drainage channels (*khals)*. Haors are particularly prevalent in the region, and may be unique to it. They occur throughout the region but are most numerous in the topographical trough running east-west along the foot of the Shillong plateau and containing the flood plains of the Surma and Kangsha, and on the flood plains of the Baulai and Kushiyara. A few are also found on the flood plain of the Barak river in the contiguous Cachar district of Assam, India. They are rarely, if ever, found on lands having an elevation greater than 10 m above sea level; this indicates that very flat river gradients are essential to their formation.

Characteristically, haors fill with water during the pre-monsoon and early monsoon periods, and empty during the early dry season. During the late monsoon they are essentially full, and in the late dry season they are essentially empty. When empty in the late dry season (February-March) the beels may be dry, or nearly so, depending on their bed elevation relative to ground water table, the elevation of which is controlled by water levels in adjacent rivers. In this condition

Figure 8



LEGEND

International Border

Northeast Region

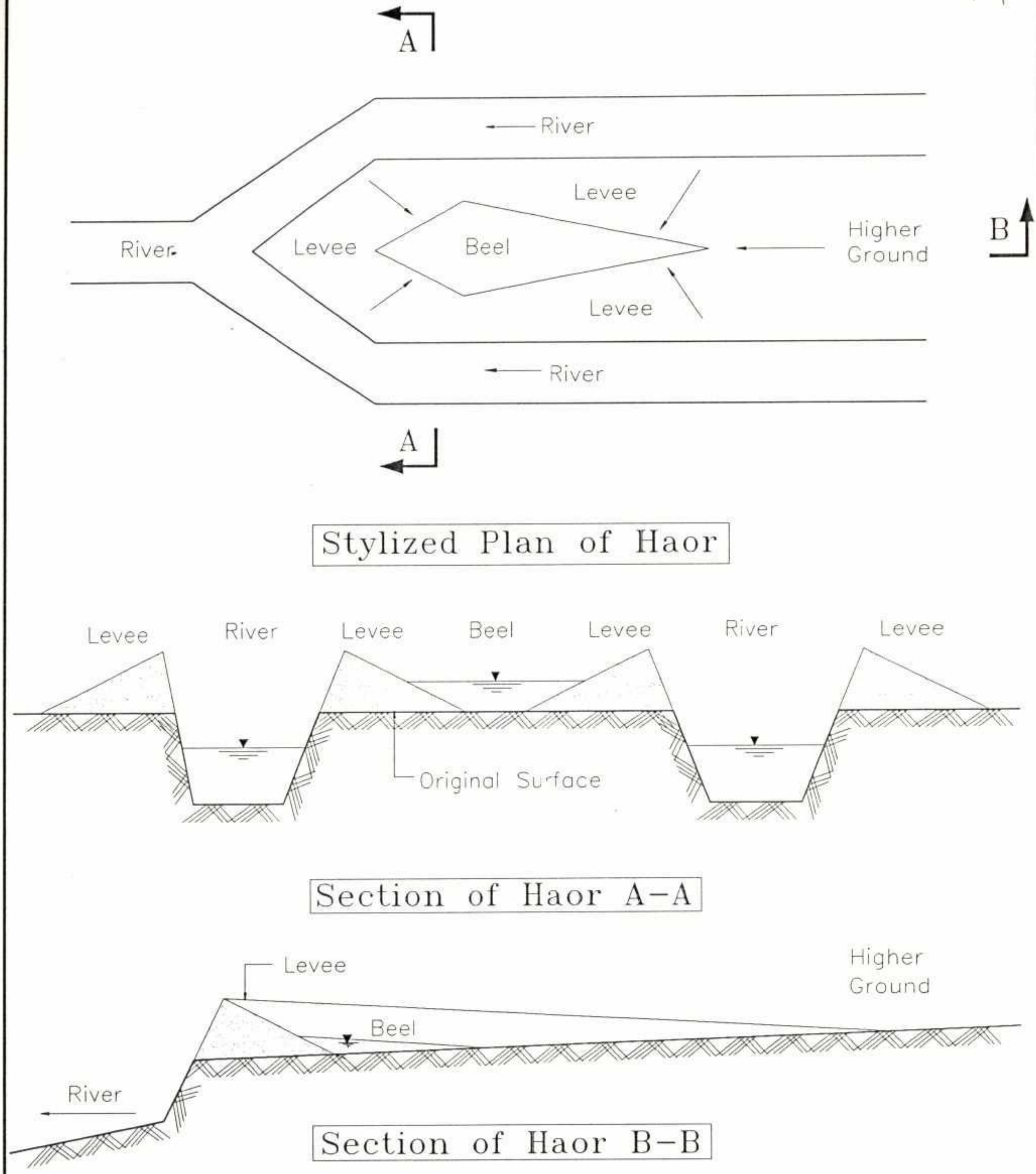
1988 Flooded Area

Northeast Regional Project

Extent of Flooding in Northeast Region in 1988

Prepared by: BNP/Jalal | April 1993

FILE: FISH-111.DWG



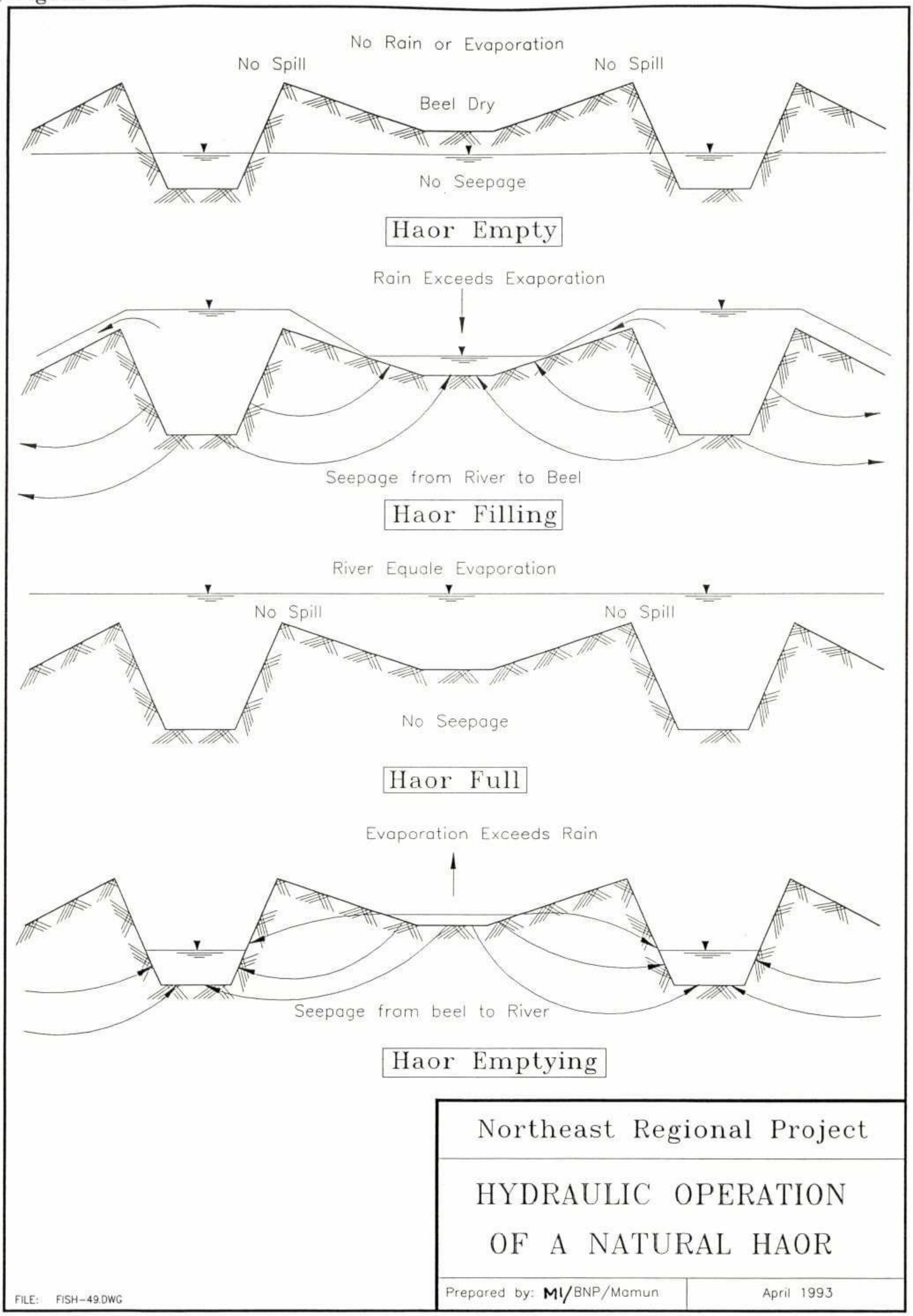
Northeast Regional Project

BASIC STRUCTURE OF A NATURAL HAOR

Prepared by: MI/BNP/Mamun | April 1993

FILE: FISH-48.DWG

Figure 10


No Rain or Evaporation
No Spill
No Spill
Beel Dry
No Seepage
Haor Empty
Rain Exceeds Exaporation
Seepage from River to Beel
Haor Filling
River Equale Evaporation
No Spill
No Spill
No Seepage
Haor Full
Evaporation Exceeds Rain
Seepage from beel to River
Haor Emptying
Northeast Regional Project
HYDRAULIC OPERATION OF A NATURAL HAOR
Prepared by: MI/BNP/Mamun
April 1993
FILE: FISH-49.DWG

there is very little, if any, exchange of water between the haor and its surroundings as rainfall, evaporation, spill or seepage. During filling (April-July) water enters the haor as rainfall, by spill over the banks of adjacent rivers, and by seepage of river water through the ground. All this water collects at the centre of the haor to form one or more beels, depending on the micro-topography of the haor bed. In the late monsoon season (August-September) the entire haor is usually flooded, and the river levees are usually completely submerged. The depth of inundation is commonly as much as 6 m above the haor bed. During emptying (October-January), water leaves the haor as evaporation, and by seepage through the ground back to the rivers. Drainage will also occur through khals on the haor bed if these cut through the levees into the adjacent rivers. Depending on the intensity of the wet and dry seasons in any year and on the topography of a particular haor bed, filling and emptying may or may not be completed in some years. The most important fish producing haors in the region are shown in Table 2.3.

Table 2.3: Important Fish Producing Haors

Haor	District	Area km^2
Hakaluki	Moulvibazar	204
Hail	Moulvibazar	244
Tangua	Sunamganj	130
Dekker	Sunamganj	466
Matian	Sunamganj	63.8
Sunamoral	Sunamganj	37.3
Gurmar	Sunamganj	53.6
Khaliajuri	Netrokona	975
Companiganj	Habiganj	506
Humaipur	Kishorganj	62.6

Source: NERP

The total number of beels in the region have been variously reported between 3,440 (covering 585 km sq, 17 ha mean size) and 6,149 (covering 635 km sq, 10 ha mean size) (CIDA, 1989). Some 58% of the beels in the region are permanent, while 42% are seasonal, or temporary.

Sunamganj District has the largest number of beels of any district in the region and in Bangladesh. About half are large (over 8 ha in area). About 400 are permanent. Of the remainder, 500 are likely to desiccate completely each year, and 500 might still retain some water at the end of the dry season.

During the rainy season, the entire floodplain (with haors and beels), rivers and khals become a single sheet of water. Fish are widely dispersed, and access is freely open to the public. During the dry season individual beels emerge and are an overwintering refuge habitat for brood stock of many commercial and subsistence fish species. Thus, important and valuable fisheries *(jalmohals)* operate in the beels during the dry season, and large landings of both broodstock and juveniles are realized. Over the last few decades a major change has occurred in the quality of the haor environment, as many typical wetland areas as well as grazing pasture lands have been

Table 2.4: Beels in the Region

Districts	Number of Beels	Area (km^2)
Habiganj	1,003	49.3
Moulvibazar	413	65.9
Sunamganj	1,841	171.9
Sylhet	1,084	118.7
Kishorganj	821	117.8
Netrokona	987	111.1
Mymensingh	85	64.0

Source: NERP

converted into rice fields. This represents a serious threat to biodiversity in the region.

Embankment of a haor under a typical FCD/I project involves raising the crest level of the river levees by constructing an embankment upon them. It is undertaken primarily to benefit agriculture, the intention being to prevent spill from adjacent rivers entering the haors and damaging standing crops. Haors are embanked by constructing either a "submersible", or a "full" embankment on the encircling river levees. The objective of a submersible embankment is to prevent spill entering the haor from adjacent rivers when they are in spate during the pre-monsoon period (April-May), and so to protect the standing boro crop. In this period the river water levels rise but, generally, not to such high levels as during the monsoon. Embankments therefore do not need to be of the height needed to exclude monsoon flooding. After the boro harvest, this type of embankment is normally submerged throughout the monsoon period (June-September). The objective of a full embankment is to exclude flood waters on a year round basis and so enable cultivation of crops in all seasons. Drainage works, in the form of regulators, pipe sluices or pumping stations, are essential to facilitate early emptying of the haor which, despite the exclusion of river spill, still tend to fill as a consequence of rainfall on the haor area (typically, 2 to 3 m) and the seasonal rise of the water table. Ideally, pumping stations would be provided to enable rapid and complete drainage and so enable normal agriculture.

The cycle of operations for a haor with submersible embankments involves drainage, irrigation, flood protection and flooding. The cycle begins with haor drainage, As river water levels fall in the post-monsoon period regulators and pipe sluices are opened to enable water trapped in the haor to drain out into the rivers. As the haor lands emerge from the water the boro crop is sown. It survives on the moisture remaining in the haor until this is exhausted at which point irrigation is necessary if crop yields are to be optimal. Irrigation is achieved by opening irrigation inlets and channelling the incoming river water to the fields. As the crop nears harvest the irrigation inlets, and the drainage regulators and pipe sluices, are closed to prevent influx of pre-monsoon flood waters. After the boro harvest, the regulators and pipe sluices are opened to let river water flood the haor to the same level as in the river so that when the embankment is overtopped during the monsoon, water does not flow rapidly across the crest and down the inner slope of the embankment causing erosion of the embankment. The cycle of operations for a haor with full embankments is characteristically more complex and continuous. It involves exclusion of all river flood waters throughout the year, continuous drainage by gravity through regulators, etc. whenever river water levels are low enough, and by pumping when they are not, supply of irrigation water whenever river water levels are high enough, and by pumping when they are not.

The major problems with water management of embanked haors for agriculture in the region are:

- breaching and cutting of embankments
- siltation of the channels of adjacent rivers, and of haor drains
- lack of pumping for drainage and irrigation

Figure 11

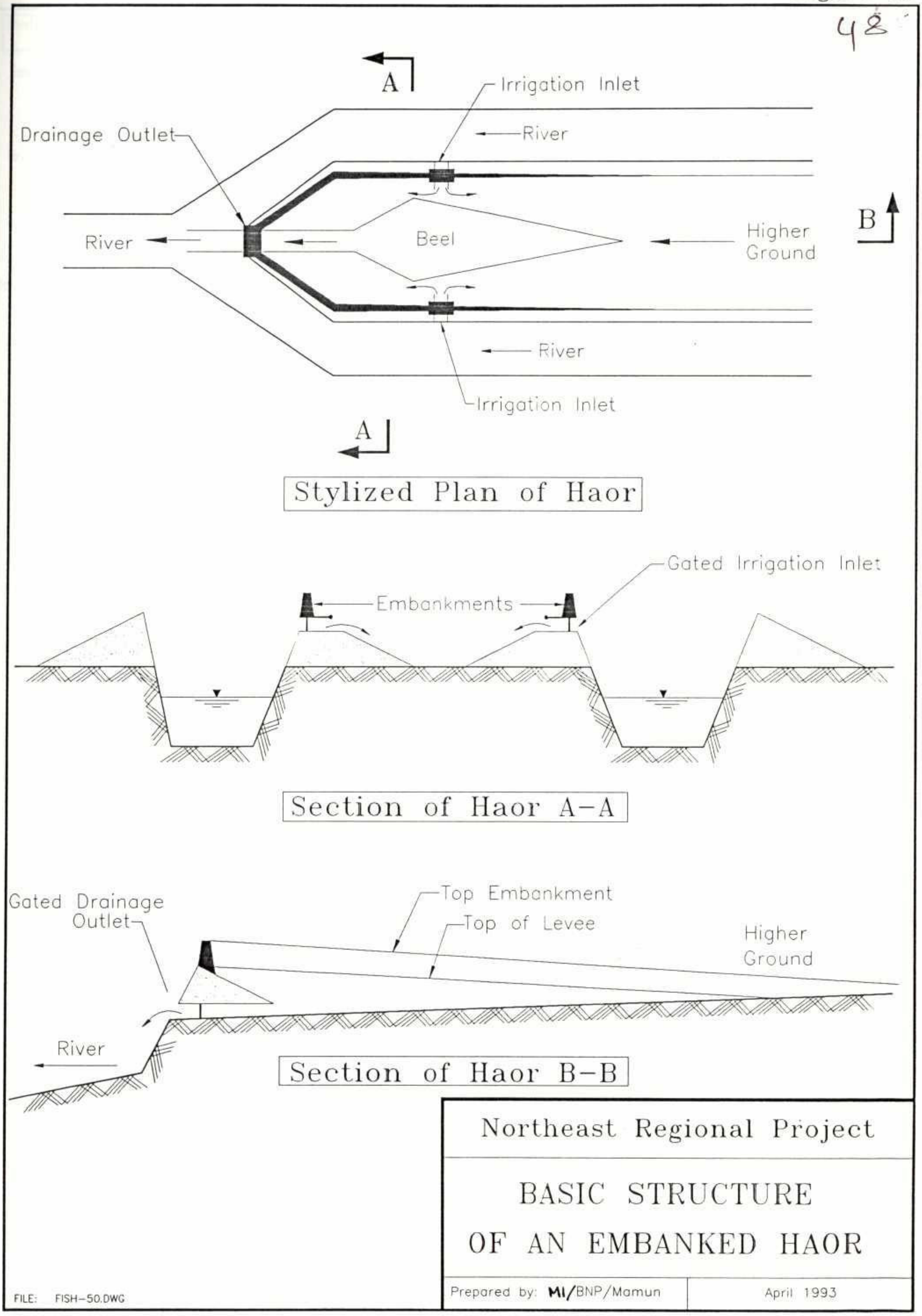
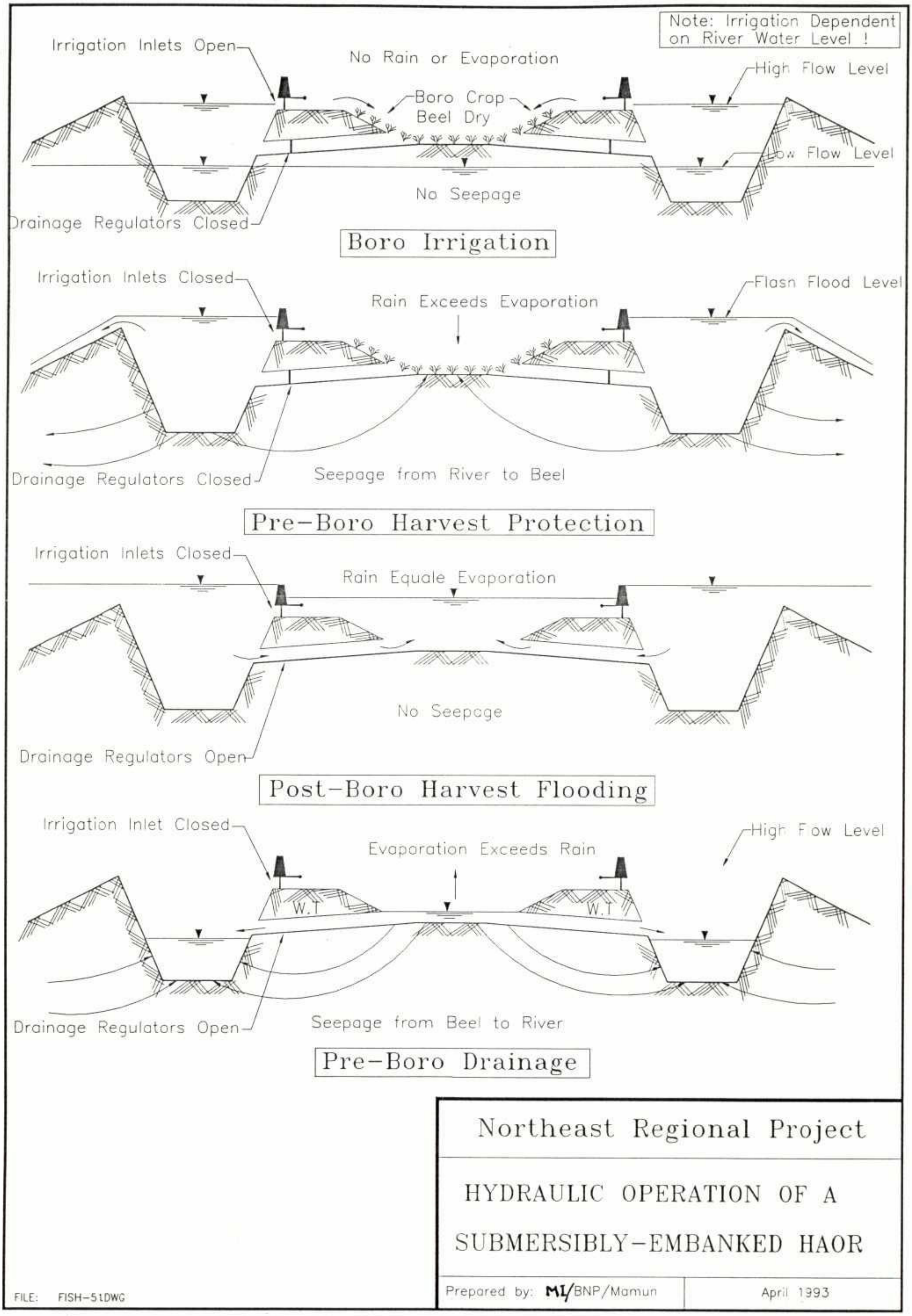

48
A
Irrigation Inlet
Drainage Outlet
River
River
Beel
Higher Ground
B
River
Irrigation Inlet
A
Stylized Plan of Haor
Gated Irrigation Inlet
Embankments
Section of Haor A-A
Top Embankment
Gated Drainage Outlet
Top of Levee
Higher Ground
River
Section of Haor B-B
Northeast Regional Project
BASIC STRUCTURE OF AN EMBANKED HAOR
Prepared by: MI/BNP/Mamun
April 1993
FILE: FISH-50.DWG

Figure 12



Note: Irrigation Dependent on River Water Level !
Irrigation Inlets Open
No Rain or Evaporation
High Flow Level
Boro Crop
Beel Dry
Low Flow Level
No Seepage
Drainage Regulators Closed
Boro Irrigation
Irrigation Inlets Closed
Rain Exceeds Evaporation
Flasn Flood Level
Drainage Regulators Closed
Seepage from River to Beel
Pre-Boro Harvest Protection
Irrigation Inlets Closed
Rain Equale Evaporation
No Seepage
Drainage Regulators Open
Post-Boro Harvest Flooding
Irrigation Inlet Closed
Evaporation Exceeds Rain
High Flow Level
W.T
W.T
Drainage Regulators Open
Seepage from Beel to River
Pre-Boro Drainage
Northeast Regional Project
HYDRAULIC OPERATION OF A SUBMERSIBLY-EMBANKED HAOR
Prepared by: MI/BNP/Mamun
April 1993
FILE: FISH-51DWG

The breaching of embankments is widespread and appears to be a continuing problem. It is due to natural causes in some cases, to the action of boatmen, farmers and fishermen in most cases, and sometimes to a combination of both causes. Natural breaching results from river floods scouring the outer foot of the embankment or, more frequently, scouring the inner slope of the embankment when overtopping occurs and the water level inside the haor is lower than in the adjacent river. In the latter case the situation is often aggravated by embankment crest levels being below needed levels as a result of elevated river water levels due to siltation, scouring of the crests, subsidence of peaty embankment materials or foundations, failure to construct to design level, or under-estimation of the required design level. Man-made breaching occurs as a result of farmers attempting to drain or flood their lands when controlled drainage or flooding is impossible due to regulator failure or inadequacy. Such breaching is also made by fishermen, particularly commercial fishermen working for Jalmohal lessees, to drain out the haor and hence facilitate an easy and massive fish catch. Cuts are also made to extend the period of cross-haor navigation.

Siltation is occurring in the region, and is getting worse over time, in both the channels of adjacent rivers and in drainage channels within the haors. Siltation of the river channels causes river water levels to be higher for the same discharge than previously. As a result original design embankment crest levels are no longer adequate and embankment overtopping occurs more frequently. When an embankment breaches silt accumulated on the river beds is carried into the haors by the river water rushing through the breach. Siltation of the haor drainage channels results from these avulsions of river bed silt, and from the deposition of suspended sediments carried by river water entering the haor through regulators or by overtopping of the embankments. The effects of siltation are to restrict or inhibit navigation in both the river channels and the haor drainage channels, and the flow of water through regulators, pipe sluices and irrigation inlets. In extreme cases navigation has to be re-routed, usually over a much longer route, and regulators become inoperable and damaged by attempts to operate them.

The relatively high cost of electricity in Bangladesh, has frustrated the use of drainage pumping stations which are essential if the drainage of haors is to be fully controlled. A lack of pumping capacity may also be present in some haor projects. The high price of electricity also restricts irrigation pumping to diesel operation the cost of which, although lower than that of electricity, is often too much for farmers operating at the margin to bear. As a result neither drainage nor irrigation of the embanked haors is as effective as it must be for satisfactory agriculture.

The effects of FCD/I projects on flooding are complex and difficult to track on a regional basis from year to year. Submersible embankments do not reduce the area flooded but hectare-months of inundation and flood water residence time are reduced. Full flood embankments severely reduce the latter two inundation indices, as well as area flooded, but even under full flood protection conventional paddy field flooding is carried out. This highly restricted form of inundation still yields some fish production. Intentional cutting of embankments and embankment/regulator failures are non-design events which counteract flood protection restrictions on natural flooding, thus increasing inundation areas and pushing inundation indices upwards.

51

2.1.5 Ponds and borrow pits

There are about half a million ponds in the region with a total area of 18,700 ha (1988/89 BFRSS data). Many of these are borrow pits resulting from homestead site preparation. The DOF classifies ponds as cultured (49.1% by area), culturable (22.8%) and derelict (28.1%).

Table 2.5: Pond Area by District

Districts	Ponds	Area (ha)
Sunamganj	32594	2524
Sylhet	32307	2504
Moulvibazar	29179	2260
Habiganj	23186	1796
Kishorganj	20791	2333
Netrokona	25413	2852
Sherpur	3999	564
Mymensingh	17519	1966
Narsingdi	8110	1026
Narayanganj	3660	420
Gazipur	4070	502
TOTAL	**200828**	**18744**

Source: BFRSS

Another important microfishery real estate are the borrow pits running along road embankments. These are owned by the Department of Roads and Highways and are leased out for fishery purposes. Their water supply is dependent on river overspill flooding and rainfall, while their fish resource is dependent on movement of fish on to the floodplain during the monsoon season. The stocks of mainly miscellaneous species are exploited for subsistence and minor commercial sale. During the early dry season katha are installed to harvest the larger species. Borrow-pits are often subdivided by fish fences with basket traps or bunds. Later the entire pit may be drained to remove all fish. Borrow pits are vulnerable to water deficits. As many are < 1 m deep, they are prone to desiccation by the end of the dry season (if they have not previously been artificially drained, which is the usual practice when harvesting the fish). A constraint on improving the water storage capacity is that borrow pits cannot be excavated to deepen them because this might endanger the road embankment.

Borrow pits created during the course of FCD/I construction works are owned by the BWDB and are also leased out for fish production by auction.

2.1.6 Sediments

Because of their steep gradients the piedmont affluent rivers arising in the Indian catchment area carry large quantities of sand, gravel and stone. Stone and gravel is deposited in the alluvial fan zones (ie the Luba and the Rakti). Most of the sediment that is deposited on the floodplain is silty washload.

Peat deposits in the form of lenses are fairly common. They are usually exposed along river banks, or may be uncovered during FCD/I excavations in haors or during road building. Peat is the object of a cottage mining industry. The dried peat is used for fuel.

2.1.7 Limnology

Although high turbidity due to silt and clay loads characterizes flood waters during the monsoon, the water gradually clears during flood recession. This allows good growth of algae and aquatic macrophytes in beels and some river stretches during the dry season. Apart from providing a source of food to secondary trophic producers, algae (*shawla*) in the form of periphyton also constitute the most important pathway for fixing of atmospheric nitrogen, upon which good yields of rice in the haors are partly dependent (Catling et al, 1981). In shallow rivers during the dry season (such as the Surma near Kanaighat), algae grows directly on the sandy river bed, as well as on the brush and bamboo used in kathas. Sometimes algal growth is excessive. In Halir Haor fishermen complain that it forms large mats at the bottom of beels which interfere with fish movement and nets.

Infestation and overgrowth of smaller water bodies with *kachuri pana* (Water hyacinth, Eichhornia crassipes) appears to be a problem almost everywhere. Some domestic uses (fertilizer, fuel, cattle feed) and fisheries (mat for covering katha) are made of kachuri pana, but extensive overgrowth depresses fish production. It lowers water quality, plankton production and dissolved oxygen content (which many species cannot tolerate), and interferes with fishnets, thus reducing catchability of the stocks. Water lettuce (Pistia stratoides) also occurs in the region but is not particularly abundant, and therefore not a pest.

Water buffalo are plentiful in some areas and spend much time wallowing in borrow pits. Their dung undoubtedly directly contributes to the fertility of water bodies. Cattle graze on fallow rice fields and pasture lands of haors during the dry season and cattle fattening is an important economic activity. Cattle dung increases the productivity of flood lands when they are inundated (although much of this dung is collected and dried for use as fuel).

Some water quality problems exist in the region. Serious problems of water pollution exist in the Surma due to discharge of effluent from the bleach kraft pulp mill at Chhatak, and in the Kushiyara due to the urea fertilizer plant at Fenchuganj (although the latter is now scheduled to be shut down). Increasing use of insecticides may be reducing environmental quality and affecting fish catches. The use of fertilizers probably has a beneficial effect on fish production. Moreover, the roots and cut stems of rice plants also contribute after decomposition to the bioproductivity of the floodplain. Excessive eutrophication due to these factors has also been recorded however.

2.1.8 Wetland forests

Historically, much of the region was covered with inundation resistant tree species and bushes. An Agricultural Officer from Kishorganj has reportedly identified 21 species of flood tolerant tree species. Two species are dominant: *hijal* Barringtonia acutangula and *koroch* Pongamia pinnata. Others common trees are *mandair, mera* and *barun*. These species grow in many haors (especially in Sunamganj District), often in plantations or gardens. A list of *hija*l and *koroch* gardens in the region is given in Appendix D.

Information from various parts of the region indicate that *hijal/koroch* trees and plantations serve at least six environmental and economic functions:

- They serve as a wave break to protect homesteads during the flood season;
- They provide shade during the dry season;
- They are a source of fuel during the flood season (straw and cow dung is normally used during the dry season);
- They provide a source of income through sale of branches for katha;
- They create upland by enhancing sedimentation around the planted area; and

53

- They increase fish production.

Trees and bushes which become submerged during the monsoon apparently act like a natural katha. Beels with *hijal* are known to have much more fish present than beels without. *Hijal* can grow into a large tree, but most examples seen are short with a thick trunk. This is because the branches are coppiced periodically for use in pile fisheries.

Because of the various benefits that flood tolerant trees yield to fisheries, homestead protection, fuelwood and income, there is widespread interest in the region in afforestation at individual, and community levels. For example, at the eastern side of the Medhol beel in Medhol haor (Jaitipur, Sylhet District) *hijal* trees were planted by the local people. The plantation is managed by the village people as *hijal* not only saves their village from wave damage during the flood period, it also generates income from selling tree branches. This helps to meet some community expenditures such as repairing the school and the mosque. The DOFr has also initiated a program, albeit at a modest level. The floodplain of Rouchunni beel has been put under a water resistant tree plantation program. A few hectares of Government khas land was appropriated for this purpose and *hija*l and other plants were planted around the beel. The program was initiated and supported by the lessee of the Rouchunni beel as he thinks that wet land forests will definitely increase fish production by providing shelter and food for fish. Privately owned plantations exist in Tangua Haor, Hakaluki Haor and Kaliajuri area (Appendix H), and in Tangua Haor Project and Gurmar Haor Projects (Appendix K). A large *hija*l plantation was established near Ajmiriganj 50-60 years ago on the grounds of the Bithalong Hindu Temple. Apart from serving the local demand for branches for katha, the plantation was also intended to provide shade from the sun for worshippers.

Near Jagannathpur *Duar* large *Borun* (Crataeva nurvula) trees occur. Fishermen state that the fruit of *Borun* is very tasty and that fish like this fruit. These trees also occur in Pangasiar Haor, Faridpurer *Duar*, Ranichapur and Dhalimati Fishery. People traditionally believe that if a haor has abundant trees and bushes, then it will produce large fish. Water resistant trees were planted on the road sides of Sylhet-Fenchuganj highway. The main species are Koroch, Barun, Mera and *Hijal*. They were planted by the DRH to protect the road from waves of the Damrir haor (on one side) and Dubrir haor (on the other). Now these trees not only protect the road, but have also created an unique shelter for birds. Around the Tangua haor project, numerous *Koroch* and *Hijal* trees occur naturally. Near Islampur and Bhatidal villages, which are adjacent to Tangua and Bhadalia beels about 1000 *Koroch* and 3-400 *Hijal* trees are present. At sunset seagulls and herons roost in the trees. The fishermen group of Bhatidal village reports that fish abundance is always high around the semi-inundated trees. On the bank of the Rakti River and the Ghagotia River at Karchar haor project, about 100 *hijal* and 10-15 *koroch* trees are present. The *hijal-koroch* gardens are owned by the local mosque and maintained properly by the management. At Hakaluki haor in Barlekha thana, Mr. Rashid Mia (Chatla beel lessee) had started a plantation on the embankment of the Chatla beel. He planted about 5000 *Hijal, Koroch* and *Cipti* trees.

In addition to wetland trees, several water resistant herbs and grasses occur in the region:

Table 2.6: List of Water Resistant Herbs and Grasses

Local name	Scientific name	Local name	Scientific name
Nol Khagra	Phragmities karta	Tara	Alpinia sp.
Chailla	Hemarthria protensa	Ban tulshi	Lippia javanica
Kashiya	Saccharum spontaneum	Kaisa	Lagarosiphon roxburghii
Ban lat	Ficus heterophylla	Keoroli	Potamogeton nucronatus
Pataseola	Vallisnaria spiralis	Parua	Echinochloa colonum
Binna	Vetiveria zizanioides	Echor	
Erali	Pseudoraphis spinescens	Phutki	Hygroryza aristata
Satamuli ·	Asparagus racemosus	Khagra	Xanthium indicum
Dol kolmi	Ipomoea fistulosa	Mutha	Cyperus sp.

2.2 Fish Biodiversity

2.2.1 General aspects

Of the 260 species of freshwater fish known to inhabit Bangladesh, over 130 native plus 8 exotic introductions are known or suspected to inhabit the water bodies of the region (see Appendix B). Cyprinids and catfishes dominate the ichthyofauna. Virtually all species are of some commercial importance in so far as they appear in retail markets. Major carps and large catfish are the most commercially valuable, but other groups such as the knifefish, "livefishes" *(Koi, Magur, Singi)*, and herring *(Ilish)* are also important. Miscellaneous species are of the highest importance for subsistence and self-provisioning. It is significant that even these species are attaining market importance and entering commercial networks.

A widely used popular terminology groups fish species into two categories:

- *Boromaach,* or large fish. This includes major carp, large catfish, *Chital,* Gangetic stingray, *Gazar, Shol* and *Ilish.* All *boromaach* are commercially important species. Most boromaach carry out longitudinal spawning migration. Thus, the group is defined also by ecological and economic factors.
- *Chotomaach,* or small fish. This includes the vast majority of species. Most are important for subsistence consumption, although a few are commercially in demand (such as *Rani*). Most *chotomaach* do not carry out spawning migrations, or at most move short lateral distances into shallow water.

Life history information presented below is based on field findings, and from information presented in Azadi (1985), Rahman (1989) and Tsai and Ali (1985).

2.2.2 Major carps

There are four cyprinid species which are commonly called the major carps:

- *Rui* Labeo rohita
- *Catla* Catla catla
- *Mrigel* Cirrhinus mrigala
- *Kalibaus* Labeo calbasu

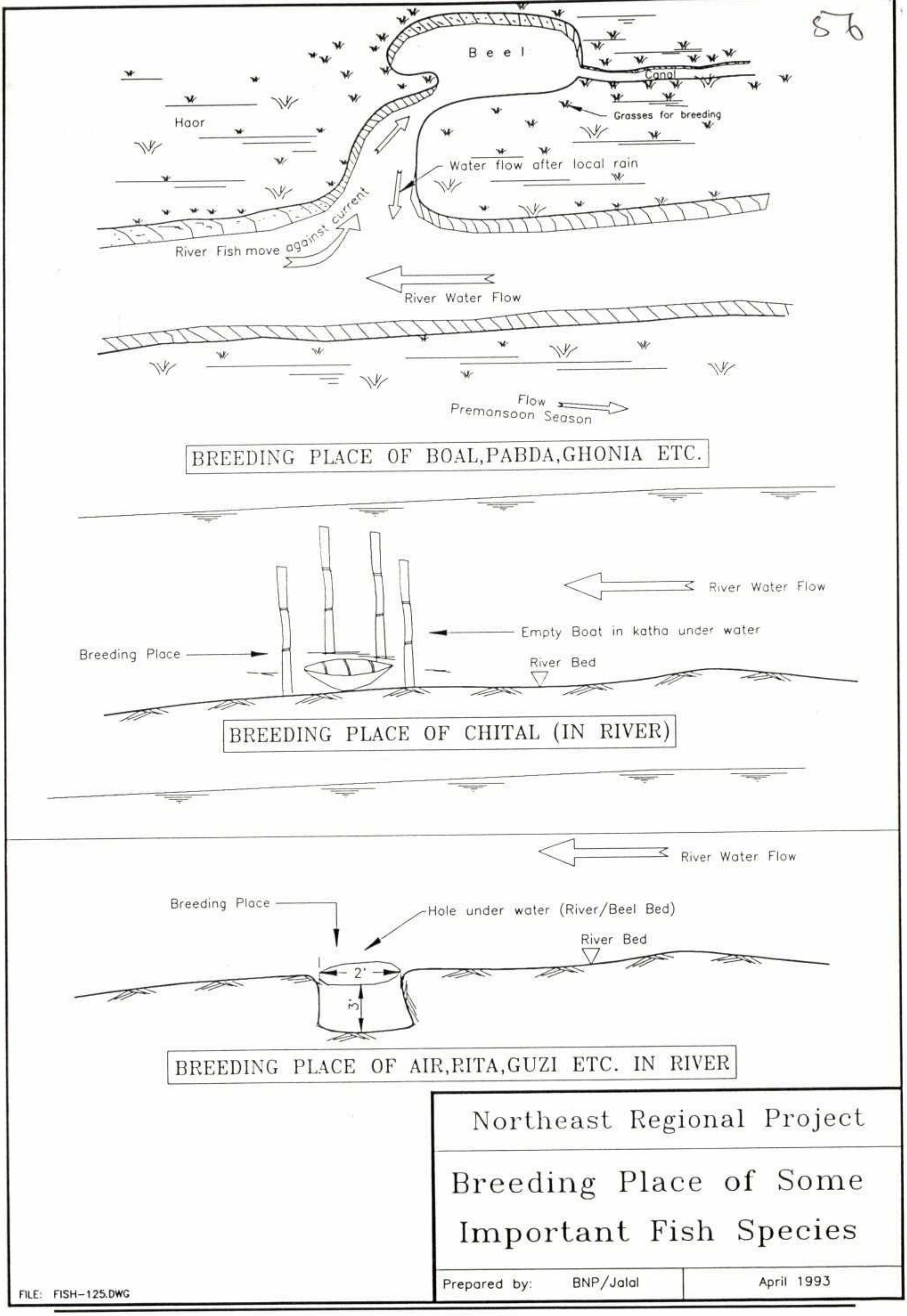
The *mohasols* (Tor tor and (T. putitora) are generally rare in the region. In years of very heavy rainfall in the Indian watershed (as occurred during the 1993 monsoon) individuals may be 'washed down' from the Meghalaya Hills (especially the Somerwari River) and show up in catches in the northern part of the region.The major carps are important commercial species. *Rui* is the most highly esteemed food fish in Bangladesh. *Kalibaus* and *Rui* are generally more abundant in catches than *Catla* and *Mrigel*. *Rui, Mrigel* and *Kalibaus* feed at the bottom on plant matter and decaying vegetation. *Catla* is a surface and midwater feeder. *Mrigel* attains sexual maturity at 2 years of age, *Rui* at 2 to 3 years, and *Catla* and *Kalibaus* at 3 years (Azadi, 1985). Tsai and Ali (1987) suggest that the major carp populations of the Surma and Kushiyara River basins might differ and that several different geographical populations may exist. All four species are thought to have similar reproductive strategies. Brood stock overwinter the dry season in large rivers and beels. Spawning migrations occur during the early monsoon. Typically brood stock from beels swim down the khals and out into the rivers, then upstream to reach shallower areas which are suitable spawning localities. Ox-bow bends in particular appear to be favoured, probably because they possess unique hydrological features (deep pools in the outer bend, turbulence, upwelling and backwater currents at the inner bend [Tsai et al, 1981]). Eggs are non-adhesive and drift with the current. The embryo hatches out in 5 to 24 hours, depending on the species. Yolk absorption takes 3 to 4 days, after which the fry begin feeding. Occurrence of drifting fertilized eggs and hatchlings is an indication of major carp spawning grounds nearby. Information on spawning localities in the region is fragmentary. Well known spawning localities (ie spawn collection sites) are in the Old Brahmaputra River where spawn and hatchlings are collected from May to July. Jhingran (1983) notes that in India major carp spawn is found in the headwater streams of the Surma (ie Barak River basin). This suggests that some of the Upper Meghna basin broodstock present in Bangladesh swims upstream into India to spawn and is thus an internationally shared stock. Local fishermen and fisheries officers in Bangladesh state that "major carp fry are available in many tributaries" (Tsai and Ali, 1985). A full account of information collected about carp spawning is presented in Section 2.3.3 below.

While major carp are known to spawn in rivers, it is interesting that some fishermen state that they spawn in beels. This needs to be investigated further. Khan and Jhingran (1975) and Jhingran and Khan (1979) report that *Rui* and *Mrigel* spawn in fields adjacent to rivers which are flooded after heavy showers, and in shallow marginal areas of bunds on flood fields. It may mean that major carp brood stock does not necessarily have to migrate across embankments into rivers to spawn. Increasing beel water levels during the early monsoon may be sufficient stimulus to induce them to spawn in their overwintering beels or on the flooded haor. Broodstock which have overwintered in rivers might thus have two options for spawning migrations at the onset of the monsoon: 1) swim upstream to locate suitable spawning habitats (ie oxbow bends) in the river, or 2) remain in the vicinity of the overwintering ground, wait until the river bank is overtopped and then move laterally on to the floodplain to spawn.

2.2.3 Large catfishes

Six species of large catfish occur in the region:

- *Boal* Wallago attu
- *Pangas* Pangasius pangasius
- *Air* Aorichthys aor
- *Guizza Air* Aorichthys seenghala
- *Baghair* Bagarius bagarius
- *Rita* Rita rita


Beel
Canal
Grasses for breeding
Haor
Water flow after local rain
River Fish move against current
River Water Flow
Flow
Premonsoon Season
BREEDING PLACE OF BOAL,PABDA,GHONIA ETC.
River Water Flow
Empty Boat in katha under water
Breeding Place
River Bed
BREEDING PLACE OF CHITAL (IN RIVER)
River Water Flow
Breeding Place
Hole under water (River/Beel Bed)
River Bed
2'
3'
BREEDING PLACE OF AIR,RITA,GUZI ETC. IN RIVER
Northeast Regional Project
Breeding Place of Some Important Fish Species
Prepared by: BNP/Jalal
April 1993
FILE: FISH-125.DWG

Boal is the most common species seen in markets followed by *Guizza Air, Air* and *Rita*. A few large *Baghair* are regularly seen. *Pangas* is rare, at least in the upper parts of the region. It is very occasionally caught in the Kushiyara around Sherpur.

Boal inhabits all manner of lotic and lentic water bodies. It breed on floodplains during the pre-monsoon and monsoon. It is an extremely voracious piscivore. Its flesh is very tasty with few bones. *Air* and *Guizza Air* inhabit both rivers and beels. Spawning may take place from early April up to the end of August. A nest (breeding pit) is dug in the soft mud of river beds where the current is sluggish. Both males and females guard the nest. Egg incubation lasts about 26 hours. Yolk absorption takes 7 days. *Pangas* usually lives in large deep rivers. It carries out long distance spawning migration, from the brackish estuarine lower delta up the Jamuna and Ganga Rivers into India. It spawns early in the monsoon over the inundated muddy islands of the main river channel. There is no evidence that *Pangas* spawns in the region. Occasional individuals appear at markets, and originate from the Kushiyara. *Baghair* occurs in low abundance in the Surma, Kushiyara, Kangsha and Old Brahmaputra. It is a voracious predator. Large specimens have been landed from the Surma (150 kg from near the confluence with the Luba River) and the Kushiyara (120 kg from near the confluence of the Manu River). The latter specimen was sold in Moulvibazar market for Tk 15,000. *Rita* is found in muddy rivers and is carnivorous.

2.2.4 Minor carps

The most common of the minor carps is *Gonia* (Labeo gonius), followed by *Lasu* (Cirrhinus reba). *Nanid* (Labeo nandina) and *Angrot* (Labeo angra) were previously quite abundant but are now almost extinct in the region. *Lasu* feeds on plankton and detritus. *Gonia* breeds during the pre-monsoon on floodplains.

2.2.5 Small catfishes

Several of the numerous small catfish species are important commercially:

Magur (Clarias batrachus) is able to breathe air and is usually sold live (livefish). It can live in almost any type of habitat, but is usually found in stagnant and muddy water, in association with *Singi*. *Magur* breeds during the rainy season (April to August) in shallow water. A hole is excavated for a nest, or nesting may take place in bamboo or hollow palm trees. The eggs are guarded by the male and hatch out after 20 hours.

Singi (Heteropneustes fossilis) is also able to breathe air and is sold as "livefish". It lives in ponds, ditches and haors, often in waters with decomposing organic matter or under water hyacinth mats. Sexual maturity is reached at one year of age. Spawning takes place during the monsoon months, April to July. There is no brood care. Incubation lasts 18-20 hours. Yolk absorption takes four days.

Kani Pabda (Ompok bimaculatus) and *Madhu Pabda* (Ompok pabda), inhabit all types of inland waters, from beels to rivers. They are commercially valuable. Little is known about their habits other than that they are omnivorous.

Two small schilbeid catfishes, *Basa* (Eutropiichthys vacha) and *Ghaura* (Clupisoma garua), are commonly available at retail markets. They are omnivorous and found mainly in rivers.

Tengra refers collectively to a group of small bagrid catfishes of the genera Batasio and Mystus.

They are considered very highly as both commercial and subsistence food fish. They are widely distributed in various habitat types and are very abundant.

2.2.6 Ilish

Although of the greatest economic importance in Bangladesh fisheries as a whole, *Ilish* (Hilsa ilisha) is of only secondary importance in the region. The adults migrate from the sea far up rivers to spawn. Some stock enters the Upper Meghna and penetrate far up the Kushiyara and Surma. Thus, 1-2 kg females with eggs are caught in the Kushiyara River near Sherpur during the monsoon season. Two major spawning migrations of 4 and 5 year olds occur, peaking in March and August. Breeding, egg development and fry development take place in rivers. Eggs hatch after 18-26 hours. Yolk absorption is completed after 8 days. Small *Ilish* (*Jatka*) are the object of a special river fishery as they move downstream to the sea and are caught in the Surma and Kushiyara in Sunamganj District. Small *Ilish* occasionally appear in markets in the region. Most adult *Ilish* sold is iced product originating from Chittagong and Chandpur.

2.2.7 Snakeheads

Five species of Channa occur in the region:

- *Shol* (Channa striatus)
- *Gajar* (Channa marulius)
- *Tila Shol* (Channa barca)
- *Taki* (Channa punctatus)
- *Cheng* (Channa orientalis).

They are voracious predators. Equipped with breathing organs, they are often marketed in "livefish" form. They can travel overland and are capable of aestivating in the mud of dried out pond and ditches (to revive at the onset of the next monsoon). They are usually found in stagnant waters including beels. Breeding takes place during the pre-monsoon (March-April) in stagnant waters. A nest is constructed of aquatic weeds. The fry form shoals and are guarded by their parents.

2.2.8 Knifefishes

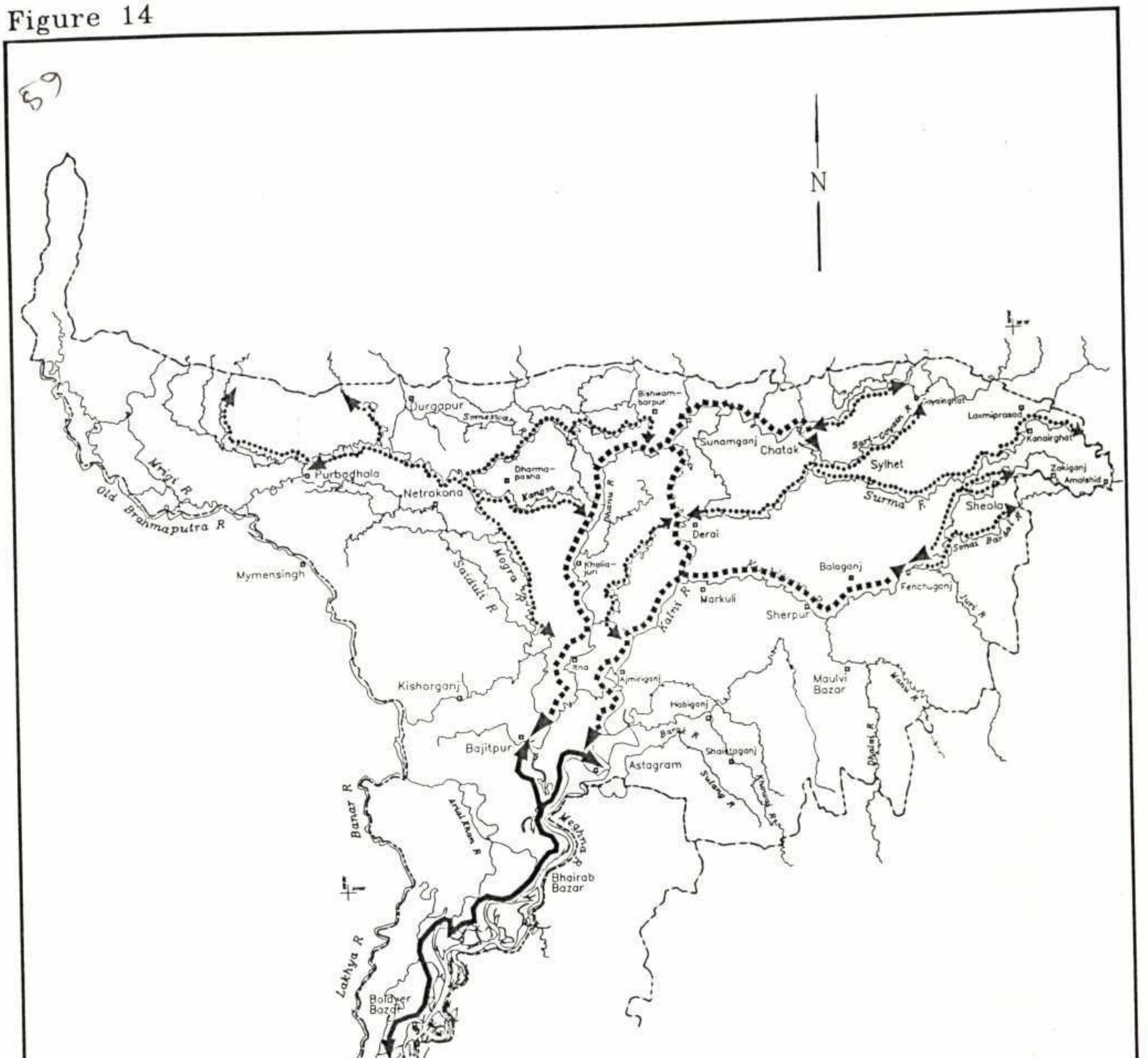
Chital (Notopterus chitala) is a *boromaach* of substantial commercial importance and is routinely seen at markets. It inhabits beels as well as rivers, but prefers clear water. During the rainy season it spawns in rivers. Breeding takes place in June and July. A nest is over hard structures. The adhesive eggs are deposited in the nest, on submerged aquatic plants or on branches of submerged trees. Both parents guard the nest. *Chital* is a carnivorous and predatory feeder.

Foli (Notopterus notopterus) is a second but smaller species of knifefish. It is very abundant in stagnant as well as running waters. Breeding takes place in May and June. The eggs receive parental care. The diet is carnivorous.

2.2.9 Stingray

Shakush, the large Gangetic Stingray (Himantura fluviatilis), occurs in the Kushiyara. Fishermen caught one specimen weighing 150 kg on 21 July 92 in the Kushiyara a few hundred meters downstream from the confluence of the Manu River.

Figure 14


N
Durgapur
Purbadhala
Netrokona
Dharma-pasha
Bishwam-barpur
Sunamganj
Chatak
Sylhet
Laxmiprasad
Kanairghat
Zakiganj
Amalshid
Sheola
Derai
Balaganj
Fenchuganj
Markuli
Sherpur
Maulvi Bazar
Mymensingh
Kishorganj
Bajitpur
Astagram
Hobiganj
Bhairab Bazar
Old Brahmaputra R
Surma R
Kalni R
Meghna R
Banar R
Lakhya R
Scale
25km
0
25
50km
LEGEND
NERP Boundary
International Boundary
River/Khal
High Abundance
Medium Abundance
Low Abundance
Northeast Regional Project
Abundance of Ilish
Prepared by:
BNP/Jalal
April 1993
XREF: FISH-6.Dwg
FILE: FISH-113.DWG

2.2.10 Miscellaneous species

The remaining part of the indigenous ichthyofauna has been lumped together here as "miscellaneous" species. This includes both commercial and subsistence taxa:

Needlefishes: *Kaikka* (Xenentodon cutcutia) is a very common predator in beels and flood lands. It is usually marketed in sun dried form.

Minnows, Rasboras and Barbs: Various small cyprinids such as *Punti, Chela, Mola* and *Jaya* regularly appear in markets in both fresh and sun-dried form. These species are also very important for subsistence consumption. They occur widely in virtually every type of aquatic habitat. The previously important *Sarpunti* (Puntius sarana) has declined in recent years.

Loaches: *Rani* (Botia dario) is regularly seen at markets and is in demand for export. It occurs in the Surma and its tributaries around Sylhet, Chhatak, and Sunamganj. *Gutum* (Lepidocephalus guntea) is widespread and used for subsistence.

Anchovies and Sardines: *Phasa* (Setipinna phasa), *Kachki* (Corica soborna) and *Goni Chapila* (Gonialosa manminna) occur mainly in rivers, while *Chapila* (Gudusia chapra) is also found in beels, ditches and flood lands. They are important subsistence species and often sold in dry form.

Spiny eels: *Baim* (Mastacembelus aculeatus) is widely distributed in rivers, beels and flood lands. It is regularly seen at markets and is in demand.

Climbing Perch: *Koi* (Anabas testudineus) possesses a breathing organ and is usually sold as "livefish". It is tasty and popular, and sold at most markets. It is also a staple subsistence food item. It prefers stagnant water habitats and can travel overland. During the dry season it remains buried under the mud. Breeding lasts from May to July. Eggs float at the surface and there is no parental care. Hatching takes 18 hours, and yolk absorption 4 days.

Gobies: *Bailla* (Glossogobius giuris) is common in rivers, and caught at night during the dry season by constructing low bunds out from the shore. It is carnivorous and primarily of subsistence importance.

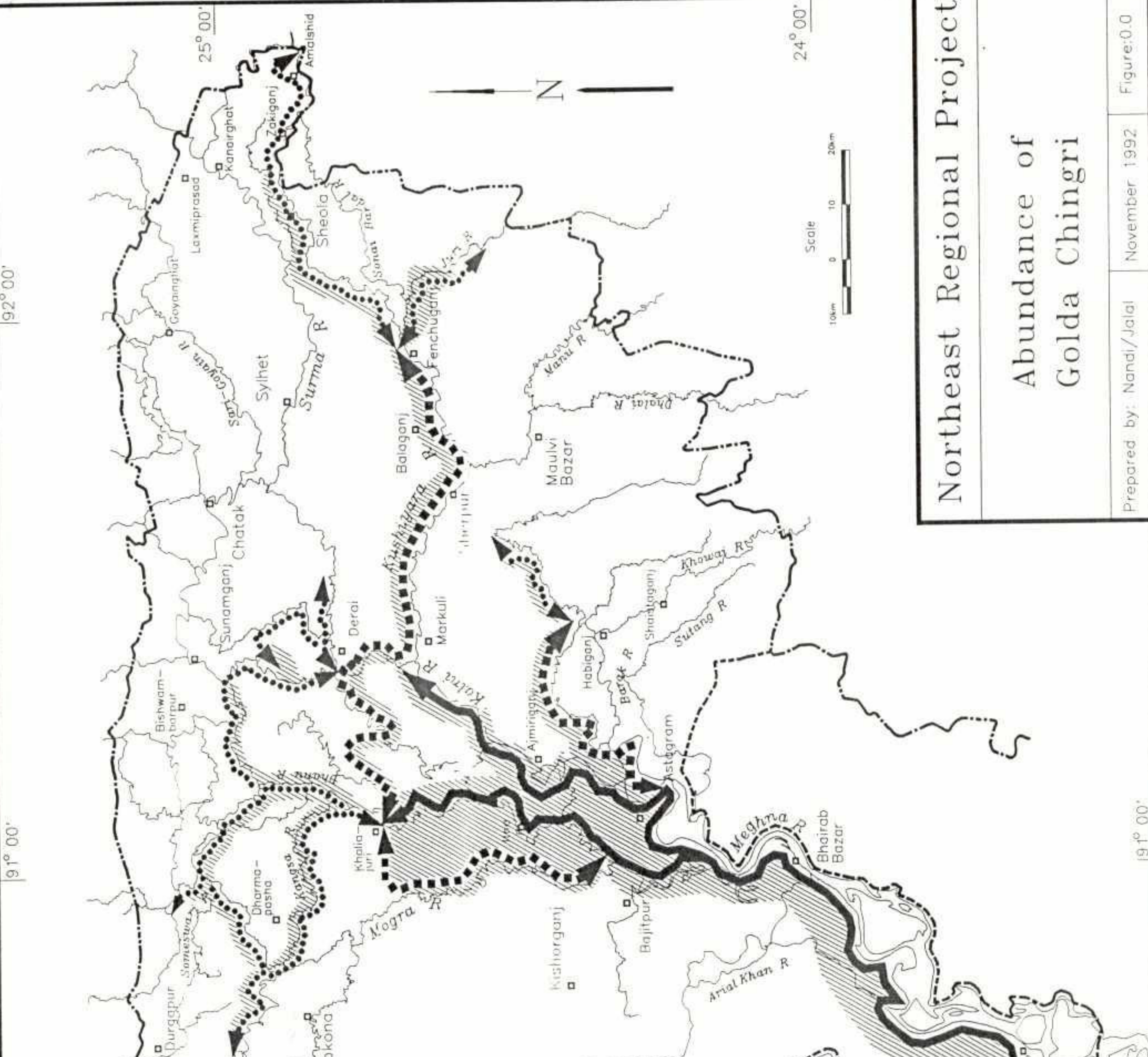
Mud Perches: *Bheda* (Nandus nandus) is occasionally seen at markets. It is predatory and common in ditches and on flood lands.

Glassfishes: *Chanda* (Chanda spp) is found in beels and is marketed in fresh and dry form.

2.2.11 Prawns

The giant freshwater prawn (*Golda Chingra*, Macrobrachium rosenbergi) is widespread in rivers and beels and economically very valuable. Adults migrate downstream to spawn in estuaries and the sea. Juveniles move back into rivers to grow and mature. Small prawns species are also abundant and are collectively known as *Itcha*. (Note: The generic term "shrimp" is now applied only to species inhabiting the marine environment).

Figure 15



Northeast Regional Project
Abundance of Golda Chingri
Prepared by: Nandi/Jalal
November 1992
Figure:0.0
FILE: FISH-4.DWG
LEGEND
NERP Boundary
International Boundary
River/Khal
High Abundance
Medium Abundance
Low Abundance
Distribution on Floodplain During Monsoon Season
Scale
N
25° 00'
24° 00'
92° 00'
91° 00'
90° 00'
Amalshid
Zakiganj
Kanairghat
Laxmiprasad
Sheola
Goyainghat
Sylhet
Surma R
Fenchuganj
Balaganj
Kushiyara R
Maulvi Bazar
Manu R
Dhalai R
Chatak
Sunamganj
Derai
Markuli
Khowai R
Shaistaganj
Sutang R
Habiganj
Bishwambarpur
Ajmiriganj
Kalni R
Astagram
Meghna R
Bhairab Bazar
Khaliajuri
Dharmapasha
Mogra R
Kishorganj
Bajitpur
Arial Khan R
Durgapur
Netrokona
Purbadhala
Mymensingh
Old Brahmaputra R
Banar R
Lakhya R
Boidyer Bazar

2.2.12 Exotic Introductions

Five carps, two cichlids and one barb have been introduced to Bangladesh. All are present within the region. The two *Tilapias* were intended primarily as pond fish and are widely distributed. Common carp appear to be established on floodplains and small numbers of adults are seen regularly at markets. Silver carp are raised in ponds and 0+ and I+ year classes are occasionally marketed. Bighead, grass and black carp are as yet not often seen at markets. The Thai Barb is not yet widely cultured.

2.2.13 Dolphin

The Gangetic dolphin, *sisu* (Platanista gangetica), is a mammal, not a fish. It is included in this report because its distribution and habits overlap many *boromaach* species. *Sisu* are especially abundant in the rivers during the rainy season and may also move on to floodplains. During the dry season they stay in deep duars in the larger rivers. Their food consists of most varieties of fish species. A high abundance of fresh water dolphins is one of the indicators of deeper places in a river, higher boromaach abundance and fish migratory routes within the river channel.

Sisu is common in the Surma and Kushiyara, as far upstream as their point of origin from the bifurcation of the Barak River at the Indian border at Amalshid. Dolphins are also seen in the Babur *duar* near Sheola ferry ghat of the Kushiyara River. Further downstream, dolphins occur at the junction of the pumphouse khal of the Manu River Irrigation Project and the Kushiyara, and at the confluence of the Manu and Kushiyara. Dolphins are especially abundant in the Ajmiriganj area. Near Sullah bazar, a large number are present. This is an inundated shallow area and the presence of dolphins is an indicator of fish abundance. Bordair *duar* is located at the confluence of the Bheramona River and the Bordair khal. The duar is renowned for larger sized catfish (particularly *Air*), *Chito*l and *Guz*i and a number of dolphins inhabit the duar. Dolphins also occur in the Surma River at Sunamganj and near Jamalganj. Fresh water dolphins are most common in the Chamraghat area, particularly at the confluence of the Narasunda and the Dhanu River (near Noagaon village) where they occur in large numbers.

There is no targeted fishery for dolphin. Some are occasionally caught by accident in fishermen's nets. The oil is extracted and thought to be beneficial when consumed by pregnant women.

2.3 Annual Life Cycle of Floodplain Fish Species

2.3.1 Migrations and general floodplain fish ecology

In general, during the pre-monsoon and early monsoon period fish migrate into shallow areas. During flood recession fish migrate to deeper areas. Migrations are usually countercurrent during pre-monsoon and early monsoon. If rain falls in the upper catchment area (in India), rivers rise and water flows from the river up the khals and into the beels. Fish will tend to swim from the beels down the khals to the river. If rainfall is localized on the haor, the haor will drain into the beel and then water will flow from the beel down the khal into the river (but this is a less common event). In this case, fish will tend to swim from the river up the khal to the beels.

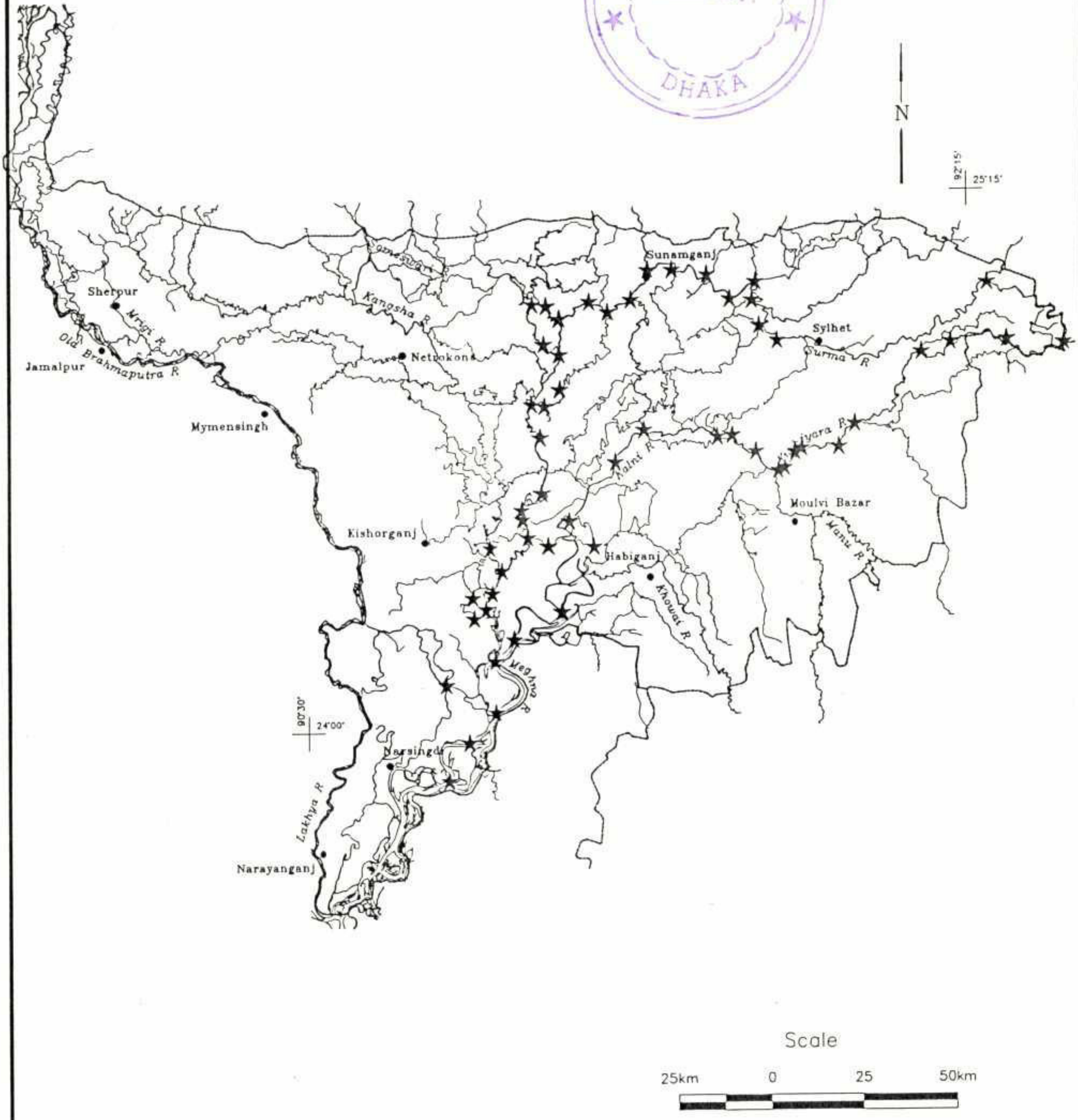
Table 2.7: Fresh Water Dolphin Occurrence in Major Rivers

District	Adjacent Village
River: Kushiyara	
Sylhet	Amalshid
	Mewa
	Sheola ghat
	Kakairdi
Moulvibazar	Abdullapur
	Islampur
	Manumuk
	Perkul
Habiganj	Digholbagh
	Pechirbazar
	Bagmayna
	Roail
	Markuli
	Bherardohor
River: Kalni	
Habiganj	Ajmiriganj
	Abdullapur
	Isapur
River: Upper Meghna	
Kishoreganj	Echordia
	Chatalpar
	Ainargoop
	Mendipur
	Paniswar

District	Adjacent Village
River: Ghorautra	
Kishoreganj	Dighirpar
	Sutarpara
	Dilalpur
River: Kawnai	
Sunamganj	Daulatpur
	Pratappur
	Milanpur
	Mukshedpur
River: Kangsha/Mogra	
Netrokona	Bandukhali
	Jaria
	Chandragona
	Nazirganj
River: Piyain	
Netrokona	Rangchapur
	Rautala
	Chakua
	Elongjuri
River: Abbua and Rakti	
Sunamganj	Behili-Alipur
	Nawagoan
	Mamudpur
	Joypur

District	Adjacent Village
River: Surma	
Sylhet	Laxmiprashad
	Digholi
	Muktigaon
	Bausha
Sunamganj	Dwarabazar
	Jamlabaz
	Jamakganj
River: Old Surma	
Sunamganj	Sujanagar
	Narsinghpur
Kishorganj	Katore
River: Dhanu/Baulai	
Sunamganj	Kalipur
	Dalakandi
Netrokona	Gaglajur
	Barantar
	Laipsa
	Nawtana
	Faridpur
	Jaganathpur
	Kaliajuri
Kishoreganj	Pashat
	Dhanpur
	Itna
	Elongjuri
	Boribari
	Simulbagh

Source: NERP



LEGEND

- International Boundary
- NERP Boundary
- Rivers/Khal
- ● District HQ.
- ★ Dolphin Area

Northeast Regional Project

Occurence of Fresh Water Dolphin (Sishu)

Prepared by:	BNP/Jalal	April 1993

XREF: NERP-075.Dwg
FILE: FISH-130.DWG

65

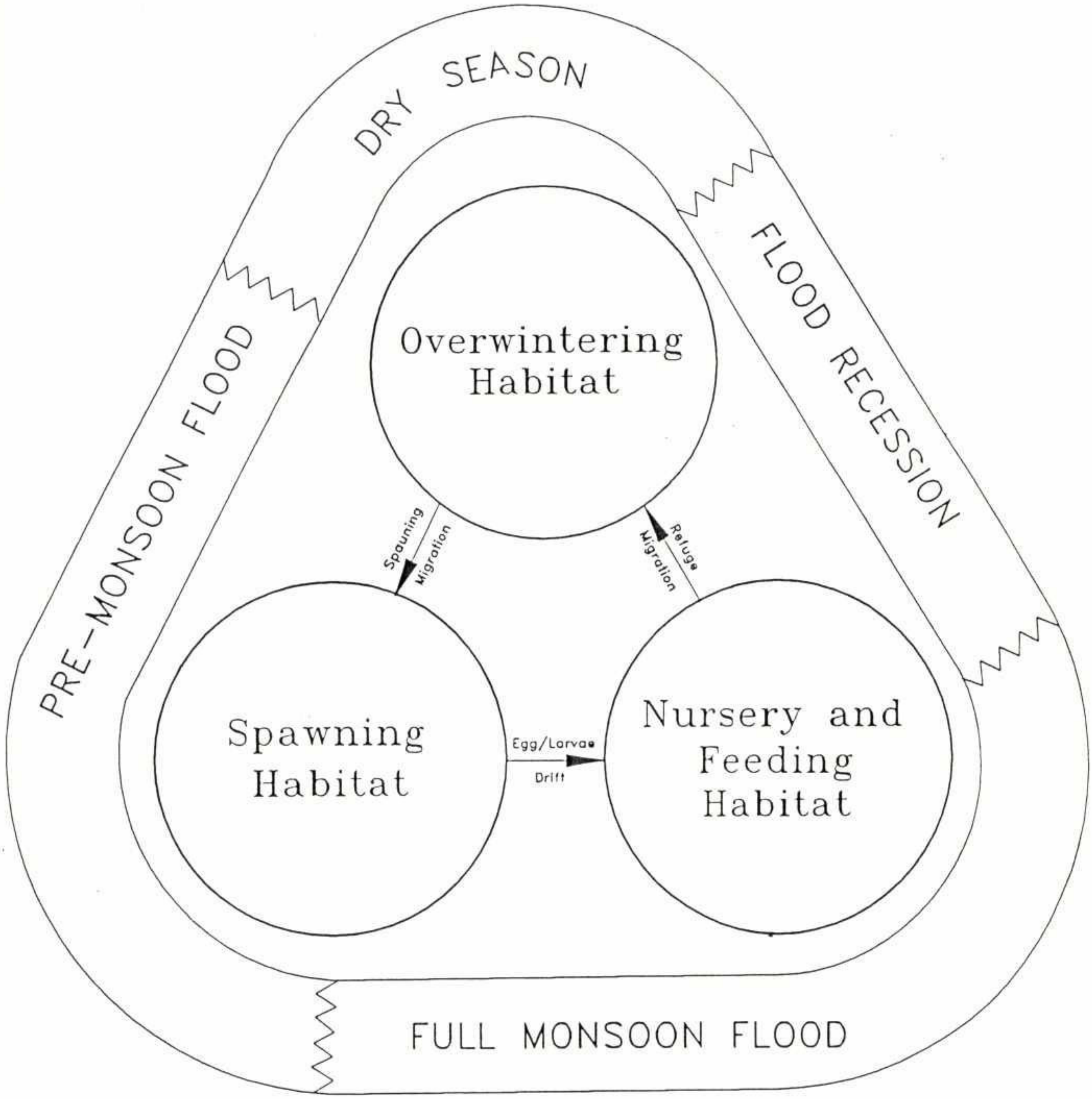
The "fish year" can be divided into four seasons:

The overwintering dry season (December to March): Broodstock and juveniles approaching recruitment size are concentrated in river duars and beels. No migratory movements take place at this time. These habitats (especially beels) are fished heavily during this season, and whatever fish survive enter the next season.

The spawning migration season (April to June): This season usually begins during the pre-monsoon flood phase of the hydrological year and can continue into the first part of the full monsoon flood phase. Fish generally move from deeper waters (such as duars) to shallower waters. Breeding takes place in shallower waters. Almost all fish species can be separated into two distinct groups:

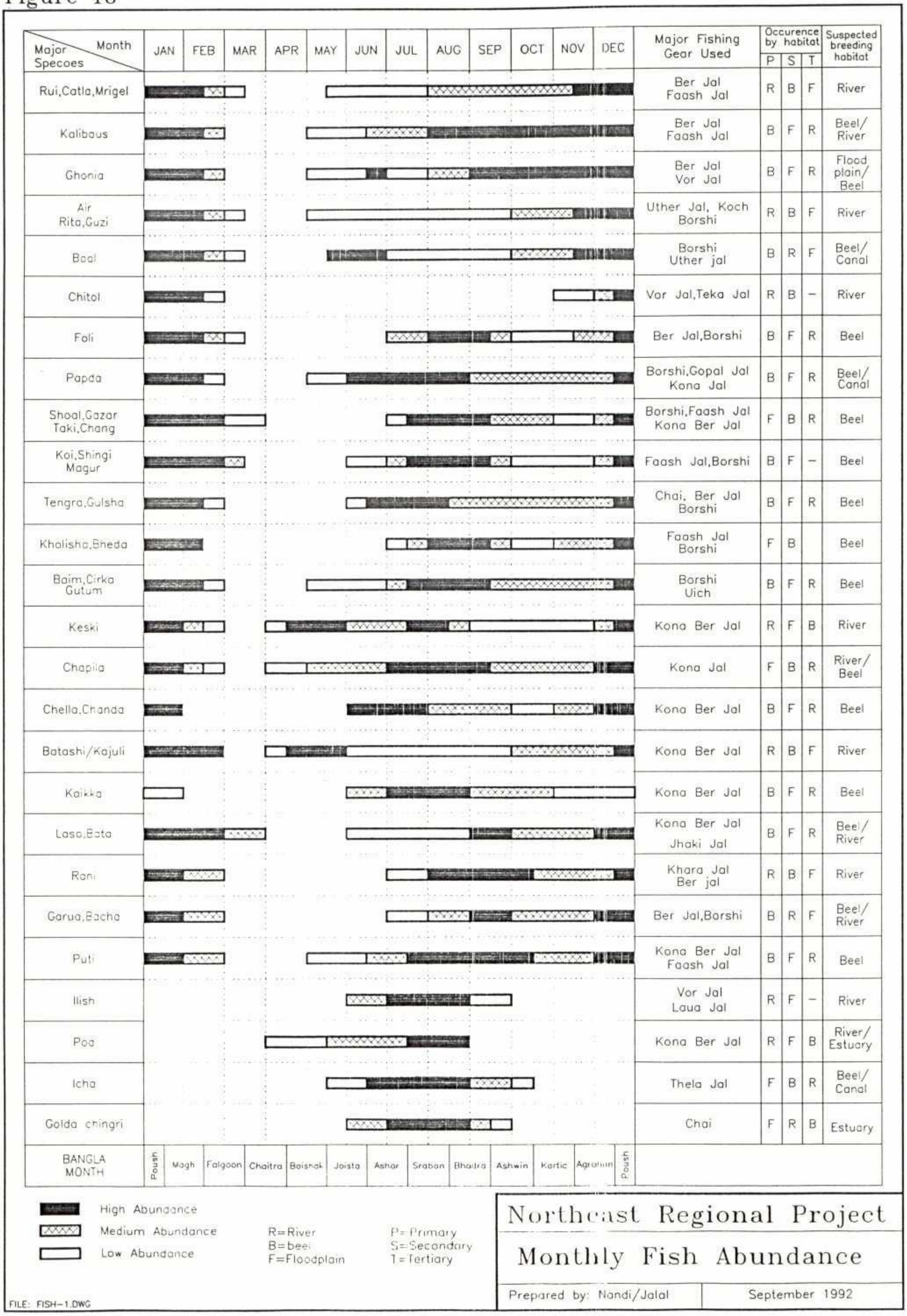
- Species which breed in the river: Among *Boromaach* this includes the major carp *Rui, Mrigel, Catla* and *Kalibaus*, the knifefish *Chital* and the large catfish *Baghair* and *Air* (see below for *Pangas* and *Ilish*). Among *Chotomaach* this group includes *Katchki, Batashi, Kajuli, Baim, Rani, Bailla*, and some others. Regardless of where these species have overwintered (and many of them are not very selective in this regard), all will attempt to migrate into river channels. Those individuals that overwintered in rivers are not inconvenienced. Those which overwintered in beels will have to swim out of the beel, down the khal (and this will be a countercurrent migration, because river water will already have begun to spill into the haor via the khals), and out into the river. Once in the river, it is assumed all species will swim upstream (countercurrent) until they reach spawn grounds which they find suitable for their requirements. The specifications of suitable spawning grounds varies from species to species. Major carp apparently prefer river bends. *Chital* prefer submerged structures such as trees and artificial structures such as submerged canoes. *Air, Guiza* and *Rita* make pits on the river bed as breeding "nests". The common requirement for all these species is that they need to be able to swim out from beels into the rivers (ie countercurrent). Bypass structures in FCD/I project embankments need to allow this to happen.

- Species which breed on the floodplain: The great majority of *Chotomaach* breed on the floodplain once inundation starts during the pre-monsoon floods. There is evidence that some *Chotomaach* species breed several times during the monsoon flood. Thus they migrate only a short distance laterally, from the beels (where they overwintered) out on to the floodplain. However there are also some *Boromaach* which breed on the floodplain, specifically *Boal* and *Ghonia*. Those individuals who overwintered in beels also only have to carry out a short lateral migration on to the flood plain. However *Boal* and *Ghonia* (and some *Chotomaach* species as well) which overwintered in rivers have to swim up the river (ie countercurrent), until they find a khal they can enter (ie then changing to swimming with the current) to get to a beel and up on to the now expanding floodplain. The requirement for these species is that they need to be able to swim from rivers into beels/floodplains. Bypass structures in FCD/I project embankments need to allow this to happen.



SEASONAL FISH MIGRATION PATTERNS ON FLOODPLAINS IN BANGLADESH

Figure 18


Month
Major Specoes
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Major Fishing Gear Used
Occurence by habitat
P S T
Suspected breeding habitat
Rui,Catla,Mrigel | Ber Jal Faash Jal | R B F | River
Kalibaus | Ber Jal Faash Jal | B F R | Beel/ River
Ghonia | Ber Jal Vor Jal | B F R | Flood plain/ Beel
Air Rita,Guzi | Uther Jal, Koch Borshi | R B F | River
Boal | Borshi Uther jal | B R F | Beel/ Canal
Chitol | Vor Jal,Teka Jal | R B – | River
Foli | Ber Jal,Borshi | B F R | Beel
Papda | Borshi,Gopal Jal Kona Jal | B F R | Beel/ Canal
Shoal,Gazar Taki,Chang | Borshi,Faash Jal Kona Ber Jal | F B R | Beel
Koi,Shingi Magur | Faash Jal,Borshi | B F – | Beel
Tengra,Gulsha | Chai, Ber Jal Borshi | B F R | Beel
Kholisha,Bheda | Faash Jal Borshi | F B | Beel
Baim,Cirka Gutum | Borshi Uich | B F R | Beel
Keski | Kona Ber Jal | R F B | River
Chapila | Kona Jal | F B R | River/ Beel
Chella,Chanda | Kona Ber Jal | B F R | Beel
Batashi/Kajuli | Kona Ber Jal | R B F | River
Kaikka | Kona Ber Jal | B F R | Beel
Laso,Bata | Kona Ber Jal Jhaki Jal | B F R | Beel/ River
Rani | Khara Jal Ber jal | R B F | River
Garua,Bacha | Ber Jal,Borshi | B R F | Beel/ River
Puti | Kona Ber Jal Faash Jal | B F R | Beel
Ilish | Vor Jal Laua Jal | R F – | River
Poa | Kona Ber Jal | R F B | River/ Estuary
Icha | Thela Jal | F B R | Beel/ Canal
Golda chingri | Chai | F R B | Estuary
BANGLA MONTH
Poush Magh Falgoon Chaitra Boishak Joista Ashar Srabon Bhadra Ashwin Kartic Agrahan Poush
High Abundance
Medium Abundance
Low Abundance
R=River
B=beel
F=Floodplain
P=Primary
S=Secondary
T=Tertiary
Northeast Regional Project
Monthly Fish Abundance
Prepared by: Nandi/Jalal
September 1992
FILE: FISH-1.DWG

The nursery/grazing season (June to September): This fish season corresponds to the hydrological height of the monsoon flood season. The fingerlings of those fish which bred on the floodplain are already on the nursery grounds so they do not have an access problem. But the fingerlings hatched from river breeding species need to get up on to the floodplain, and this can only happen in one of two ways: either they are passively swept on to the floodplain when the river overflows its banks (or overtops a submersible embankment) or are passively swept through a bypass structure such as a regulator when it is opened to effect controlled flooding of a haor. This is the season of rapid fish growth. Habitat hectarage increases enormously. In the region the dry season (river plus beel) water surface area is 1,467 sq km. During the height of the flood season this expands by a maximum factor of 15 to 21,710 sq km. Food availability probably increases by a similar factor. However fingerlings suffer a high mortality rate from piscivores, insects, snakes, frogs, otters, turtles, birds, disease, parasites and fishermen. Not withstanding this larvicide, the full flood season is still the best period for fast fish growth. Though fish movements may not be entirely random on the floodplain, there is little evidence of the mass migrations of the previous season. Schooling behaviour is more likely related to feeding tactics or a defence against predation.

The flood recession season (September to December): Flood waters start receding (ie draining). Drainage starts as sheet flow and eventually transitions to channelized flow by the end of this season. As water hectarage shrinks, fish move into deeper waters, navigating along khals and river channels, and with the currents which flow along these bottom topographies. The migrations are thus concurrent with the objective of leaving shallow water areas so as to avoid being stranded and killed by desiccation. A few species are able to aestivate (ie *koi*, Channa spp), but the majority migrate to deeper water during flood recession. A fish moving from the floodplain laterally to a deep beel does not encounter much of a problem. A fish moving from the floodplain out into a river will normally move along a khal. FCD/I embankment bypass structures need to allow this to happen. The flood recession/crowding season holds some fairly severe events for the fish stocks. Juvenile fish continue growing but their numbers decrease tremendously. This is because predation by piscivorous fish species such as *Boal*, *Air*, *Kaikka*, *Guizar*, as well as dolphins, now reaches a maximum. Most of the forage fish have not yet grown large enough to escape predation. There is a fairly direct correlation between predator and prey size. A prey species can escape the danger of being eaten by a particular predator once it grows large enough in size to pass outside of the prey size range limits of the predator. As flood water recession gradually changes from sheet flow to channelized flow, and water volume becomes reduced, the density of predators (both in terms of number per water area and number per water volume) increases and crowding together of prey results in extremely heavy predation. There occurs, therefore, a massive natural mortality of fish during this period, which is augmented by fishing mortality. The carrying capacity of the overwintering grounds is limited and sharply defined, and any "excess" ichthyomass will be eliminated.

The overwintering dry season (December to March): The annual cycle comes full circle. The floodplain has dried out and the only water left is in rivers and beels, where the entire fish population of the region is lodged. Prey species have generally grown large enough to avoid being eaten by predators. Juveniles mature into adults and gonads begin ripening in anticipation of the coming breeding season.

69

To summarize, for the majority of fish species in the region, the following principal fish migrations take place (in chronological order):

- Active breeding migration of broodstock from overwintering grounds to breeding grounds;
- Passive hatchling/fingerling migration from breeding grounds to nursery/grazing grounds;
- Active migration of juveniles and broodstock from breeding and/or grazing grounds to overwintering grounds.

There are three important species which differ from this pattern:

- *Pangas*: This large catfish spawns in major rivers during the early monsoon and the fry remain in the fast midstream of the river. They are washed down to brackish water coastal areas, where they mature. Eventually the adults swim up the major rivers (Padma/Ganges, Lower Meghna, Jamuna/Brahmaputra) to spawn over flooded chars. This is a long range migration of 1,000 - 2,000 km. The life cycle of *pangas* would appear to be restricted entirely to large rivers and the coastal estuarine environment. It would appear not to require access to floodplains during any part of its life cycle and thus does not have to be accommodated by embankment bypass structures.

- *Ilish*: This large herring constitutes about 1/3 of the total fish production of Bangladesh, so it is of strategic importance to the country's food supply. Juvenile Ilish grow to maturity in the sea, and adults ascend rivers to spawn twice each year: the major spawning runs are in June(early monsoon) and September (late monsoon). The fingerlings and juveniles (*jatka*) remain in the rivers and over the space of 4-5 months make their way downstream to the sea. Like *pangas*, the life cycle of *Ilish* appears to be restricted to the riverine habitat and completely detached from floodplains (although *jatka* do enter haors in small numbers occasionally). Thus *Ilish* does not have to be accommodated by embankment bypass structures.

- *Golda Chingri*: Adults of this large prawn inhabit mainly rivers. In the pre-monsoon season (February to April) there is a mass migration of adults downstream to estuarine and brackish water areas, where spawning takes place. The juveniles metamorphose into post larvae in brackish water and then begin a slow migration upstream into freshwater during the full monsoon (June to September). The juveniles disperse on to floodplains lateral to rivers to feed and grow. The adults return to the larger river channels. FCD/I embankment bypass structures have to allow juveniles on to the floodplains during the full monsoon and the adults back into the rivers during the flood recession period.

A special "problem" which has not yet been definitely resolved is the question of homing behaviour in *boromaach,* in particular major carp. One underlying assumption behind the use of the three year katha pile harvesting system (and a belief held by many fishermen) is that individual fish return to the same duar or beel (and the katha installed there) each year during flood recession to overwinter. Harvesting katha only once every three years allows the *boromaach* to grow to adult size and breed at least once before being caught. In the Kaliajuri mother fishery area, some fishermen maintain that if any fish escape from the net during harvesting, most of these same fish will return back to the same duar or beel after the breeding and feeding migration. The homing hypothesis was tested by the lessee of the Rangchapur fishery. He "marked" fish by cutting off one lobe of the tail fin and then returned the fish to the water. Three years later these marked fish were recaptured in the same place at the time of the pile fishing. Similar tail fin amputation marking and recapture results are reported by lessee and fishermen at Tangua Haor, which is also a mother fishery.

The implications of possible homing behaviour in *boromaach* for fishing practices and fisheries management are fairly profound. The problem can be formulated as two possible scenarios:

- If *boromaach* home back to the same duar or beel year after year, it becomes worthwhile for the katha owner to delay harvesting until the third year, because the price per kg of adult size *boromaach* is significantly higher than for juveniles of the same species (see comparative prices of major carp in Appendix G.1).

- On the other hand, if *boromaach* do not home back to the same katha, the incentive to delay harvesting is reduced, because any individual fish not caught in a particular year might overwinter in another beel or duar the following year and be harvested by some other *katha* owner or fisherman.

The second scenario might not be important if the overwintering migration of *boromaach* is completely random, as the stocks will distribute themselves more or less uniformly within the preferred overwintering habitat localities over the entire region. Under such conditions it is irrelevant if individual fish return to particular katha, because each katha will get a roughly constant proportion of the share of total *boromaach* stocks. However, any factors which upset the randomness of the overwintering migration could lead to selection of some overwintering locations, and avoidance of others. Such factors could include amongst others: a change in the drainage pattern across the region resulting from changes in sediment deposition in different parts of the floodplain from year to year, untimely pulsed releases of industrial effluent from the Chhatak Pulp Mill or the Fenchuganj Fertilizer Plant or blocking of khals for agricultural purposes.

The homing instinct (if it exists) might be strong enough to override any tendency towards selection due to shifting environmental factors. Thus a fisherman who elects to harvest his katha only once every three years would have a high confidence in realizing the higher benefits which such a restrained fish harvesting schedule would be expected to yield in comparison to harvesting on an annual basis. If the homing instinct does not exist, then there is less incentive to harvest triennially. The latter would still constitute a biologically sound resource management practice if all fishermen acted as a cartel and agreed to harvest only triennially so as to allow *boromaach* juveniles to mature and breed once before capture. However, such restraint is unlikely to be implementable or enforceable because the incentive to cheat is too great, and the number of cartel members too large. The cost of policing the cartel by a DOF fish warden squad would be prohibitive. Indeed, there is little evidence of a cartel mentality among pile operators in the region. A *boromaach* tagging program should be carried out to establish definitively whether or not homing exists. In the event of a positive result, homing should be incorporated into the regional fisheries management strategy.

A second fish migration problem that requires attention is the movement of *boromaach* stocks across the border into India. Such movements can be expected to take place in all three catchment areas of the region (Meghalaya, Barak River, Tripura). Fishermen of the Amalshid area maintain that *boromaach,* particularly carp, migrate towards the Barak River during the month of April-May and are caught by the Indian fishermen. It was also claimed that in the upper reach of the Barak (near the proposed Tipaimukh dam site), there is a spawning ground of carp. The movement of migrating broodstock up lateral tributaries of the Meghalaya and Tripura catchments is also important because some of the rivers are selected as spawning grounds due to their high water quality. Some of the boromaach stocks of the region should therefore be designated as internationally shared fish stocks which use Bangladesh waters as overwintering grounds and the Upper Barak (in India) and smaller tributaries (in Bangladesh and India) as breeding grounds. Bangladesh fishermen regard the broodstock of carp as a common property of both countries and suggest that a bilateral program is required to maintain and manage these stocks.

2.3.2 River duars and kaphs

The recession of flood water after the monsoon leads to a large reduction in water surface area during the winter dry season. Almost the entire fishery resource of the region becomes crowded and confined to two major habitats: rivers and beels. Because shallow beels and the upper reaches of rivers are prone to partial or complete desiccation, most fish (and broodstock in particular) seek out deepwater habitat locations to overwinter in. Only two such habitat location types exist in the region: *duars* in the larger rivers and the deeper permanent beels in the haors. The concentration of commercially valuable fish in a limited and circumscribed number of locations during the winter is well known to fishermen and has given rise to the existing pattern of intensive dry season fish harvesting. In particular, the *katha* harvesting method is a technical response to the overwintering crowding of fish. The extremely high vulnerability of broodstock to fishing mortality during overwintering means that the winter season is a critical period during the annual fish life cycle and that the river *duars* and deeper beels are critical fish habitats. Protection of overwintering broodstock and regulation of harvesting in overwintering refuge localities must figure as central elements in a regional fisheries management strategy. Accordingly, much attention was given to overwintering habitats by the NERP fisheries team, and a considerable amount of field data was collected.

Field studies indicate that *duars* are more important than deeper beels for survival of the region's broodstock during the winter. Except for the northernmost part of the Sylhet Depression (Tangua Haor area), most beels in the region are affected by siltation, resulting in a general region-wide decrease in the maximum depth of beels, and in some cases in a change from permanent to seasonal status. The widespread practice of extracting beel water in mid-winter to irrigate *boro* crops further reduces beel water volumes. Complete de-watering of beels is now routinely carried out in many areas in order to obtain total fish harvests, thus producing the greatest possible short term return to *jalmohal* leaseholders. Increasing the frequency of *katha* harvesting from triennially to annually has put further pressure on fish stocks overwintering in beels. The combination of sedimentation, boro irrigation, de-watering and annual *katha* harvesting has resulted in the virtual elimination of beels as secure overwintering refuge habitat for broodstock in most of the region. River *duars* are thus by default the only important overwintering refuge habitat in the region for broodstock. The sustainability of fish production in the region is thus almost entirely dependant on the degree to which natural and fishing mortality act on broodstock overwintering in the region's *duars*. While they are not invulnerable to certain threats, most *duars* are fairly stable morphological structures, and are more difficult to fish out due to high current velocities and turbulence and great depth.

To quantify the magnitude of the *duar* habitat, an echo sounding survey of *duars* was carried out in mid-December 1992 in the Kushiyara, Surma, Sari, Ghorautra and Upper Meghna. The main objectives were to identify the location of *duars*, determine their maximum depth and to identify the main fish species present. A Lowrance X-16 echo sounder was used and depths were recorded on a strip chart recorder. *Duars* were marked on 1:50,000 topographical maps after the discussion with the local fishermen. Some 325 *duars* were identified (Appendix C). *Duar* depths during the dry season vary between 4 m in the Brahmoni and 35 m in the Upper Meghna. Duars in the Kaliajuri area are the deepest in the region. An important result of the survey was discovery of an apparent relationship between bend curvature and *duar* depth. Maximum *duar* depth occurs where the bank is comparatively stable (probably due to presence of hard soil/clay soil) and the river channel abruptly curves. *Duars* also tend to form at river confluences or bifurcations. Individual river reaches are discussed below.

Duars in the Kushiyara River (Sherpur ghat to Roail, Markuli): From Sherpur to Roail bazar 20 *duars* were identified.The depth of the *duars* ranges from 14 m to 32 m. The deepest *duars* on this part of the Kushiyara are near Digholbag village and an artificial *duar* at Brahmangaon (see Section 5.2.7), both 32 m deep. Most of the *duars* were found either at the middle point of bends or 100-150 m downstream. In most bends, bank erosion was found where the radius of curvature decreases. In most of the places a substantial amount of clay was seen at the bends, and this might be a factor in the formation of deep *duars*. Moreover due to curvature of the river, the velocity of water current suddenly rises, which results in a *duar* at that point. Instead of installing *katha* at the deepest point, fishermen generally put *katha* around the periphery of *duars* at comparatively shallower places. Most of the *duars* act as refuges of the following fish: *Ghagot, Air, Boal, Rui, Catla, Mrigel, Chital* and *Bagair*. In some *duars*, dolphins are also seen. A few days before the survey, a large *Bagair* (weight 120 kg) was caught by the fishermen from the Digholbag *duar* of the Kushiyara and sold in Moulvibazar market (*Shafali arat*) for Tk 12,000. Gear used to catch *duar* fish are *Uther jal, Borshi* and *Ber jal*. Fishermen claimed that in the past some of the *duars* were maintained as pile fisheries which resulted in sustainable yields throughout the year. At present, annual fishing of the duars is widely practiced and has resulted in serious depletion of broodfish stock in the area. In addition, chemical effluent from the Fenchuganj fertilizer factory affects fish in the Kushiyara.

Duars in the Kushiyara River (Sherpur ghat to Balaganj): From Sherpur to Balaganj, eleven *duars* were identified. The depth of these range from 11-21 m, of which the deepest was chokrir *duar* found near Abdullapur village. Fishermen of the Monumuk area stated that siltation in the deepest point of the *duars* is negligible. As stated above, *duars* are located either at the bend or a few hundred meters downstream of the bends.

Duars in the Sari River (No man's land to Sari ghat): The Sari River has been declared a fish sanctuary by the DOF. From the border up to the Sari ghat four *duars* were identified. Due to the absence of navigable routes in some parts of the river, no soundings were done. Local fishermen stated that the *duar* range in depth from 13 - 31 m. The deepest *duar* is located near the border and is called *Telanjir duar*. It was reported that *Jalmara duar* near Lala khal Tea garden is the most important fish overwintering locality in the Sari River. The main fish species in duars are *boal, ghagot, kalibaus, ghonia, rui, catla, bagair, ghora, chital, mohashal, bacha and chela*. During the field visit duar water was found transparent to greenish in colour. Stones and rocks are covered with periphyton. The *duars* are apparently more or less structurally stable.

73

Over the last two years mass mortality of fish has been occurring in the *duars* during the first flood *(goola)*. Fishermen are of the opinion that effluent from a coal mine in India is being released into the river an is causing the mass fish mortality.

Duars in the Goyain River (Sari ghat to the Surma River confluence, Perkul village): Duars were identified through interviews with local fishermen. From Sari ghat to the Perkul village, 26 *duars* were identified in the Goyain River (Chenguar khal). Based on the information provided by the fishermen and lessee, these ranged in depth from 7 - 15 m. The main species of the Goyain duars are *boal, ghagot, kalibaus, bacha* and *pabda*. Fishermen of the area mentioned that the Chenguar khal *duars* are much more important than the Surma *duars* since the Chenguar khal flows through an area where a number of haors and beels are located (Rouchunni beel, Shilchand beel, Langura haor and Zilkar haor are the most important). These beels and floodplain are the main source of fish in that area.

Duars in the Surma River (Sylhet to Sunamganj): From Sylhet to Sunamganj 20 *duars* were identified and from Pirpur to Dwarabazar 12 duars were measured by echo sounding. The depths of the measured *duars* range from 9 m to 26 m. The deepest *duar* on that part of the river was found near Dwarabazar (26 m). Most of the deeper *duars* are located after the confluence of the Surma and Old Piyain. In contrast to the Kushiyara, the Surma banks are composed of a sandier soil and the Surma channel is straighter than the Kushiyara. In some areas *duars* are found near distributaries to the haors. In the Surma *duars*, the main fish species are *chital, air, boal, ghagot, kalibaus, rui, catla (few), bacha, chapila* and *chela*. *Mohajal, Uthar jal, Jaam jal* and *Borshi* are used to catch duar fish. Local people demanded that the *Jaam jal* be outlawed for *duar* harvesting, since the *jaam jal* catches almost all broodstock.

Upper Meghna River (Paniswar to Echodia, Astagram): From Paniswar to Echordia (Astagram) eight *duars* were identified and measured by echo sounding. The depth of *duars* ranges between 15 m to 35 m and the deepest duar on that part of the Upper Meghna was found between Mendipur and Rajapur village (35 m). Mendipurar *duar* is located at the confluence point of the Kali *nadi* and the Upper Meghna. Like other rivers, Upper Meghna *duars* are also located at the middle of the river near bends. In all cases siltation occurred at the opposite side of the bends. As in other rivers, katha are not installed at the deepest part of the duars. Usually kathas (*Jaak*) are installed at the shallower part around the *duars* during the month of November or December and harvesting started at the end of January. Around each *duar*, several *katha* are usually installed and each *katha* is encircled by hundreds of bamboo. During fishing operations, shallower *kathas* are harvested first. These yield mainly *icha, golda chingri, bacha, rui, catla* and *chapila*. After that the deeper *kathas* are harvested and these yield *air, chital, rui, catla, pangas, boal, golda chingri* and *bacha*. After encircling the *katha* by a *dal jal (ber jal)*, the branches are removed and harvesting is done using a *goyra jal*. Out of the eight *duars,* mendipurar duar is the most productive, yielding large fish including Pangas. Fishermen of the Mendipurar *Duar* is the most productive, yielding large fish including *Pangas*. Fishermen of the area also mentioned that it is the deepest *duar* in the Upper Meghna (and in region) and should be designated a fish sanctuary.

Duars in the Kali river (Kuliarchar to Manikdi): Two *duars*, about 16 m in depth, were identified in the Kali River near Kuliarchar. The Kuniamuk *duar* has been declared a fish sanctuary by the DOF. The main fish in that *duar* are *air, boal, chital (rare), rui, kalibaus, chapila* and *gulsha*.

Duars in the Ghorautra River (Kuliarchar to Itna): *Duars* were identified by interviews with fishermen. The Ghorautra River has six *duars* from Kuliarchar to Itna bazar and according to local fishermen, they range in depth from 15-25 m.

Other site specific information collected about *duars* in the region is as follows:

- **Itnar** ***duar*** is an artificial duar created after the excavation of a new straight river channel and may be the spawning ground for many fish. Due to a conflict between GOB and a powerful local individual (Mr. Dewan Shaheb) most of fishery is likely to be destroyed. GOB has ordered that fishing be stopped but this individual takes no notice.

- **Dhumkhalar** ***duar*** (Zilkar Haor Project) is located in front of the Dhumkhal regulator outside the project in the main channel (Sarigowian River). The total area is between 30 and 40 ha and it retains water throughout the year (in March and April the water depth is between 20 and 30 m). The major species of the duar are *rui, mrigel, catla, kalibaus, bacha, air, chitol, boal, garua, chapila, laso, pabda, batashi* and *kajul*i. Local people state that the duar is used by the fish as an overwintering ground and, before the Zilkar project was constructed, the Haparu and Zilkar haor were used as breeding grounds. In the past, water flowed from the Surma via Haparu and Zilkar haor to the Chenguar khal. Local people caught large fish during the early flood period (late March through late May).

- **Bordair duar** is located near Ajmiriganj at the confluence of the Bheramona and the Barodair Rivers. The duar is well known for larger sized catfish (particularly *Air*), *Chitol* and *Guzi*. A number of dolphins live in the duar and an abundance of dolphins is one of the indicators of deeper places in a river and fish migratory routes within the river channel. During the dry period (March and April), the duar is said to retain water to a depth of 10-13 m. This well known duar is now rapidly silting up.

- **Kaliajuri area**: There are several *duars* within the *jalmohals* and some of these *duars* are quite deep (the deepest are about 20-22 m during the dry season). Fishermen state that most of the *jalmohals* produce larger fish. During the 1992 fishing season they caught fish in the following weight ranges:

  - *Catla*, 10-15 kg,
  - *Rui*, 8-10 kg,
  - *Mrigel*, 3-5 kg,
  - *Boal* and *Air*, 10-12 kg,
  - *Chital*, 12-16 kg,
  - *Kalibaus*, 4-7 kg.

Obviously, these *jalmohals* are important overwintering grounds for carp, catfish and knifefish brood stock. Catch composition by weight is about 50% large catfish, 30% major carp and 20% other fish. They also mentioned that *Chitol, Air, Ghagot, Boal, Ghonia, Kalibaus, Pabda, Batashi, Gharua, Laso, Baim* and most other smaller species of fish breed in this area during the months of March and April. The breeding behaviour of *Boal, Ghonia, Pabda* and *Puti* are more or less the same (that is the formation of schools, followed by congregation and spawning around the *kanda* where low velocity water currents have recently inundated grassy areas). But *Air, Guzi, Chitol* and *Kalibaus* prefer to breed in and around the *katha*. The fishermen could not confirm the breeding of other major carp in the area, but a large number of carp fry are always seen and caught by the local fishermen during the months of May and June. They call this area a "mother fishery" where many large fish take shelter during the months of September and October up to the spawning migration (March-May). Because of its greater water depth, low rate of siltation and abundant fish food, the area should be designated a fish sanctuary.

- **Fenchuganj area**: There are a number of *duars* located in the Kushiyara near Fenchuganj which are the overwintering grounds of larger size fish (mainly *Boal, Ghagot, Chitol, Catla* and *Rui*) as well as *chotomaach*. Fishermen claimed that fish production has been reduced by 70-80% following construction of the fertilizer factory.

- **Govir Dighir *duar*** (also known as *Tin Ganga*) is a well known *duar* at Amalshid where the Barak River bifurcates into the Surma and Kushiyara Rivers. It is 100 m long and has a maximum depth of 13 m in the Surma part. Both *boromaach* and *chotomaach* occur in the *duar*. Among the *boromaach, Kalibaus* and *Boal* are most common. *Rui, Mrigel, Catla, Air, Bagair, Chital* and *Pangas* are also found in that area. Among the *chotomaach, Tengra, Pabda, Baashpata, Rita, Puti, Chapila, Laso, Baim, Cirka, Rani, Jatka, Bailla, Chanda, Poa, Kaikka* are widely found in that area. *Shoal, Gazar, Taki, Singi, Magur, Koi, Mola, Gutum, Bheda, Fali*, and *Shilon* are also present.

- **Luba River *duars***: The Luba River, a tributary of the Surma River, has been declared a fish sanctuary by the DOF. There are five important *duars* within the river, of which Barar *duar* and Mainrir *duar* are very important. These *duars* are 30-35 m deep during the rainy season and apparently stable structurally. These *duars* act as refuges for *boromaach* broodstock *(Rui, Kalibaus, Catla, Boal, Bagair, Mrigel, Mohashol, Chital, Ghora, Nowraj, Pakhiranga)*. Some *chotomaach* also use the duars *(Bacha, Tengra, Puti, Baim, Chapila, Pabda, Shoal, Gazar)*. Because of ongoing road construction on the Indian side of the border, dynamite/explosive is easily available in the area and some miscreants throw dynamite into these duars to kill broodstock. This happens on a regular basis. Hook and line fishing (*Shish Borshi/Matuk Borshi*) is most commonly used to catch *Catla, Rui, Mrigel, Air, Boal, Ghagot* and *Kalibaus*. On the other hand, *Jam jal* are used to catch broodstock. *Jam jal* is a rectangular net (100 m x 100 m in size, 8-10 cm mesh) which is only used to harvest *duars*. It is put over the *duar* by using four ropes and is heavily weighted (stones). It was claimed that *jam jal* is another cause for the rapid decline of broodstock in the area and it was also stated that the use of the *jam jal* should be prohibited.

- **Chenguar khal**: A number of *duars* exist in the Chenguar khal near Shalutikar, Sylhet. It is claimed that the Chenguar khal *duars* are more important than the Surma duars because they are directly connected with the Sari and its adjoining hills, water is less silty and fish (carp) have easy access to their breeding grounds. During the field survey, it was found that the Chenguar khal flows through an area where haors and beels are located nearby and everywhere there are interconnecting channels. Also, some of the haor and beel areas are still covered with natural vegetation and serve as a good spawning habitat for many fish species. Such high quality fish habitats are present near Shalutikar, Hatirkuri beel, Gowlia beel, Zilkar haor, Silchand beel, Nijel chanda beel, Lengura haor, Satkuri beel and Rouchunna beel. In the Chenguar khal duars large catfish and other *chotomaach* species are the dominant fish.

- **Bishnai and Mogra River** *duars: Duars* are called *duba* in this area. The *duars* act as refuges for larger catfish, *Chital* and other smaller species. It is stated that most of the *duars* have remained stable for the last 20 years. Kalibarir duba near Manisha village has been maintained for a long time as a fish sanctuary by local fishermen. It is connected with the floodplain of the Sirail beel and Chapri beel. The duba acts as a refuge for *Air, Ghagot, Boal, Chital, Rui, Catla (rare), Mrigel (rare), Garua, Pabda, Bacha, Laso, Chapila* and *Chela*. The dry season depth and area are estimated by the fishermen to be 10 m and 0.8 ha respectively. Fishermen of the nearby village have mentioned that they keep the duba as a sanctuary in the traditional belief that in this way the Goddess Kali will help to preserve their resource and means of sustenance. They strongly believe that if they conserve the broodfish then fish will be abundant in the openwater and they will never be unemployed in the fishery profession. To protect the duar, they sometimes fight against miscreants.

Kaphs are another river morphology structure of importance to fisheries. These are scour pockets in the river channels, usually situated in its lower part. Some species (ie Nanid) are known to use kaphs are refuges.

2.3.3 Spawning patterns and locations

Except for major carp, *Pangas* and *Ilish*, most fish species breed more or less everywhere in region. The species can be separated into two groups based on their preferred breeding habitat:

- Floodplain and beel breeders: *Boal, Ghonia, Sarputi, Shingi, Magur, Koi, Bheda, Puti, Icha, Chanda, Mola, Ghonia, Boal, Sarputi, Gulsha, Tengra, Laso, Kholisha, Along.*

- River breeders: *Chital, Ghagot, Kalibaus, Catla, Rui, Mrigel, Chital, Air, Rani, Pabda, Pangas, Basa, Ghagot, Garua, Shilon, Baspata, Kajuli.*

Floodplain and Beel Breeders: Breeding begins during the premonsoon flood. Depending on the rain and water volume in the river and floodplain, most of the catfish, live fish and other species (*Magur, Singhi, Koi, Tengra, Pabda, Air, Boal, Gazar, Shoal*) start breeding at the end of March and early April. Piscivorous species (*Boal, Shoal, Gazar*) breed earlier than the non-piscivorous species. The optimal meteorological conditions for fish breeding are tempestuous. Flash floods, heavy continuous rain and thunder together stimulate fish breeding, particularly for *Boal, Ghonia, Pabda, Koi, Batashi, Puti* and *Laso*. When the first pre-monsoon flood water *(goola)* enters into the beels, fish begin moving against the current to search for suitable spawning habitat. *Ghonia, Boal, Foli, Pabda, Shoal, Gazar, Lati, Cheng, Koi* and *Laso* prefer to breed on newly inundated grassy areas on kanda where the current is slow, water depth is low (about 0.5 m) and bush/reeds (*Chailla bon, Nol Khagra, Bon tulshi, Parua, Binna bon, Hugol bon*) are present. These species are called *Jangal* breeders. *Boal, Pabda* and *Ghonia* also breed in the canals connected with beels. During the spawning period, the following species form groups or schools which are called *Jaak dhora: Boal, Ghonia, Kangla, Laso, Koi, Puti, Shingi, Magur, Tengra, Cirka, Batashi, Kholisha, Bheda, Pabda*. The migration of a typical *jaak* toward a spawning place is called *Uijja*. At the time of mating, fish behave incautiously and can even be caught by hand. No aggressive behaviour is exhibited. The mating pair bend against each other when expelling eggs and milt. Normally the schools are segregated by species. Usually the schools move at night during the new or full moon phase. Except for the snakeheads, most species do not have parental care of their offspring.

River breeders: Reproductive patterns are more diverse among river breeders. *Air, Rita, Ghagot* and *Guizza* make pits in the shallower part of the river in April and May. They are also known to breed around katha. Each pit is about 1 m in diameter and 0.6 m in height. They choose an area with clay soil and excavate the pits with their mouths. A single female uses one pit, but one male can service 3-5 females. Local fishermen know their behaviour and brood fish are caught by the anglers with bait. They exhibit parental care. *Chital* and *Foli* prefer to breed in shallower parts of the river over hard structures such as stones, bamboo or submerged tree branches. A sunken boat under a katha is an excellent artificial breeding site. Eggs are sprayed over the structures and adults carry out brood care. The breeding period of *Chital* and *Foli* is May and June. A number of *chotomaach* breed in rivers, including *Batashi, Bashpata, Chela, Kachki, Bailla* and *Baim*. Shallow areas are selected and breeding takes place in April. *Rani* prefers to breed in the rivers particularly in any quiet undisturbed shallower place where water current is weak and the river bed consists of course sand. They shelter in the holes of bamboo *(chong)* during the breeding period. The occurrence of substantial jatka schools in the Upper Meghna, Baulai and Kushiyara suggests that *Ilish* probably spawn in the region. Spawning probably takes place in the rivers during the premonsoon (March) and monsoon (August) floods. Spawning sites in the region have not yet been identified.

Major carp are thought to spawn mainly in rivers. The breeding period of most species is in early April to June and depends upon rainfall. From June to September, large numbers of fry and fingerlings are present in the beel areas (5-13 cm size). *Kalibaus* is more abundant than *Rui* and *Catla*, while *Mrigel* is becoming rare. The following areas are suspected to contain important carp breeding areas:

- Tangua haor,
- Pasuar haor,
- Laudi and Bawa beels of Companiganj area,
- Erali beel,
- Hakaluki Haor.

Fishermen of the region record that carp spawn occurs in the following areas:

- Kawnai River near Daulatpur and Milanpur (Dharmapasha thana),
- Boroiya River near Shanbarir bazar (Dharmapasha thana),
- Boulai River near Mukshedpur (Dharmapasha thana),
- Alamduarer baak in Tanguar haor,
- Surma River near Sunamganj town,
- Dhanu River near Ranichapur and Dhalimati (Kaliajuri area),
- Kalni River near Markuli (Derai thana),
- Khoiltajuri River near Dighirpar (Companiganj area).

Some site-specific information on major carp spawning localities is presented below:

Surma River Basin: A number of collections of carp spawn have been made from the Surma River:

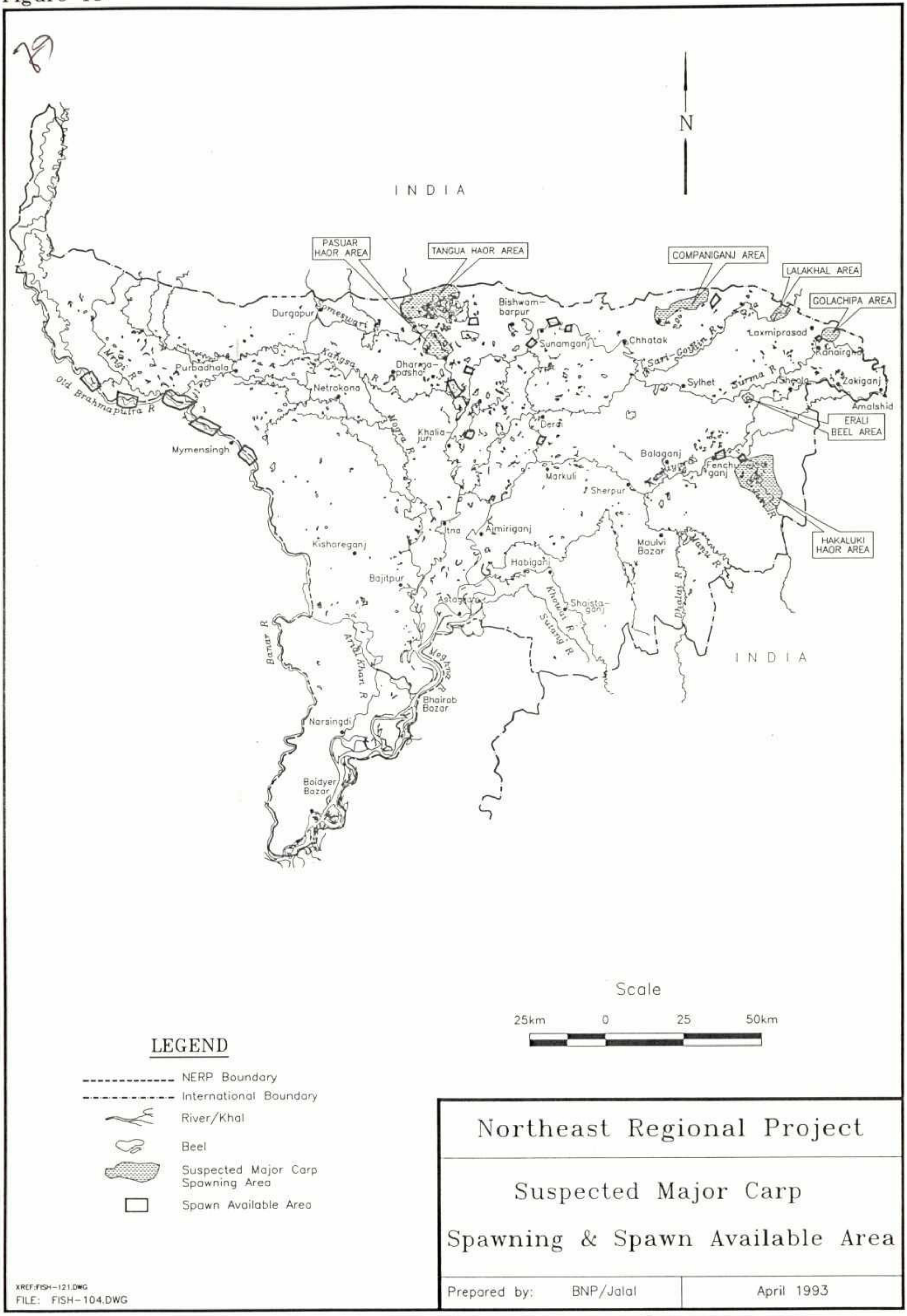
- In 1983 a small quantity of carp spawn was collected at Dohali area in the Surma (1st part);
- In 1983 a small quantity of spawn was collected near the Bangladesh Rifles ghat in Sunamganj town;
- 125 gm of carp fry (10-15 days old) have been collected during the period June, 1986, at Mallikpur ferry ghat, Sunamganj. They were collected by *savarjal* fixed against the current. At that time, water was highly turbid.
- In 1989 a small quantity of spawn was collected at Pandarkhal dyke near Dawarabazar (river section 79x2), in the Surma;

Fishermen say *Rui* and *Catla* spawn in the Surma River near Kanaighat. Females with eggs are caught, but spawn in not seen drifting in the river.

Elsewhere in the basin, there are reports from:

- Luba River: It was reported that *Rui, Mrigel, Kalibaus* and *Ghonia* are common in the Luba (a tributary of the Surma) and people suspect they bred in the river. Large numbers of fry are found in the river and surrounding beels during the monsoon period.
- Tangua Haor: In general, spawning migration starts during the premonsoon flood phase (usually during the month of April-May) and continues into the first part of the full monsoon flood phase (May-June). Breeding takes place in shallower waters. *Kalibaus, Catla, Rui* and *Mrigel* breed in the rivers, while *Ghonia* and *Laso* breed on the floodplain. There may be some carp spawning grounds in the area, particularly in the border rivers.
- Dekker Haor might have some breeding grounds of *Kalibaus* (also *Ghonia* and catfish) as large number of fry are always seen in early May each year.

Figure 19


79
N
INDIA
PASUAR HAOR AREA
TANGUA HAOR AREA
COMPANIGANJ AREA
LALAKHAL AREA
GOLACHIPA AREA
ERALI BEEL AREA
HAKALUKI HAOR AREA
Durgapur
Bishwambarpur
Sunamganj
Chhatak
Laxmiprasad
Kanairghat
Zakiganj
Amalshid
Sylhet
Surma R
Sari-Goyain R
Purbadhala
Netrokona
Dharmapasha
Kangsa R
Mogra R
Khaliajuri
Derai
Old Brahmaputra R
Mymensingh
Balaganj
Fenchuganj
Markuli
Sherpur
Itna
Ajmiriganj
Kishoreganj
Moulvi Bazar
Habiganj
Bajitpur
Astagram
Shaistaganj
Khowai R
Sutang R
Dhalai R
Banar R
Arial Khan R
Meghna R
Bhairab Bazar
Narsingdi
Baidyer Bazar
INDIA
Scale
25km 0 25 50km
LEGEND
NERP Boundary
International Boundary
River/Khal
Beel
Suspected Major Carp Spawning Area
Spawn Available Area
Northeast Regional Project
Suspected Major Carp Spawning & Spawn Available Area
Prepared by: BNP/Jalal
April 1993
XREF:FISH-121.DWG
FILE: FISH-104.DWG

Kushiyara River Basin: A number of locations are important:

- Erali Beel: People in the area suspect that there may be some carp breeding grounds within the beel. Large numbers of carp fry were seen during the month of May in 1992. Course sand and rocks are present at the bottom of some areas and due to special topographical features (i.e bends, gradual slopes, presence of shallow and deeper areas and creation of temporary currents during the period of heavy rain fall and river flooding), the Erali beel is suspected to be a carp breeding locality.

- Hakaluki Haor: No studies have been conducted regarding carp breeding in the area, but local people suspect that there might be some carp breeding grounds near Islampur village where the Juri enters into the Kushiyara. In 1992, large numbers of carp fry were caught in some areas of the Hakaluki haor. Fishermen had observed the zigzag movement and jumping behaviour of carp broodstock during the new/full moon time in April/May when new goola water entered the area. A number of canals (Continala and Juri are the most important) flow from the adjacent hills to the Kushiyara River through the Hakaluki haor. Small hills are present near the confluence of the Juri-Kushiyara River near Gilachara bazar. Parts of the river beds are covered by stones, gravels and course sand. There is continuous discharge from the inflowing canals and sometimes there is backflow of water from the Kushiyara. The presence of a unique topographical situation, existence of pile in the perennial beels and continuous discharge probably create conditions favourable for carp breeding.

- Major carp are reported to spawn in the Kushiyara near Fenchuganj.

- Amorkona is a fishing village near Sherpur bridge. The villagers have tenure of the Beribeel under NFMP. The source of water of Beribeel is the Kushiyara. No spawning grounds are known to fishermen in the beel, but during March-June a large number of big carp, *Chital* and *Boal* have been caught full of eggs, mainly from shallow bends in the river. Chengua and Sadipur may be the spawning grounds.

- Sherpur on the Kushiyara River: On 25 April 1992, 15-20 large *Catla, Rui, Boal*, and *Chital* were examined at the fish market. Observations are presented in Table 2.8.

  Fishermen reported that they caught the fish 2-3 hours earlier from the Kushiyara slightly upstream of Sherpurghat. It is suspected that there may be breeding ground(s) in the Kushiyara. Large ox-bow bends are present in this stretch. In late April 1992, numerous large *Rui* (weighing about 10 kg) full with eggs or milt were caught. Fishermen reported that the fish were migrating upstream. Adult *rui* and *catla* (females with eggs) are present in the Kushiyara near Sherpur during the rainy season according to local fishermen. They are said to spawn in the river. Other fishermen say they spawn mainly in beels. *kalibaus* are said to breed mainly in beels, and then move into the river.

81

Table 2.8: Observations of Fish at Sherpur

Species	Sex	Number	Individual Weight (kg)	Condition
Catla	female	2	20	Full of eggs
Rui	male	1	8	Dense milt expelled by pressing abdomen
Rui	female	2	25	Full of eggs
Boal	female	6	10-12	Full of eggs
Chital	unknown	5	6-10	Unknown

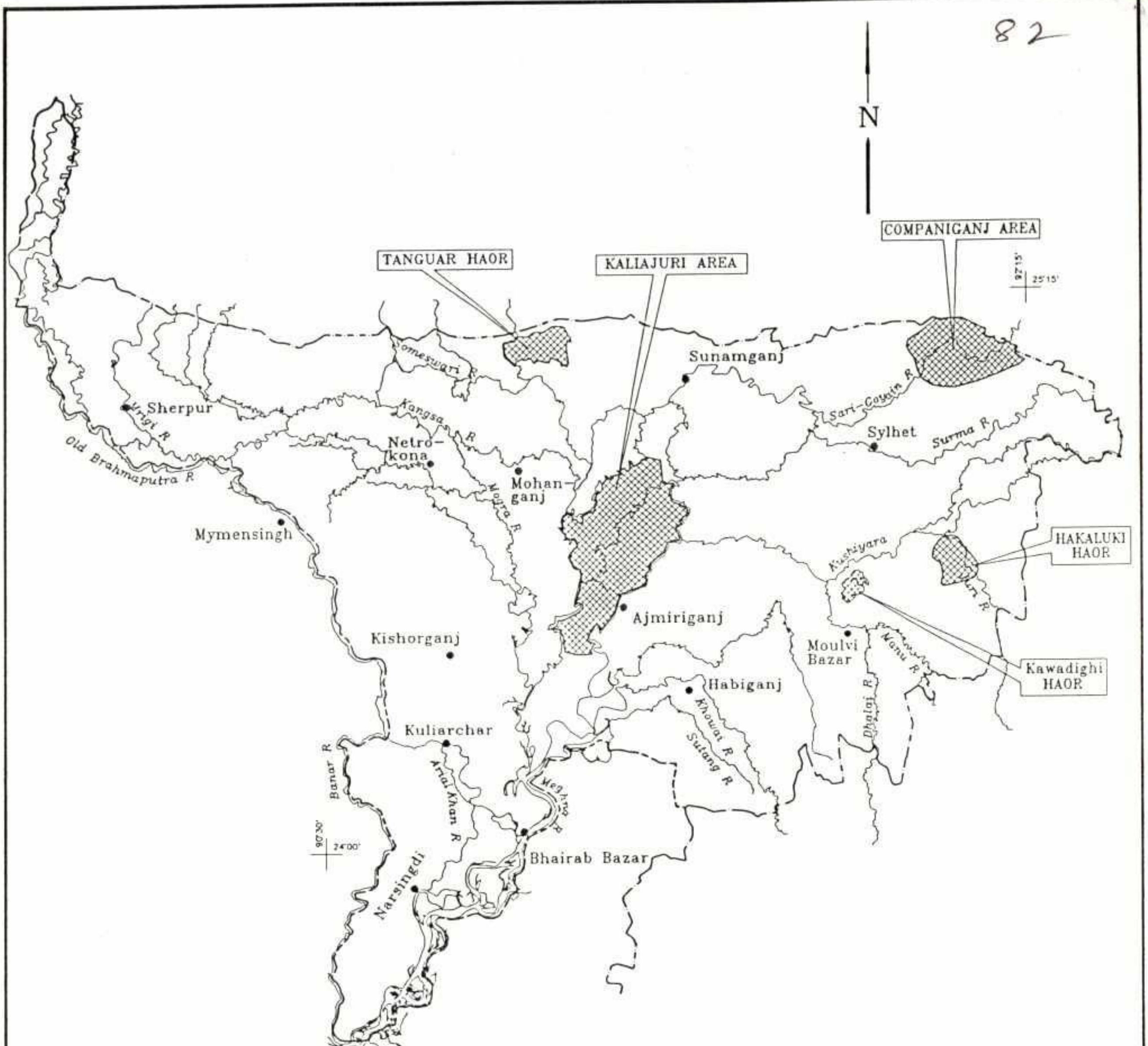
Source: NERP

- In Habiganj District, carp eggs (species unknown) have been found in the Kushiyara. According to the Habiganj DFO major carp spawn from February to May. The spawning season has been gradually advancing in the calendar year. Previously spawning used to begin only around mid April and extend to the end of May. Carp are thought to also spawn in haor areas.

Baulai River Basin: In the Piyain River, *Ghonia* and *Kalibaus* spawn are said to be found. A large quantity of egg/spawn was observed near Bilajare village in 1991. In the Sainna beel (Itna area), *Kalibaus* (as well as *Ghonia, Boal, Air, Pabda, Tengra, Foli Magur, Singhi, Koi, Puti* and other economically important species) breed during April and early May. In the Kaliajuri area, fishermen state that *Kalibaus, Ghonia*, and *Lasu* (as well *as Chitol, Air, Ghagot, Boal, Pabda, Batashi, Gharua, Baim*, and many small fish species) breed during the months of March and April. The fishermen could not confirm the breeding of other major carp in the area, but large numbers of carp fry are always seen and caught by the local fishermen during the months of May and June.

Old Brahmaputra River Basin: Well known carp spawn collection sites occur between Jamalpur and Mymensingh. At Kewatkhali fishermen village, carp spawn are collected with a special type of net called *savarjal*. Normally 10 individual nets are installed in one area and constitute one unit. Units are placed near the shallower part of the river and face into the current (one foot below the surface). Depending upon spawn abundance the "collection chambers" are cleaned every 5-10 minutes. The maximum spawn are collected 3-4 days after the new moon or full moon period. Last year the first spawn was collected in the period May 29-June 2. The first phase of spawn collection occurs in May and is called *sheet*. At this time major carps are dominant, thus the selling price is also high (3-5000 Tk/kg). The second phase is called *galan and* usually lasts for 5-10 days near the end of June when minor carp and catfishes are dominant. No single spawning grounds of carp were identified near the area but fishermen reported that they sometimes found bunches of egg (species unidentified) in newly inundated lands. They own the *Savar Jal* only, and have no nursery or any other ponds to release the eggs/spawn. The price of spawn usually depends on season (early or late), quantity of catch, and number of purchasers.

Figure 20


N
TANGUAR HAOR
KALIAJURI AREA
COMPANIGANJ AREA
Sunamganj
Sherpur
Old Brahmaputra R
Netro-
kona
Kangsa R
Mohan-
ganj
Mymensingh
Sylhet
Surma R
Kushiyara
HAKALUKI
HAOR
Ajmiriganj
Kishorganj
Moulvi
Bazar
Manu R
Kawadighi
HAOR
Habiganj
Khowai R
Sutang R
Dhalai R
Kuliarchar
Banar R
Arial Khan R
Meghna R
Bhairab Bazar
Narsingdi
Scale
25km
0
25
50km
LEGEND
International Boundary
NERP Boundary
River/Khal
Mother Fishery
Northeast Regional Project
Location of
Mother Fisheries
Prepared by: NCP/Jalal
January 1994
XREF:NERP-075.DWG
FILE: FISH-122.DWG

83

2.3.4 Mother fisheries

Discussions with fishermen revealed the existence of several major centres of fish production and dispersal within the region. These areas are called mother fisheries by the fishermen. The concept (or phenomenon) of a mother fishery does not appear to been previously identified or its importance recognized in floodplain fisheries literature. Functionally, a mother fishery exerts a controlling influence on fish abundance over a wide area. Thus, if fish abundance is high in a particular mother fishery in a particular year, fishermen expect fish abundance also to be high in the surrounding areas. The reverse would also be expected: low fish abundance in the mother fishery would result in low catches in the surrounding areas.

Structurally, a mother fishery could consist of a single beel, or duar or spawning locality. For example, there are 25 important jalmohals in the Purbadhala thana. Out of those, six jalmohals are considered important as mother fisheries: Mora nadi jalmohal, Bonduk khali (in the Kangsha River), Rajdhala beel, Bais dar duba (in the Kangsha River) and Bagruar duba (in the Kangsha River)

But the concept of mother fishery is more commonly used in the region to describe a larger geographical area possessing a dense concentration of diverse high quality fish habitats and supportive flora (deep river duars, clear tributary streams, deep beels, sediment-free khals, wetland forest stands, reedbeds, floodland with wetland grasses). There appears to be a general consensus among the many individuals involved in the field that there currently exist four important mother fisheries in the region:

- Tangua Haor
- Hakaluki Haor
- Kaliajuri area
- Companiganj area

Previous to the construction of the Manu River Irrigation Project, Kawadighi Haor was also a major mother fishery. Unfortunately, this FCD/I project has completely decimated Kawadighi Haor as a mother fishery.

A more detailed examination of Tangua Haor (considered to be the single most important mother fishery in the region) reveals the important components of a mother fishery. The area of the haor is about 80 sq km. Few villages exist in comparison with other haor due to less opportunity for agriculture. The haor is located just adjacent to Indian hill from where a good quantity of organic nutrient is carried to the haor with run off water. Unlike many other haors, no major khal or river connects with the Tangua haor which might carry silt from Indian hills like many other haors in the region. A few hundreds of beel are connected with each other by small canals. About 25 permanent beels are used as over-wintering grounds by fish. The entire haor is mainly fed by the back flow of water which carries only a small amount of silt in comparison with the other haors and by low turbidity hillside runoff. A relatively small hectarage of land is used for agriculture, so that the negative impacts of pesticides and fertilizers are almost non-existent. Clear water without silt increases the survival of fish spawn. The rate of subsistence fishing is low due to the small population within the haor area. Natural reeds and other vegetation provide natural ecological balance. A low siltation rate helps to maintain the natural fish habitat at a high quality level. The fish conservation act is generally implemented by the lessee. The three year pile fishing system is used and harvesting rotates among different beels in the haor. This plays an important role for maintaining the production level. The two-way water supply system (hillside runoff water, back flow flushing) provides circulation which helps to maintain the natural environment.

Because of their importance as fish production and dispersal centres within the region, mother fisheries need to come under special resource and environmental management planning and implementation regimes, which will be necessarily more complex and comprehensive than for single site refuge localities.

2.4 FISHING PRACTICES AND MANAGEMENT

2.4.1 Fishing vessels

Many types of fishing boats are used in the region, depending on water body type and fishing gear employed. These include:

- *Chandi nauka*, 5 - 17 m, drift netting for *Ilish*;
- *Bachari nauka*, <17 m, seine netting;
- *Dinghi nauka*, <10 m, various types of nets;
- *Kosha nauka*, 4 - 10 m, various types of nets;
- *Donga*, dugout <6.5 m, light gear.

Most fishing boats are un-motorized plank canoes, using sail, paddle or pole propulsion. For operating large nets such as *utarjal*, two boats are joined together end-to-end with a bamboo bridge to form a long working platform. Rafts made out of banana tree trunks are used for angling in calm waters in many places.

2.4.2 Fishing gears

A great many different types of nets and gear are used in the region and are testimony to the ingenuity of the region's fishermen in devising means to harvest virtually any life stage of any species. The specifications depend on target species, hydrological conditions, portability, labour intensiveness, capital costs, gear material availability and profitability. Nets used in rivers are typically equipped with meter long bamboo floats which ride vertically in the water. This sinks the headline sufficiently to prevent it from becoming entangled in boat propellers. The juice of a local fruit called GAB is used to preserve nets. Although net factories are operated by BFDC, many nets are woven by hand by women.

The more commonly observed fishing gears and methods are listed in alphabetical order below. Specialized gears are illustrated in Appendix D.

Bandoira jal: An uncommon net mainly used to catch Catla, Rui, Mrigel, Laso and Kalibaus. It is operated near embankments of inundated rivers. It is a fixed gear (25 m x 25 m in size, fixed with 20 bamboo poles). Four persons are required to operate the net.

Bel jal: A triangular bigger size net (like Thela jal) used in the rivers to catch mainly *icha, chanda, puti, tengra, chapila*. It is a fixed gear and one person is required to operate the net. Bel jal operation system is similar to Khara jal operation.

85

Ber jal: Conventional beach seine. It is hauled by a team of fishermen (usually 12 to 15) whose number depends on the size and weight of the net. It is used in beels, and also rivers during the dry season when water flow is minimal. Large mesh sizes are used for *Rui* and *Catla*. Small mesh sizes are used in rivers for *Tengra, Basa, Puti* and *Itcha*. License fees vary from Tk 7,000 to 50,000 per year.Borsi: Hooks and long-lines, baited with *punti*, are used in many places for large catfish such as *Boal* and *Bagmas*. Small hooks are used for *kaikka, Bheda*, and *Taki*.

Chai: A basket trap used for *Golda Chingri* and *Tengra*. It is baited with snail meat, *Itcha* or red bricks.

Coach: This is a spear used for large catfish.

Table 2.9: Current Jal Markets

Market Name	District	Market Day
Jawar bazar	Sunamganj	Sat, Tue
Patharia bazar	Sunamganj	Tue
Derai bazar	Sunamganj	Sat
Tanakhali bazar	Sunamganj	Sun
Shasna bazar	Sunamganj	Mon
Nabiganj bazar	Habiganj	Sat, Tue
Sherpur bazar	Moulvibazar	Fri, Mon
Goala bazar	Sylhet	Sun, Wed
BSIC IA	Sylhet	Everyday
Mohanganj bazar	Netrakona	Wed
Bhairab bazar	Kishorganj	Everyday

Source: NERP

Current jal: A small mesh (2 to 5 cm stretched) monofilament net used to catch small species. It is an extremely effective net and has been declared illegal because of its potential to over-exploit juvenile fish. The Jawar bazar is famous for current jal marketing. It is located on the Sylhet-Sunamganj high way (about 30 km from Sunamganj). The *current jal* is considered one of the most important cause for fish decline and it is officially a banned item. The *current jals*, however, are sold openly at Jawar Bazar where more than 1000 of these *jals* are usually displayed. It was reported that the entire net market is controlled by influential elites. DOF officials should monitor all market outlets of the *current jal*. Without proper control of the market outlets, it will not be possible to regulate *current jal* operation in the field. Controlling smuggling and restricting production and marketing might be the most cost effective way to control current jal usage. Well known *current jal* markets in the region are described in Table 2.8. It is claimed that at the Mohanganj market, *current jals* are sold openly and the total value of the sales is between Tk 80 and 100 million per year.

Cungi: Series of bamboo (0.5 m long) with hole joint together by a continuous nylon thread (2-3 m distance each), used to catch mainly BAIM and occasionally RAIN.

Dak jal: A large mesh gillnet used for *Rui, Catla* and *Boal*. Group fishing characterizes the use of this net. Typically, a group of eight canoes (each with 2 fishermen and a *Dak jal* played out from the stern) arranges itself into a rough circle. Each canoe drops a *Dak jal* and then is vigorously paddled outward away from the center of the circle, in a characteristic "sunburst" pattern. The center of the circle is situated over a duar known to harbour large carp and catfish.

Dara jal: The net is attached to a long rope which is operated by two fishermen. The net is used to encircle fish and an auxiliary net is used to scoop harvest the fish so trapped. This net is used in the Sunamganj area and is used to catch fish that feed at river bottoms.

Dol jal: This is a specialized net which is used for enclosing katha set in a river duar. The length of the net is dependent on the area of the katha and the depth of the duar. Bigger nets are made by joining together several stock net pieces. For example, the depth of the Jamuna khew in the Rangchapur fishery during the dry season is about 40-50 feet during the dry season. To perform one katha harvesting operation, it is necessary to join 3-4 pieces of net vertically. At the time of the operation, the net is set and tied to bamboo poles fixed around the katha. The net is set by two or three boats from two ends, quickly enclosing the area. The net is gradually drawn together as the tree branches are removed from the katha. The net served as an enclosure while actual harvesting is made by uther jal, small mesh ber jal and cast net. Encircling one katha takes 5-8 hours and employs from 10 to 30 persons.

Dori: A fish trap used to catch small prawns and all types of fish fry. It is regarded as a destructive fishing gear.

Dormo jal: A small, simple lift net, operated from the shore. The net is allowed to sink to the bottom, and then raised by pulling on a rope. The net is portable and can be moved easily and quickly from one fishing spot to another, but is limited to application in very small water bodies and from the shore. License fee is between Tk 1,000 - 2,000 per year.

Dowjala: Specialized gear used to catch mainly BOAL in Kalmakanda area.

Duri: A reed fish fence with basket trap(s). These can be quite small (ie spanning a bund opening in a rice field or a roadside borrow pit) to quite large (ie spanning the Surma River near Kanaighat). *Duri* are erected during the dry season from late October to March. Mostly small species of fish are caught (*Chankira, Kachki, Bailla, Rani, Chingri* on the Surma River).

Faash jal/Piya jal: A rectangular large mesh (2.5-3 cm) net used to catch kalibaus, bacha, ilish, garua, koi. The net is more common in the Hari Goyain River and Zilkar haor area.

Flan jal: Same as *Thela jal* (see below).

Ghana Ber jal: A net used in the Kaliajuri area *for Chapila, Pabda, Puti, Gulsha* and *Bashpata*. It is set in floodplain canals and near katha in rivers.

Ghora jal: A net used in the Kaliajuri area mainly for *Ilish*. It is set at the confluence of rivers and floodplain canals.

Ghurti jal/Goin jal: This is a specialized type of net operation which is used mainly on the shallower part of the Humaipur haor. Three persons are required to operate the net. It is a rectangular net (1 cm mesh) used to catch kaikka, chela, puti, kalibaus, laso (basa).

Goira jal: A rectangular shaped basket type net (1-1.5 cm mesh) is 2-3 m long and 3-4 m mouth opening, used in the rivers to catch mainly prawn. The net is fixed with a bamboo at the opening and a 30-35 m long rope is used to pull the net against current. The gear is mainly used in Kaliajuri area.

Horhoria jal: A rectangular box type net (mesh 1-1.5 cm) is 3.65 m long, 4.5 m breadth and 1.3

m height, used in rivers to catch mainly tengra, baim, ghagot, ghonia, icha. Appropriate weight and floats are present in the net and two persons are required to operate the net.

Jam jal: This net is used to catch broodstock in the river duars (ie Luba River fish sanctuary). *Jam jal* is a rectangular net (100 m x 100 m in size, 8-10 cm mesh). It is placed over a duar by using four ropes and is weighted down with heavy stone. It is claimed that the *jam jal* is one of the causes for the rapid decline of broodstock in the area. Use of the *jam jal* should be prohibited. *Jam jal* is only used to catch duar fish.

Jhaki jal: This is a castnet. It is owned mainly by subsistence fishermen and is also used to harvest beels. Mainly small fish are caught *(Tengra, Singi, Koi, Taki, Itcha, Punti*).

Kati jal: This is a seine net with a large mesh size. This net is used in the Sunamganj area and is operated by 7 fishermen.

Kapri jal: A large net with very small mesh size, used for diminutive fish species such as *Kachki*.

Khara jal: A large, fixed lift net with a complicated frame. The net includes two horizontal lever arms to which the net is attached and a platform for the fisherman to sit on. It catches small fish *(Punti, Tengra*). Middlemen often own *khara jals*, and the fisherman who actually operates the net makes little money. License fee for this apparatus is Tk 3,000 - 4,000 per year.

Kona jal: A fine meshed net having 1/16 inch mesh and is completely illegal. The net is 100 m x 10 m in size. The time required for each haul is about one hour (The net may be hauled 10-12 times per day). Seven or eight fishermen are required to haul the net. Species caught are *Chapila, Kachki, Batashi* and *Dhela*. .

Laua jal: A net used in the Kaliajuri area mainly for Ilish. It is set at the confluence of rivers and floodplain canals.

Leski jal: This fine-meshed net is 60 m long and 9 m high. Four fishermen are required to operate the net which is mainly used in rivers and deep floodplains. The gear is mainly used in Bajitpur and Nikli areas of Kishoreganj.

Lori jal: A large mesh net (3-5 cm), with a length 4 m and a depth 1.5 m used to catch gazar during the dry season and all other carps and large catfish during monsoon. Two persons are required to install the net near to paddy field and one person to find fish home. The net is very common in Kaliajuri and Itna areas.

Moha jal: A small mesh seine net, used in rivers for small species such as *Basa, Laria, Bapta, Kachki, Chapati* and *Chapila*. Large mesh sizes are used for *Rui, Catla* and *Boal*. It is also fished from twinned canoes (see *Utar jal* below). Eight fishermen are needed to operate the net.

Pati Ban: This is a bamboo pen which has a number of baskets and is placed horizontally across canals and rivers. This gear is mainly used during rising and falling water levels; not during the peak of the monsoon.

Pawla jal: A seine net, with a length of 35-45 m and a depth of 13-17 m. The mesh size is 4 cm. It takes about 1.5 to 2 hours to haul the net and is used in the Kushiyara River downstream of Sherpur.

Pine jal: This is a net with a mesh size of about 1 cm and is used in the Sunamganj area and in Hakaluki haor. It is operated by 14 fishermen using two boats. It is used to catch *Chapila* fry.

Sangla jal: A net used in the Surma River in midstream (observed below Chhatak) for *Ilish*.

Savar jal: A very fine-meshed net used to catch carp spawn and fry. It is shaped like a cone.

Shib jal: This is a lift net used to catch *chotomaach* in the canals and floodplain.

Sitka jal: A large mesh (5-7 cm) seine net with appropriate weights and floats, used in rivers to catch mainly ghonia, boal and sarputi. Monofilament twine (current jal materials) is used to prepare the net and is highly detrimental to fish. Complete ban on Sitka jal is demanded by the jalmohal operators.

Thaki jal: This is a conical shaped net between 24 and 30 m in length and about 7 m in depth. It is used to catch Prawn, *Gulsha, Air, Kalibaus* and other bottom dwelling species in Khaliajuri, Itna, and Ajmiriganj.

Thela jal: A small triangular push net on a bamboo frame. It is the most widely used subsistence fishing gear (ie the "poor person's net"). Men, women and children use it. The fisherman or fisher-woman wades in the water, sometime up to his/her neck, pushing the net along the bottom. No fishing license is normally required to own and operate a *Thela jal*, however, a middleman might ask for a fee of Tk 100 per year. It is also known as a *Flan jal*.

Uich: This is a fish trap set in the bottom of flooded areas to catch *Cirka* and *Baim*. This gear is used in the Kaliajuri area.

Uthar jal: A large conical net, 12.5 cm stretched mesh size, fished like a seine net. It is used for *Boal, Air, Chital* and *Bagmas*. Typically, two canoes are joined together end-to-end with a bamboo bridge to create a long working platform from which to operate the net.

Vat jal: A net used in the Sunamganj area. Operated by two fishermen.

Vim jal: A new type of net introduced to the Astagram area in 1990. The net is used mainly for catching prawns during the period of high current velocity (May-June and September-October) in the river.It is a fixed gear faced against the current at the bottom of the river. It looks like a Savar jal (spawn collection net) and can catch almost all type of fish, from broodstock to fry. People in the area maintain that this net is an important reason for declining fish population in the area.

2.4.3 Specialized fishing methods

Certain special fishing methods and practices have developed in the region which are more complex than the simple deployment of a fishing gear in a routine manner. These have been developed in order to achieve higher levels of productivity.

Katha: By far, the most widespread and common special fish production method used in the region is the *katha*. This structure consists in its simplest form of a pile of tree branches and

\ 89

bushes (hence the quasi-synonymous term "pile fishery") set on the river or beel bottom. Fish are probably attracted into katha by the shelter provided and by the increased food supply (bark and periphyton). During the dry season, fish can become densely amassed in a *katha* and thus become easier to catch once they have taken refuge there. To harvest a *katha* a blocking net is set around the *katha* (often raised up to 2 m above the water surface to prevent carp from jumping out), the branches are removed and blocking net is closed up. Final harvest may be with a beach seine or castnet inside the blocking net.

The preferred furnish for *katha* is the branches of *hijal* because of their hardness and resistance to rot. *Hijal* branches can last 3 or more years in water without decomposition. *Koroch* is also used but the wood is lighter in weight and more buoyant and the bark is thin and not liked by fish. At least one species is not used because it releases a toxic chemical into the water. *Hijal* and *koroch* branches are not available everywhere in the region. In Hail Haor, Mango (Magnifera indica) *Am*, *Jam* (Syzygium cumini), *Bot* (Ficus benghalensis), *Shobri* and *Shawra* are used. In the Kangsha mainly *Shawra*, Mango and *Jam* tree branches are used. In the Kaliajuri area *Barun, Mera, Jarul* (Lagerstromia speciosa) and *Jam* are used, along with *Hizal* and *Koroch*. Bamboo stakes are often used to "fence" the *katha* so as to anchor it and prevent it being swept away. Some *katha* even have elaborate cane fences around them, and this converts them into a form of fish pen.

In a variant of *katha* known as *dol* fishing a cap of floating water hyacinth *(Kachuripana)* is held in place over the *katha* with bamboo stakes. This was observed in Hail Haor, the Upper Meghna at Bhairab Bazar and in roadside borrow pits at the edge of Hakaluki Haor near Kulaura. Fishing with lights is common, and people believe that a water hyacinth mat protects their *kathas* from poachers using lights.

Neem fishing is a method similar to katha. Usually tree branches are installed in the deeper part of a particular water body. During the time of fish harvesting the areas is demarcated by floating bamboo to warn off navigation. Deeper water bodies are called NEEM in Sunamganj, Sylhet, Ajmirigong and Khaliajuri area.

Another variation on the *Katha* is called *khaw*. In Ranichapur there are ten fish *Khaw* and in Dhalimati there are five. *Khaw* consists of one or more *Katha* encircled by a large number of bamboo stakes. *Khaw* are usually located near *hijal* plantations. Important *khaw* at Ranichapur are Jamuna, Phada Auti, Faridpur, Agarar khaw, Bangani, Mominar khaw, Khorkoria and Hatbila and at Dhalimati are Boiragir Khaw, Borkir took, Bagar khaw and Shaintar Duar.

Materials for a *katha* typically cost Tk 1,500-2,000. Quantities and costs of *katha* can be substantial, as the alternative use of the wood is for domestic fuel. Large consignments of *katha* furnish are usually transported from tree plantations to their fishery destination by lashing two engine boats together and piling the branches on the deck to about 3-4 m high. Such a double boat load of *katha* furnish is called a *jurinda*. One *Jurinda* costs about Tk 10,000. The Tangua haor fishery, for example, requires about 40-50 *jurinda* of furnish each year.

Normally *katha* are installed during the time of water recession. In beels, *katha* are usually installed in the deepest part where soil type is clayey or loamy. The number of *katha* installed depends on the area of the beel. Usually one *katha* covers an area of about 35 m x 15 m (525 sq m). In rivers *katha* are usually installed near *duars*. In the Kushiyara, *katha* are installed at the erosion zone of the river (probably deepest part). Each *katha* is about 25-35 m long and 10-

15 m wide. Middlemen may charge Tk 100-200 for the right to install a *katha* in a river.

Katha fishing in running waters (open rivers) is not legal according to the Fish Act. This regulation is intended to protect broodfish which have moved from haors into rivers to seek over-wintering grounds. Instead of moving into the *duars*, the broodstock instead take shelter in the *katha*. However the Fish Act's provisions are ignored by leaseholders who use *katha* in rivers exclusively as a trap for broodfish. This results in heavy mortality of brood stock in rivers in the winter. Another negative impact of the installation of *katha* in rivers is increased deposition of silt which is trapped by the reduction in current velocity caused by the *katha*.

Table 2.10: Characteristics of *Pagar* Harvest

Harvesting Time	Main Fish	Income Range per *Pagar* (Tk)
End of Dec (1st harvest)	*Shingi, Magur, Koi, Shoal, Lati, Cheng*	500-1200
End of Jan (2nd harvest)	*Shingi, magur*	200-600
End of Feb (final harvest)	*Shingi, Magur*	100-300

Source: NERP

Katha are usually harvested in February and March. *Katha* is highly efficient in harvesting fish from beels and can result in a high percentage of harvest of the total beel stock each year. *Katha* selectively attract carps (*Rui, Catla, Mrigel, Kalibaus, Gonia*) as shown by the difference in species composition of annual and pile fishery catches. Small species such as *Tengra, Itcha, Puti* and *Chapila* are also attracted.

Katha installed in permanent beels are called pile fisheries and are supposed to be fished only once every 3 years in order to allow *boromaach* to grow to maturity. It is believed that individual fish return to the same katha each year. Since permanent beels cannot be drained (see entry on "De-watering" below), *katha* are installed to attract fish and facilitate their capture. Some leaseholders have begun harvesting *katha* every year or every second year. It is customary for leaseholders to allow some fishing each year for small species outside of the *katha* area for subsistence purposes, but this is no longer permitted by some leaseholders. Additional information on pile fisheries from the perspective of fisheries management and resource conservation is presented in Section 2.4.5 below. Some small *katha* installed in rivers or beels may be harvested every two to three months.

Fish exhibit special behaviour while domicile in a *katha* which gives clues to their abundance. By observing jumping patterns, an experienced fisherman can estimate the concentration of fish in a *katha*. High leaps are an indicator of low fish density. In dense schools, leaps are less vigorous and less frequent. By examining the *hijal* branches, one can estimate the concentration of fish in the *katha*. Usually, dense schools of fish will remove almost the entire bark layer of the branches. A strong fishy odour in the water of a *katha* also indicates the presence of a dense concentration of fish.

When branches are removed from a *katha* and taken out of the water, *Kalibaus* have a peculiar habit of remaining firmly attached to the branches and can be lifted out with them. Other species immediately swim away from the katha if the branches are disturbed.

Table 2.11: Harvesting Schedule (12 Year Lease)

Year	Pile A	Pile B	Pile C	Pile D
1				
2				
3	Harvest			
4		Harvest		
5			Harvest	
6	Harvest			Harvest
7		Harvest		
8			Harvest	
9	Harvest			Harvest
10		Harvest		
11			Harvest	
12	Harvest			Harvest

Dakban: De-watering is practiced in seasonal beels and roadside borrow pits. It is done by baling water out using manually operated low lift mechanical devices or low lift pumps. The objective is usually to achieve a complete harvest of the fish stocks (to maximize profit from the leased water body) and therefore is quite destructive of fishery resources. A possible justification for de-watering for fishing of seasonal water bodies is that the fish would die in any case when the water body dries out. However other approaches (excavation of refuge pits, construction of bunds to increase water storage volume) would probably yield greater returns over the long run.

Donga is a method for fishing seasonal beels. The *donga* is a pond excavated in the outlet khal of a seasonal beel. Several *katha* are installed in the *donga*. Bamboo screens and blocking nets are set across the downstream end of the donga to prevent fish from escaping. The beel is harvested by a large group of people in the conventional manner with various types of nets. To avoid capture, many fish move into the *donga* where they congregate in the *kathas* and are easily caught.

Pagar Fishing: Fifteen to twenty years ago most of the beels in Gazaria Haor retained water year round (Gatua beel was named for its greater depth). However now all the beels are seasonal as a result of the full flood control project (see Appendix N.2.12). Local people have responded by excavating several small ditches within the beels, which are called *pagar*. Dimensions of a typical *pagar* are 15 m x 10 m x 1.5 m. A low dike (0.3 - 1.0 m in height) is raised around it, and a 1.0 - 1.3 m wide opening is left on one side. *Pagars* are used to trap fish and to conserve water for irrigation. During the months of August and September, owners of *pagars* installed *katha*. For *katha* mainly *Shawra, Gub, Amli (Tetul)* and Mango tree branches are used. *Katha* installation cost of each *pagar* is about Tk 200-500. Normally *pagars* are harvested thrice in a year. Harvesting information is provided in Table 2.10.

Polo Fishing: In the Itna area, people sometimes cut shallow ditches to create a current, install a pen with bamboo trap and wait over them with *Polo* (bamboo plunge basket). Small fish enter into the trap and big fish are caught with the *Polo*. Following a heavy rainfall, large numbers of fishermen go *polo* fishing in the flooded fields. This can produce large brood fish. In one case, a man captured and sold fish with a value of Tk 8000 at Itna bazar from just one night's polo fishing operation.

Table 2.12: Harvesting Schedule
(3 year Lease — 4 Tenure Periods)

Year	Pile A	Pile B	Pile C	Pile D
1				
2				
3	Harvest	Harvest	Harvest	Harvest
4				
5				
6	Harvest	Harvest	Harvest	Harvest
7				
8				
9	Harvest	Harvest	Harvest	Harvest
10				
11				
12	Harvest	Harvest	Harvest	Harvest

Prawn Fishing with Grass: During the premonsoon season, people in the Kaliajuri area catch prawns by floating grass in the river current. They throw grasses such as *Chailla bon* and *Koipan bon* into the river and prawns cling to the roots. The fishermen then retrieve the grass with scoop nets several hundred metres downstream. Each operation takes 30-60 minutes. Fishermen from one boat can earn Tk 50-100 per day during May.

2.4.4 Reserve fisheries and pile fisheries

The most important methods of biological fisheries management and fishing effort regulation practiced in the region have been in the past (and to a lesser extent, still are in the present) reserve and pile fisheries. A reserve fishery is one where fishing is carried out only once within a medium term period of 5-7 years in order to allow a build-up of the stock. Thus, there is a conservationist element built into the management regime which rejects smaller short-term gains in favour of larger medium-term benefits. Traditionally, reserve fisheries were jalmohals which were not fished for either *boromaach* or *chotomaach*. *Katha* were normally installed in reserve fisheries.

A condensed form of reserve fisheries are conventional pile fisheries with a three year harvesting rotation schedule. *Chotomaach* harvesting is carried out every year while *boromaach* are harvested only once every three years when the *katha* is disassembled. Conservation objectives are less in pile fisheries as compared to reserve fisheries. However, pile fisheries are still superior to annual fisheries (where the katha is harvested totally each year) in terms of production and conservation functions.

93

Table 2.13: Proposed as Fisheries Reserves

Name of the Fishery	Location
Bordoi beel	Dekker haor
Rangamati	Dekker haor
Jaida nadi	Dekker haor
Shaldigha boalpushi	Near Dabar
Dabar beel	Dabar ghat
Maramohasingh nadi 3rd part (Babongaon dor)	Baro haor
Karkol nadi 1st part (chandir dor), Jagannath	Naluar haor
Tanguar beel	Tanguar haor
Pashuar beel	Dharmapasha
Kawnai nandi	Dharmapasha
Bhanda beel	Sulla
Satua nadi	Sulla
Kautskai fishery	Dowara bazar

An interesting "hybrid" practice which combines elements of both reserve and pile fisheries results when a three year pile harvesting rotation schedule is practiced within a longer term tenure or lease period (9-12 years). The history of Sunamganj jalmohals is illustrative of this practice. During the British colonial period most of the Sunamganj *jalmohals* were under the Lakkansree *jalmohal*. About 80 years before there was no leasing system in the area and *jalmohals* were mainly managed by the *Koibarta Das* and the *Zamindars*. During that period, piles were very strictly maintained as it was believed that it would not be possible to derive sustainable production from a particular *jalmohal* without creating a productive fish habitat. At that time *jalmohals* were auctioned for 9-12 years duration. This system was continued up to the Pakistan period. As a result piles were maintained properly by the lessee. A leaseholder who maintained four piles would have followed the harvesting schedule presented in Table 2.11 or 2.12.

During the start-up years, no piles were harvested, in year 3, 4 and 5 only a single pile was harvested each year. In year 6, two piles were harvested. After this start-up phase was completed, from years 7 to 12, a three year rotating cycle was followed which specified the harvest of one pile in each of the first two years and two piles in the third. Thus over the longer term (assuming lease renewal), 4 piles would be harvested in any three year period, and the schedule was arranged so that any one pile was harvested only once every three years.After the liberation of Bangladesh, lease periods where shortened to 3 year terms due to certain socioeconomic and political conflicts. The harvesting schedule took on a different form, with no piles being harvested in the first two years, and all 4 piles being harvested in the third year.

Although the rate of harvesting over a multi-year period is the same in both cases, the 12 year lease allows the realization of income from fish sales in each year, while the 3 year lease only yields income (and supply to markets) triennially. In the latter case, because there is no assurance that another three year lease will be obtained after expiry of the 3 year lease, there is no incentive to invest in infrastructure or hizal plantations. This has apparently led to widespread failure to maintain piles properly. Furthermore, the need for an annual income has led to harvesting piles annually, thus increasing fishing intensity by a factor of three and preventing maturation and reproduction of *boromaach*. As a result fish production in the area has been reduced tremendously, by about 70-80% over the last 20 years. Extreme reduction of broodfish (as well as destruction of forests and accumulation of silt) are the major causes of fish decline in the area. Fishermen and lessees of the Sunamganj area have asked that certain jalmohals (which are relatively deep and not threatened by siltation) be returned to reserve fisheries status. These are listed in Table 2.13.

In the Dharmapasha area fishermen suggested that the following jalmohals should be considered as reserve fisheries. These are presented in Table 2.14.

Table 2.14: Jalmohals Proposed as Reserved Fisheries

Name	Water Depth in March (m)	Present Major Species
Pasua beel	10-12	Rui, Catla, Kalibaus, Air, Chital, Boal, Guzi, Pabda, Golda Chingri
Ghoraduba	9-10	As above
Bain Chapra	9-10	As above
Sunai nadi	10-11	Chital, Boal, Pabda, Air, Bacha, Shilon, kalibaus, Batshi (Aluni), Golda Chingri, Chapila
Mukshedpur dighor	9-10	As above
Kawnai nadi	9-10	Pangas, Chital, Boal, Air, Kalibaus, Bacha, Shilon, Laso, Chapila

Source: NERP

2.4.6 Fish sanctuaries

A fish sanctuary is a critical habitat locality(ies) within which fishing is perpetually and completely prohibited. Because of the threats posed to floodplain fisheries by over-exploitation and environmental degradation, there has been historically a perception amongst fishermen and government alike of the need to protect certain fishery areas in order to conserve fish stocks. The creation and maintenance of fish sanctuaries in the region, and in Bangladesh as a whole, is a tried and tested approach to stock conservation which has been shown to be useful in meeting its objectives wherever it has been effectively implemented.

Most commonly fish sanctuaries are established in specific areas to protect overwintering broodstock in river duars and deep beels or to protect spawning grounds of boromaach. Usually, a fish sanctuary consists of a single beel, duar or river reach, but may also consist of aggregates of key localities.

DOF has declared the following areas in the region as fish sanctuaries:

The Ubdakhali River. This sanctuary encompasses 500 ha and includes the reach from Kalmakanda ferry ghat to Makarkhali khal near Montala village. It also includes Hogla Beel, in Kalmakanda thana of Netrokona District. Rapid sedimentation is resulting in declining productivity. The river has three duars which act as refuges for *Boal, Air, Ghagot, Rui, Kalibaus, Baim* and other *chotomaach*. The sanctuary program is not working well.

The Luba River. This sanctuary encompasses 1000 ha, and is located near Kanaighat. The purpose is to protect migrating *Rui, Catla, Gonia* and *Kalibaus*. Since the sanctuary was established, no protection or any other management practices have been implemented by the DOF aside from hiring a fish guard. In the winter season, 60% of the sanctuary area dries up. All important freshwater fish species, including rare *Mohashol, Pangas Nowraj* and *Pakhiranga*, occur in the river and its tributaries. Small *Ilish* (*Jatka*) also occur in the Luba (see also Section 2.3.2, Luba River Duars).

The Surma River. Located near Sunamganj, this sanctuary covers about 1,000 ha.

The Kali River. Located in Kuliachar thana of Kishorganj District, this sanctuary covers about 500 ha.

Uniformed "fish guards" have been appointed to prevent fishing for migrating or overwintering carp and other stocks in sanctuary areas. Fish guards have at their disposal mechanized country boats. The system is new and not yet very effective.

A natural fish sanctuary has been created after the massive erosion of Katakhali village by the Jadukata River. Due to that erosion, some large trees have fallen into the river and a deep scour hole has formed. The scour hole now serves as a protected overwintering ground for *boromaach* and local people do not fish in that area due to the inundated trees.

In addition to specifying fish sanctuaries, the government (through the ordinance entitled *The Protection and Conservation of Fish Rules, 1985*) has prohibited catching of certain fish between April 1 and June 30 of each year. These are listed in Table 2.15.

Table 2.15: Partial Sanctuaries

River or Canal	District	Location
Kushiyara	Sylhet	From the Fenchuganj Railway bridge up to Lama Gangapur village, Fenchuganj
		From junction with Luba canal up to village Kakordi, Beanibazar.
		Luba canal from its junction with the Kushiyara up to its junction with Hakaluki haor, Fenchuganj
Kalni Bheramohana	Habiganj	Karchar dala from village Karacha to Makalchandi haor,Baniachong.
		Chairaer khal from village Halalnagar up to Makalkandi haor, Baniachong.
Bibiana	Habiganj	Bahusiar dala from village Bahusa up to Mokar haor, Nabiganj.
Shaka Kushiyara		Fatepur khal from village Fatepur up to Ghardiar beel, Ajmiriganj.
Surma	Sunamganj	From its junction with Madhabpur khal to its junction with Chenger khal at the southern boundary of the village Perkul, Chhatak.
		From village Karirgaon upto the Chhatak Thanarghat, Chhatak.
		From its junction with Poinda River at the southern border of the Poinda village upto its junction with Rakiti river, Sunamganj.
Piyain		From its junction with the Surma river upto the village Peder, Chhatak.
Garakhal		From its junction with the Piyain River upto its junction with Kurdhara, Chhatak.
Katagang		From its junction with river Piyain upto its junction with Dala Dhalarmuk, Chhatak.

97

2.5 FISH PRODUCTION TRENDS

2.5.1 Collection of nominal fisheries statistics

Prior to 1983/84, fish production estimates were based primarily on fish consumption data generated by the Nutrition Surveys of Rural Bangladesh for 1962-64, 1975/76 and 1981/82. Adjustments were made for intervening years by incorporating the results of Household Expenditure Surveys and DOF surveys. BFRSS was initiated in 1983/84 to provide a more systematic and sharper focused fisheries statistics collection service. BFRSS uses different statistical approaches for different water body groups:

- River fisheries production is estimated using CAS at selected fish landing points (ie fishing villages) for riverine fisheries. Raising factors are used to estimate catch for the total number of canoes (determined from frame surveys) operating on a particular river.

- Beel production estimates are derived by determining mean yield per unit area for some selected beels through surveys, and then multiplying by the total area of beels in each greater (old) district.

- Subsistence catch on flood lands is determined by CAS of sample households in selected villages to determine the mean catch per household and raising this by the total number of fishing households. The latter is calculated by multiplying the total number of all rural households by district (as determined by the Bangladesh Bureau of Statistics) by the ratio of subsistence fishing households obtained by the DOF CAS.

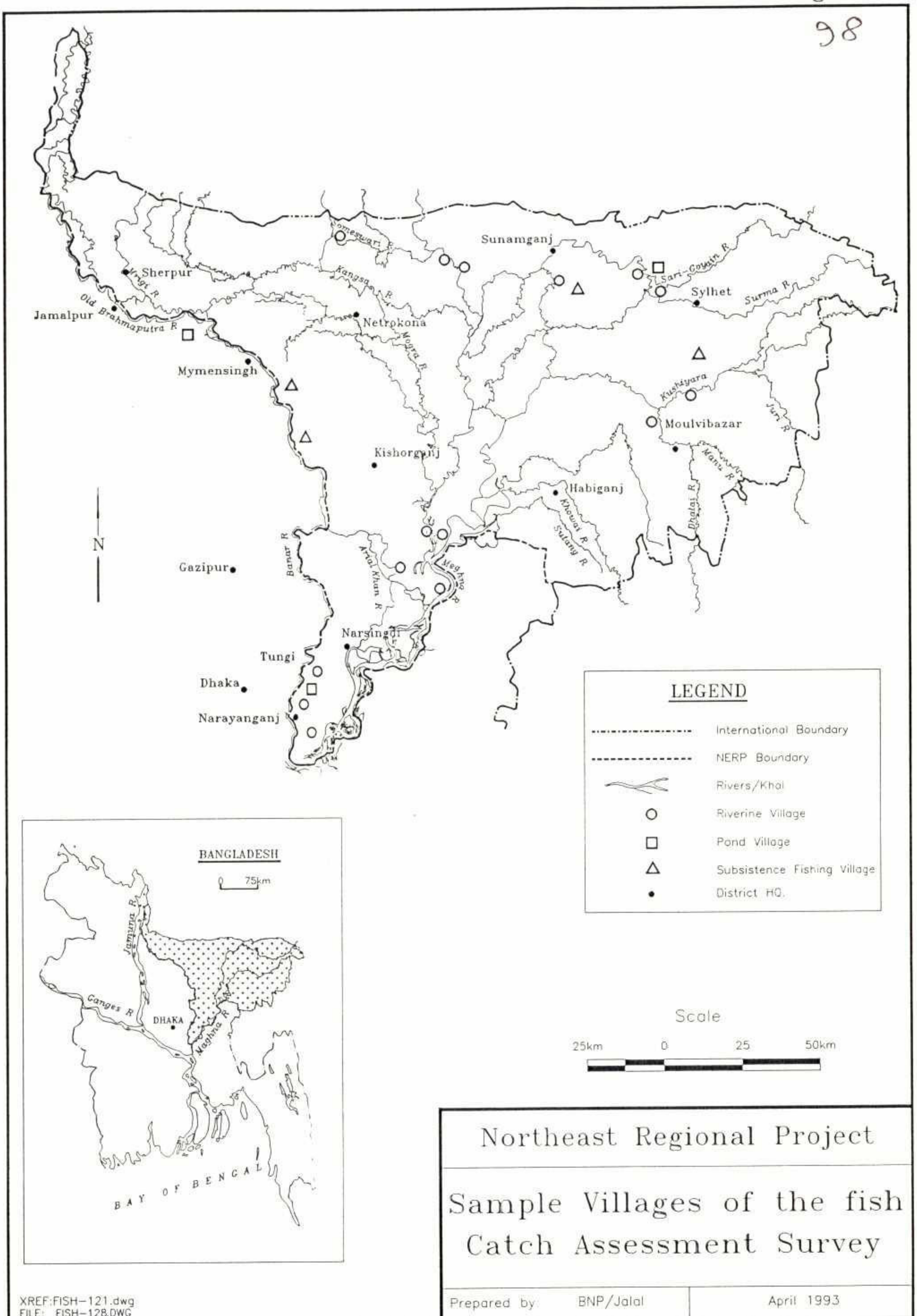
- Ponds are classified by the categories: cultured, culturable and derelict. CAS determine mean yields for each category, and total production is calculated by multiplying the aggregate pond areas by mean yields.

Raw data is collected in the field by DOF scientific officers from sampling stations and sent to Dhaka where it is processed. There is currently a two year backlog of data due to insufficient processing capacity.

BFRSS requires further development and strengthening. Shortcomings of the system include small samples and too few sampling villages. Some 24 river fishery landing points are sampled in the region, and the head of BFRSS feels that this is too few. He would like to be able to do sampling at the thana level. This requires more and better trained persons. Poor supervision of field enumerators may lead in some cases to fabrication of raw data.

Staff employed by BFRSS include 64 survey officers (one for each district), 4 divisional scientific officers and 10 technical officers in Dhaka. It is not possible to increase the number of staff out of Government revenue. So BFRSS will try to do this through a project. Besides field staff, there is also a need for more staff in Dhaka to process raw data. There is only one computer presently functioning.

98



Northeast Regional Project

Sample Villages of the fish Catch Assessment Survey

Prepared by: BNP/Jalal | April 1993

The last river fishery frame survey was done in 1981/82, with FAO support. Data on the number of fishing boats from this frame survey is still being used today even though the situation has undoubtedly changed over the years (the justification is that it is better to use the old frame survey data than no data at all). There is no data available on the numbers of fishermen. BFRSS is looking for donors to finance a new frame survey.

Given the complexity and diffuseness of floodplain fisheries in Bangladesh, collection of reliable statistics is a daunting task even with the best of conditions and resources. Greater use might be made of consumption and market surveys (carried out by other government agencies) for comparison with and enhancement of BFRSS outputs.

Opinion varies on the accuracy of BFRSS statistical data products, especially for more recent years given the use of old raising factors based on the 1981/82 frame survey. One might have some reservations on the capability of BFRSS to "see" actual production trends, but it would be unjustifiable to regard the system as completely "blind" to historical truth. As a working hypothesis it was assumed by the NERP fisheries team that the production trends indicated by BFRSS statistics are approximately correct (at a fairly robust level, and from one year to the next), but the data are probably subject to a significant enumeration error. It is presumed that the raw data forwarded each year to Dhaka for processing from the district offices would normally incorporate the sum total knowledge of the district office about fish production in the district in that year, and that the level of production reported would inherently incorporate a comparison with the level of production in the previous year. For example, if all field intelligence indicates that production in the current year is less than the previous year, data sent to Dhaka would likely reflect this decrease. Compilation of year to year comparisons will not however necessarily produce a correct multi-year long term trend line. (The reverse seems to be the case for the region).

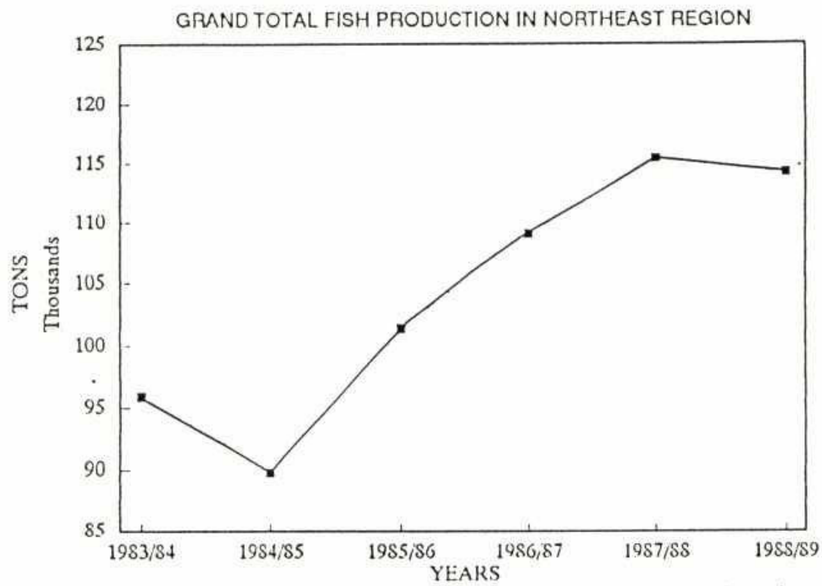
As published annually by the DOF, fish catch statistics of Bangladesh are aggregated by administrative unit into old (greater) Districts. Thus the primary statistical geo-administrative units applying to the region are old Sylhet and old Mymensingh Districts. These units approximately but not exactly overlap the area covered by NERP. Since it is not possible to conveniently re-aggregate BFRSS statistics to exactly conform to the NERP "region", they are used here in unmodified form. Pre-BFRSS statistics are not considered.

2.5.2 Production trends

Nominal BFRSS statistics for the 6 year period 1983/84 to 1988/89 (see Appendix E) show the following apparent trends in the region:

- Overall fish production in the region has shown an average annual growth of 3.8%, increasing from 95,895 to 114,273 tons (18,378 tons or 19.2% increment). Openwater capture fisheries grew by 3.0% per annum, from 83,555 to 96,198 tons (12,643 tons or 15.1% increment). Species composition of capture fisheries production is dominated by miscellaneous species, which increased from 48,018 tons (57.5% of total) to 58,331 tons (60.6% of total). Ilish and livefish production also increased. Carp and catfish production decreased over most of the period, but recovered in 1988/89. Large shrimp also declined, while small shrimp show an initial increase followed by a decrease.

Figure 22



Northeast Region is defined as greater Sylhet and Mymensingh Districts, plus the entire Upper Meghna River Channel

Figure 23

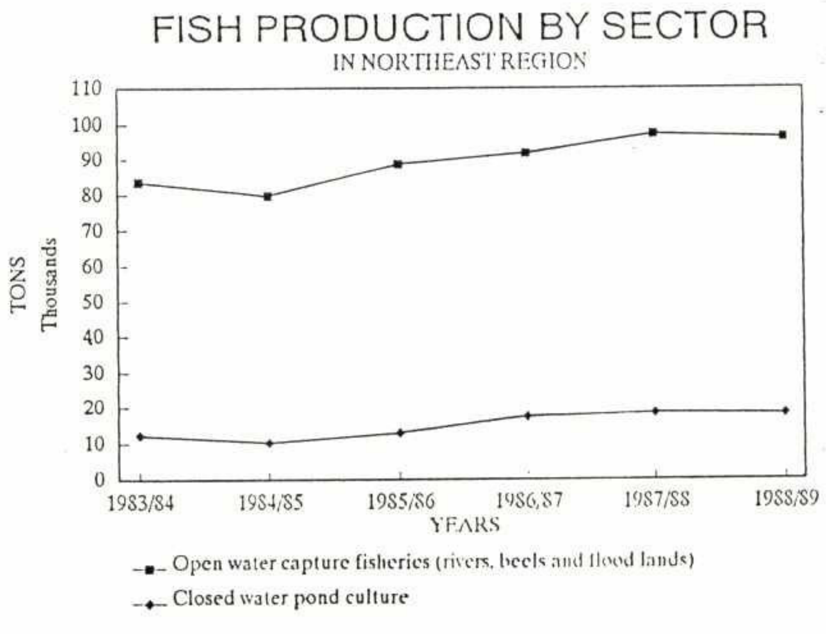


Figure 24

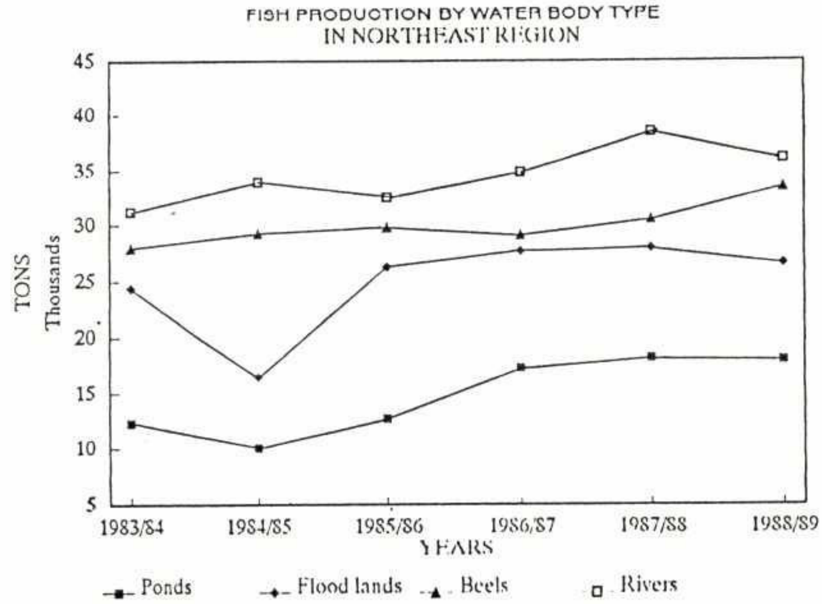
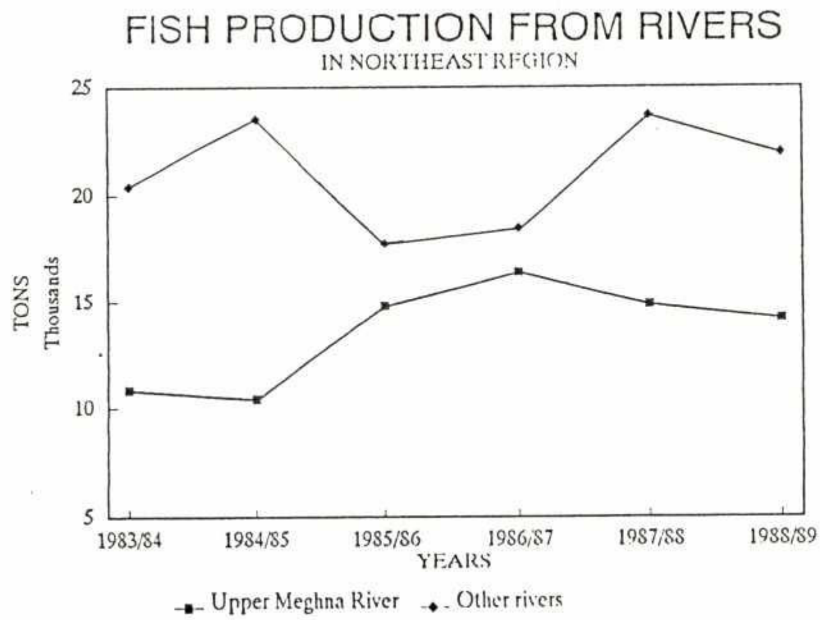
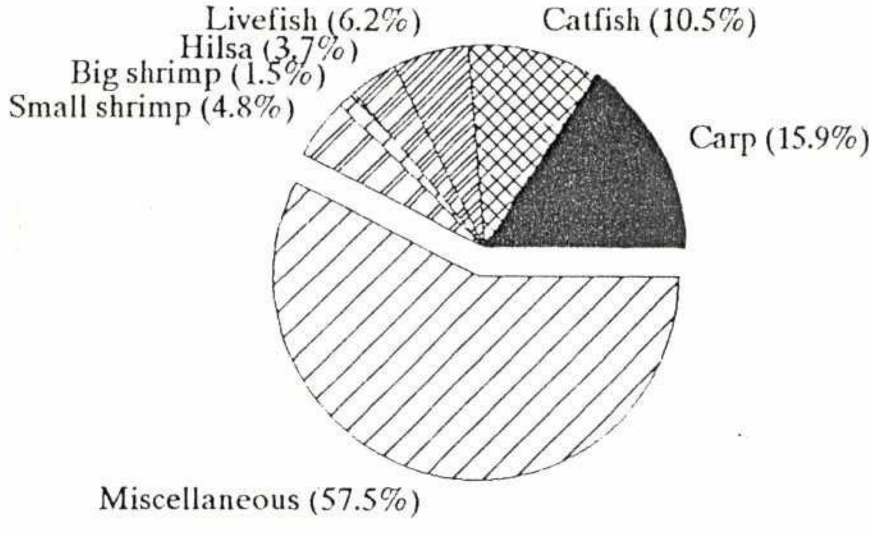


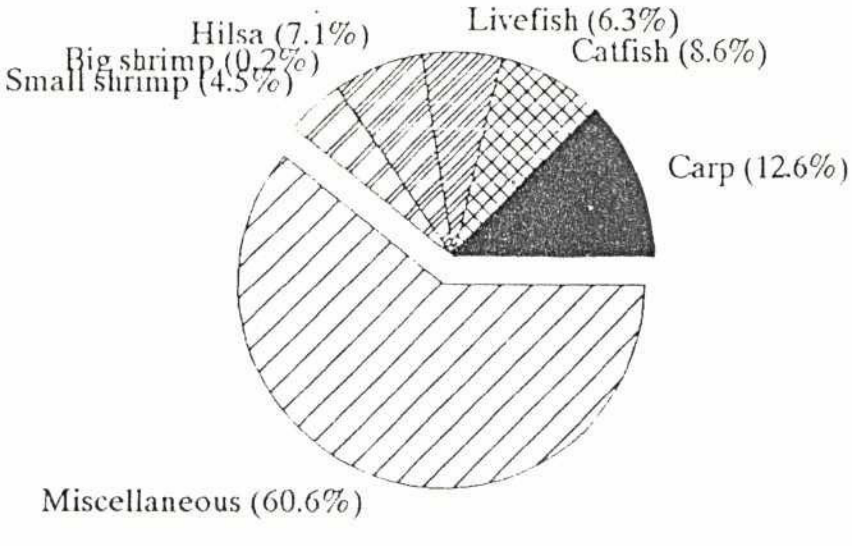
Figure 25



SPECIES COMPOSITION OF TOTAL CATCH
FROM OPENWATER CAPTURE FISHERIES IN NORTHEAST REGION



in 1983/84



in 1988/89

* Rivers are the most important harvesting habitat in the region, accounting for 31.6% of overall production in 1988/89. Mean annual growth was 3.2%. About 40% of riverine production comes from the Upper Meghna (mainly the stretch in greater Dhaka and Comilla Districts), and 60% from its tributaries (ie Surma, Kushiyara, Kangsha, etc, which are collectively termed other rivers). Upper Meghna production grew by a mean annual rate of 6.9%. Miscellaneous species and Ilish dominate the catch, the latter increasing significantly. Production from other rivers grew by 3.1% annually. There has been a major increase in catches of miscellaneous species, and severe declines in carp and catfish (although a significant carp recovery was recorded in 1988/89).

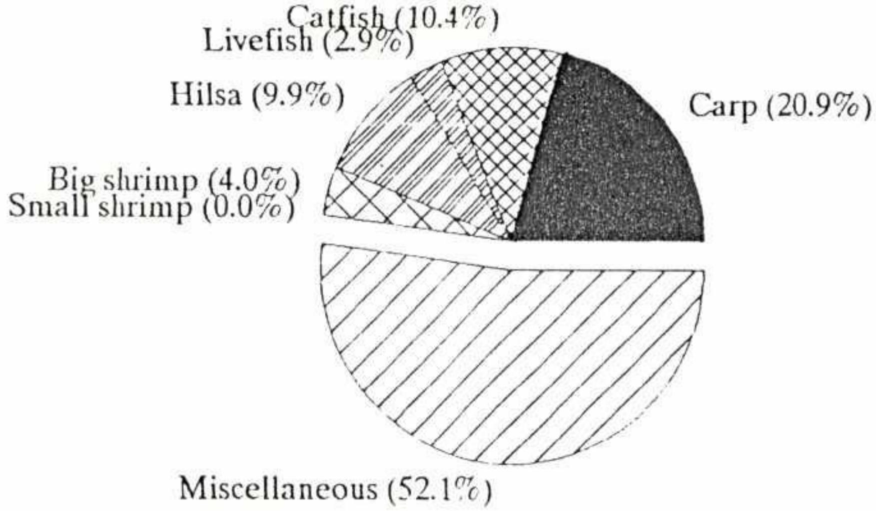
* Beel production constitutes 29.3% of overall production. Mean annual growth in output was 3.7%. It is widely reported in the region that 1991/92 catches are down compared to 1990/91. A possible explanation of this is that the production boom resulting from the extensive floods of 1987 and 1988 was fished out in 1988/89, 1989/90 and 1990/91. Thus in 1991/92 fish biomass was reduced. Around Sunamganj beel fishing began late in 1992 because of high water levels due to heavy un-seasonal rains in December 1991. Seasonal beels are termed annual fisheries. During the dry season in March-April they are completely harvested. Katha are sometimes installed in annual beels. Often the water is drained out to facilitate capture of all fish. A whole village may participate in the annual fish out, which has a festive air (community fishing). Permanent beels are termed pile fisheries and are supposed to be fished only once every 3 years in order to allow fish to grow to maturity. Since such beels cannot be drained, katha brush parks are installed to attract fish and facilitate their capture. Katha appear to selectively attract major carps *(Rui, Catla, Mrigel, Kalibaus)* and especially the minor carp *Gonia* as shown by the difference in species composition of annual and pile fishery catches. Carp constitute 29.1% of pile fishery production, but only 8.4% of annual fishery production. The aggregate percentages for large catfish *(Boal, Air)* and for small prawns are similar for the two beel fishery types. The other species not listed in the tables are much more important in the annual fishery (62.1%) than in the pile fishery (37.1%).

* Subsistence fishing on floodlands constitutes 23.3% of overall production, and has grown annually by 5.7%. The World Bank (1991) considers that the BFRSS subsistence catch statistics underestimate the true level of subsistence harvesting. Miscellaneous species dominate the catch (of which snakeheads are an important component). Catfish, livefish and small shrimp are important secondary components. Carp are of only marginal importance. Much of the floodland subsistence fishing takes place during the monsoon when the floodplain is inundated. DRH and BWDB borrow pit production is not recorded separately from floodland production. Most of the catch consists of small species: *Singi, Puti, Baim, Ithca, Gutum, Kaikka, Koi, Magur, Foli, Taki* and *Kachki*.

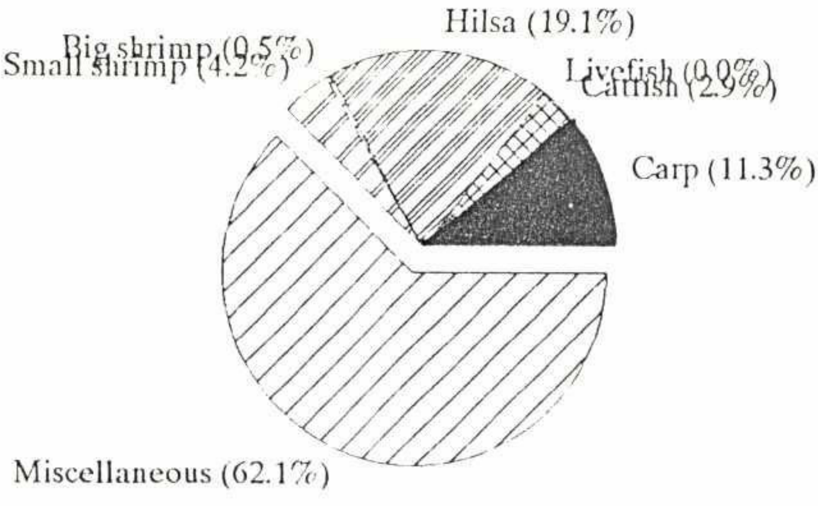
* Closed water (pond) culture production grew by 9.7% per annum, from 12,340 to 18,075 tons (5,735 tons or 46.5% increment). Ponds contribute 15.8% of overall production. Pond production in greater Mymensingh District is mainly major carps, while in Sylhet *Air, Punti* and other species are also of importance.

SPECIES COMPOSITION OF CATCH

FROM ALL RIVERS IN NORTHEAST REGION



in 1983/84



in 1988/89

Figure 28

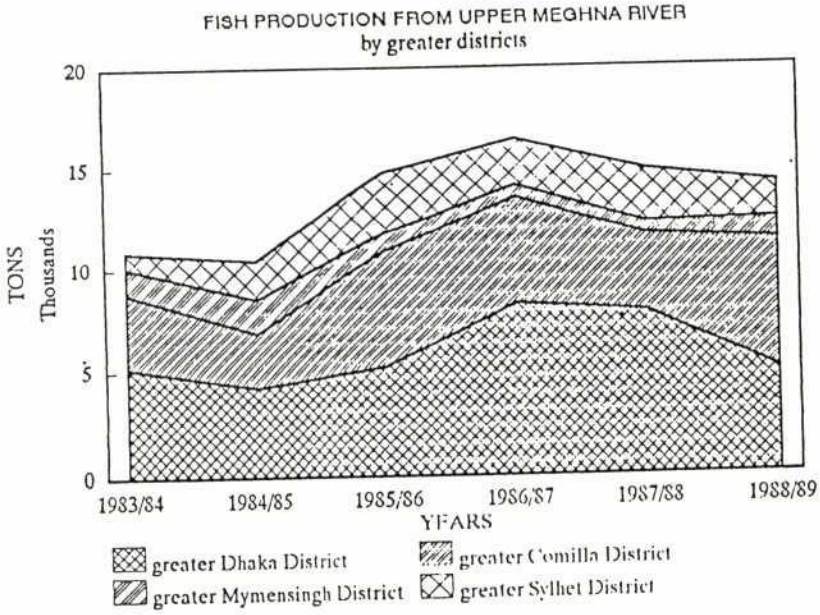
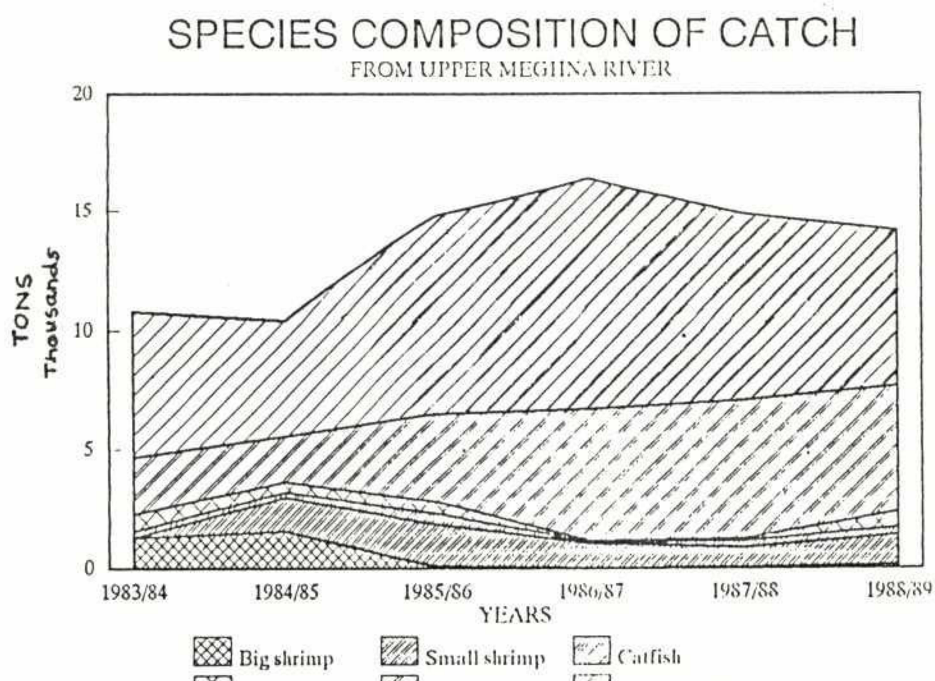


Figure 29



106

Figure 30

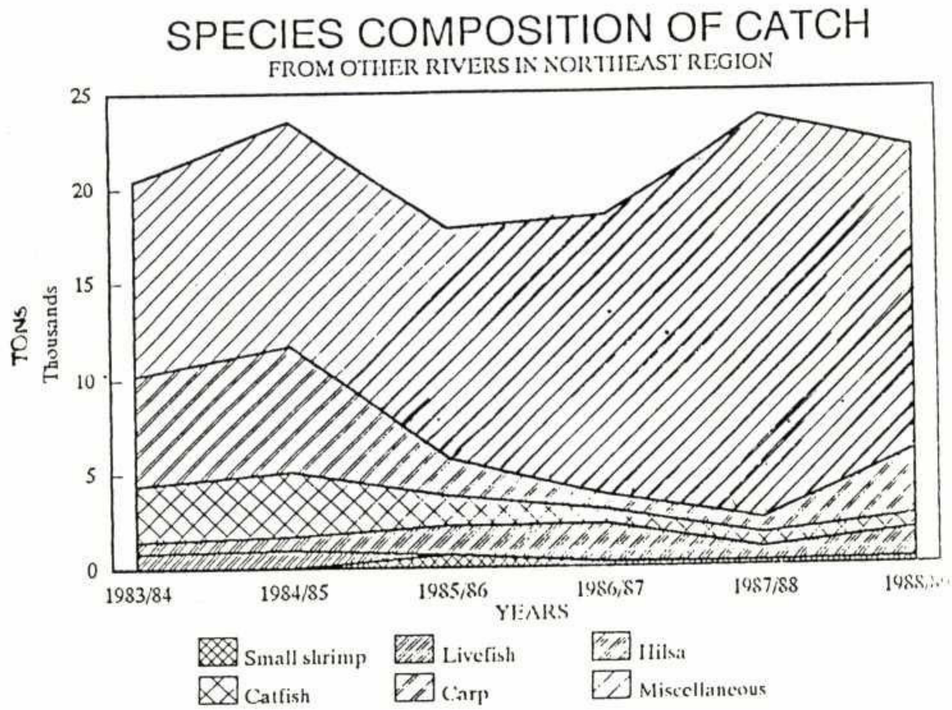


Figure 31

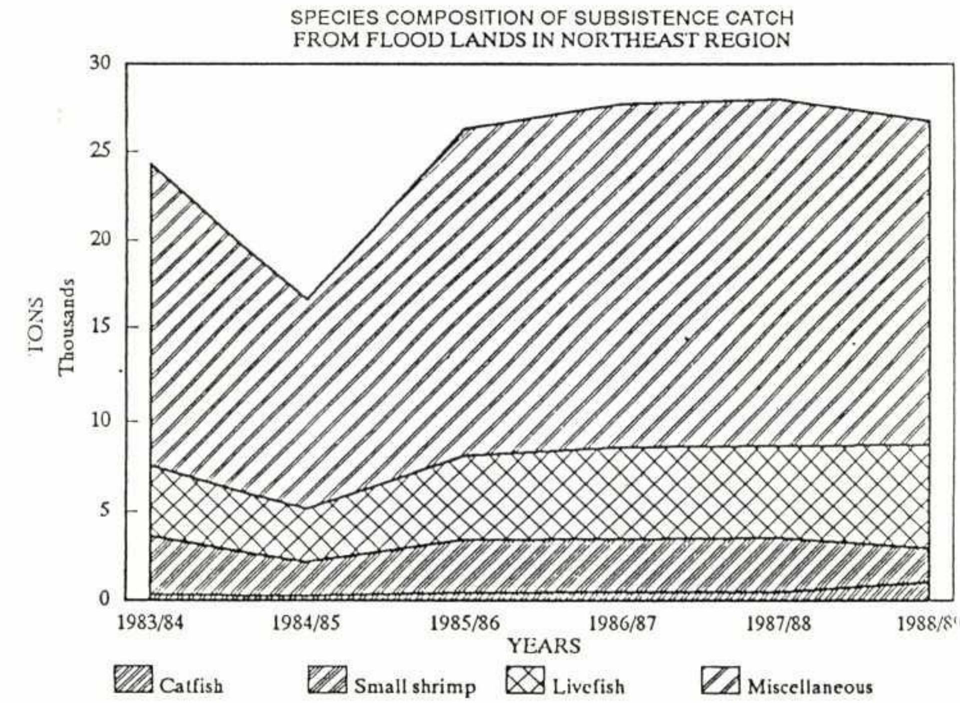
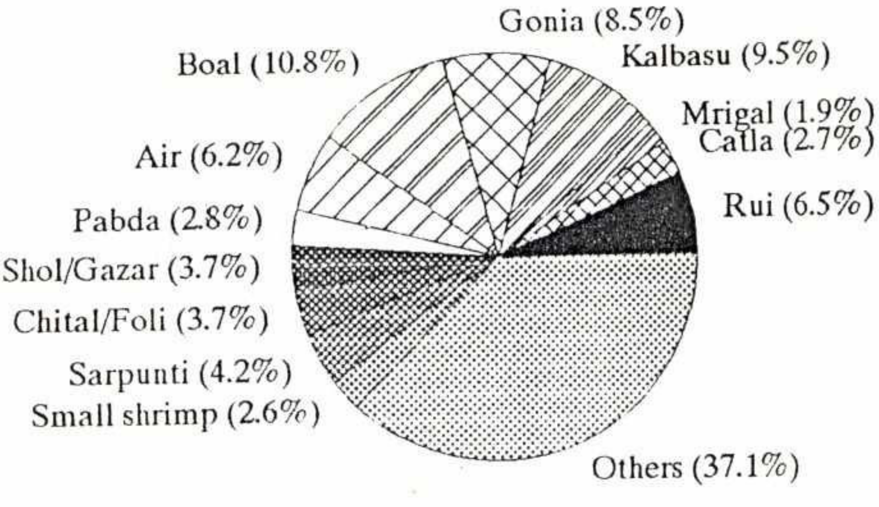


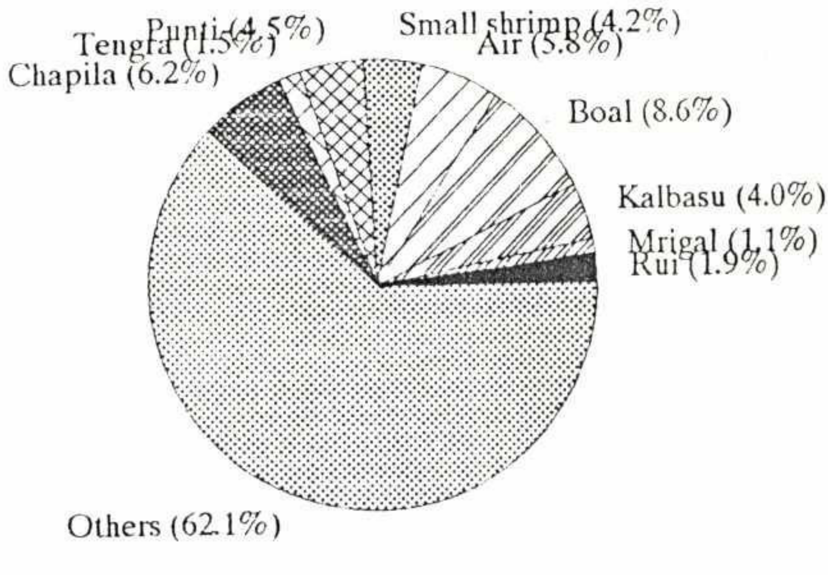
Figure 32

SPECIES COMPOSITION OF FISH PRODUCTION FROM BEELS
in Northeast Region (four year mean, 1985/86 to 1988/89)



PILE FISHERY

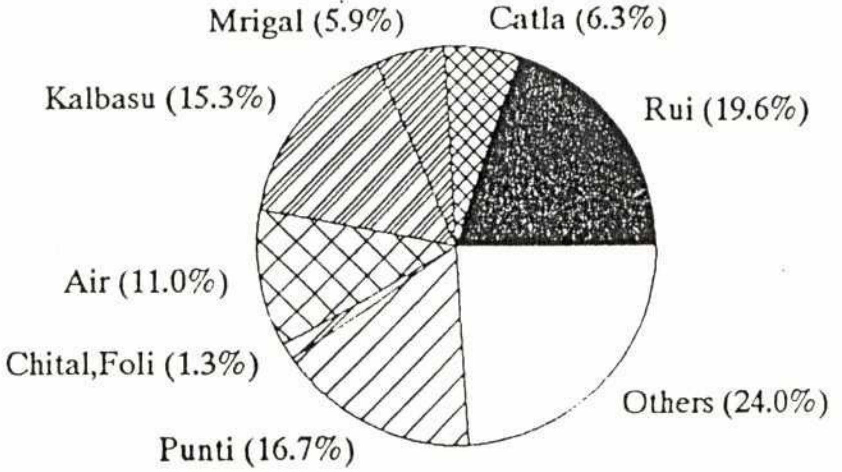
Figure 33



ANNUAL FISHERY

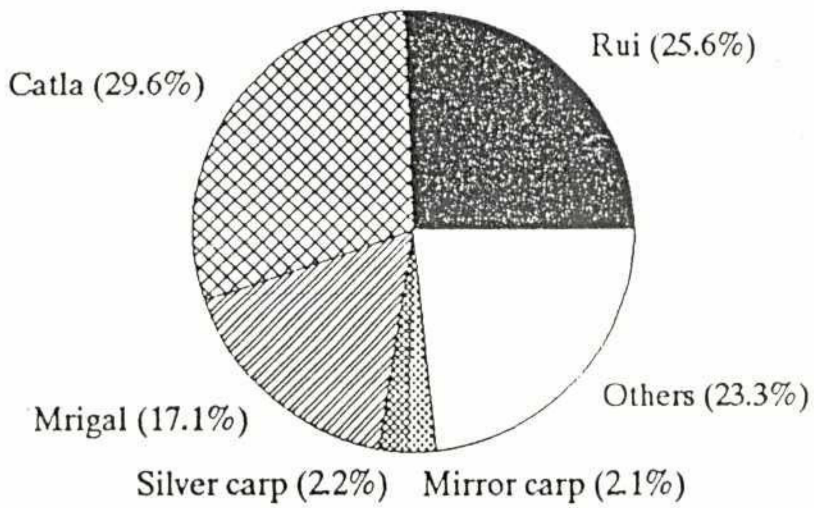
Figure 34

SPECIES COMPOSITION OF FISH PRODUCTION FROM PONDS
IN NORTHEAST REGION (four year mean 1985/89)



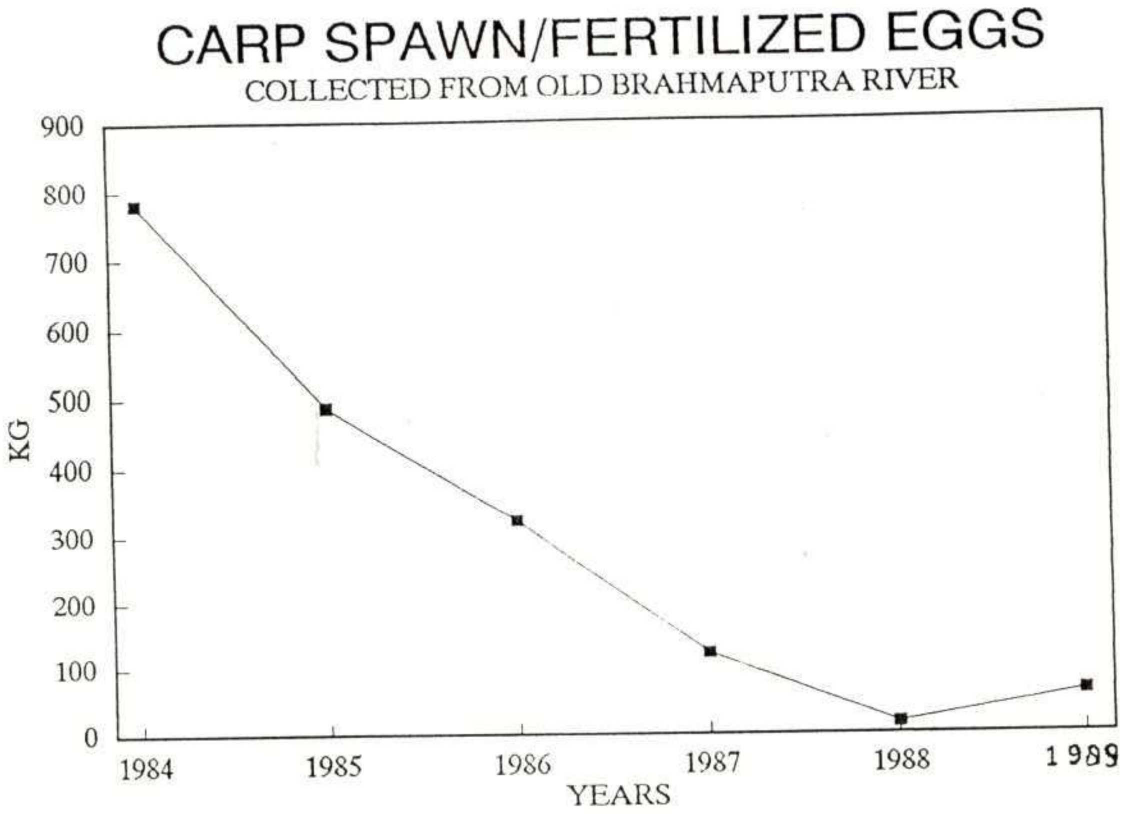
greater Sylhet District

Figure 35



greater Mymensingh District

Figure 36



Collected in May, June and July

Collection of natural carp spawn from the Old Brahmaputra to supply ponds has declined steeply, but a small recovery took place in 1989. This is a lucrative business as spawn can sell for up to Tk 5,000 per kg. Pond culture is further supported by 16 carp hatcheries in and around the region.

Excluding pond culture, the long term trend of <u>increase</u> in capture fishery production which the BFRSS data indicate for the region is at variance with sources of information in the field. Numerous interviews were conducted with fishermen, fish traders, leaseholders and DOF officials at district and thana levels. There is almost unanimity of opinion that fish production has <u>declined</u> significantly in the region over the last 10-15 years. The only species which appears to be increasing in production is Ilish. The region-wide decline in production is attributed to several factors:

- Siltation of river beds and deeper beels.
- Over exploitation of fishes, particularly use of fine-meshed net in tributaries affecting small fish species and fingerlings (March-April), and harvesting of boromaach broodfish in rivers (March-May).
- Annual fishing of the beels by complete de-watering (the present short term leasing system motivates lease holders to seek short term returns).
- Deforestation in the haor area. Only in two areas (Hakaluki haor and Tangua haor) have large *hijal* plantations been started.

UD

- Industrial effluents of Fenchuganj and Chhatak affect fish breeding.

- Poisonous plants used in India cause mass fish mortality in Sharighat and Juri river.

- Barriers to fish migration during the breeding season caused by FCD/I projects..

A special site-specific problem which appears to cause low fish production in the entire region is the bottlenecking of the Upper Meghna at Bhairab Bazar. Huge quantities of sand and silt are washed down from the hills in India due to deforestation. As a result, the downstream sections of rivers, haors, floodplains and beels are gradually silting up. The Upper Meghna near Bhairab bazar is the only outlet of the entire haor area. Slow drainage of the Upper Meghna at Bhairab bazar is due to siltation and prevents flushing of sediment out of the region.

Information from various districts confirms the declining trend in production. In Sunamganj District overall fish catch has declined markedly due to:

- Over exploitation of broodstock and nearly ripened fish.
- Mismanagement of annual and pile fisheries.
- Fishing by total de-watering (Dakban type fishery).
- Siltation of river beds and other water bodies.
- Restriction of easy migration during the spawning season (late March-June) by nets and FCD/I embankments.

In the Jamalganj area, the overall fish production in the area has declined by 40-50% over the last 10 years due to:

- Overfishing and annual fishing.
- Deforestation within the haor area. Expansion of agricultural land and fuel crises have led to rapid deforestation.
- Siltation reduces the water retention capacity of jalmohals (Bolhor beel has been silted up by this process).

In the Nabiganj area of Habiganj District, fish production has gradually declined due to complete de-watering of beels, overfishing, and sedimentation.

In Mohanganj area of Netrokona District, fish production has declined by 70-80% over the last 20 years. Some respondents mentioned that the rate of decline might have been 10-20% per year. The following causes are identified:

- Overfishing.
- Use of current jal and kona ber jal.
- Annual fishing.
- Short term leasing period.
- Transfer of jalmohals to non-fishermen.

Information from individual rivers also points towards a decline in production. In the Luba River area fish production is said to have declined at least 50-70% over the last 3-4 years. The suspected causes are mass mortality due to ulcerative disease, siltation of the river beds and overfishing. In the Ghorautra River near Bajitpur, fishery resources have declined about 70% over the last 5 years. Rui, Mrigel and Pangas once occurred widely in the Ghorautra river, but at present very few carp are caught and the catch of Pangas is more or less nil. In the Kangsha

River, fish biomass in the Jaria, Durgapur and Purbadhala area has declined by 75-80% over the last 10 years due to:

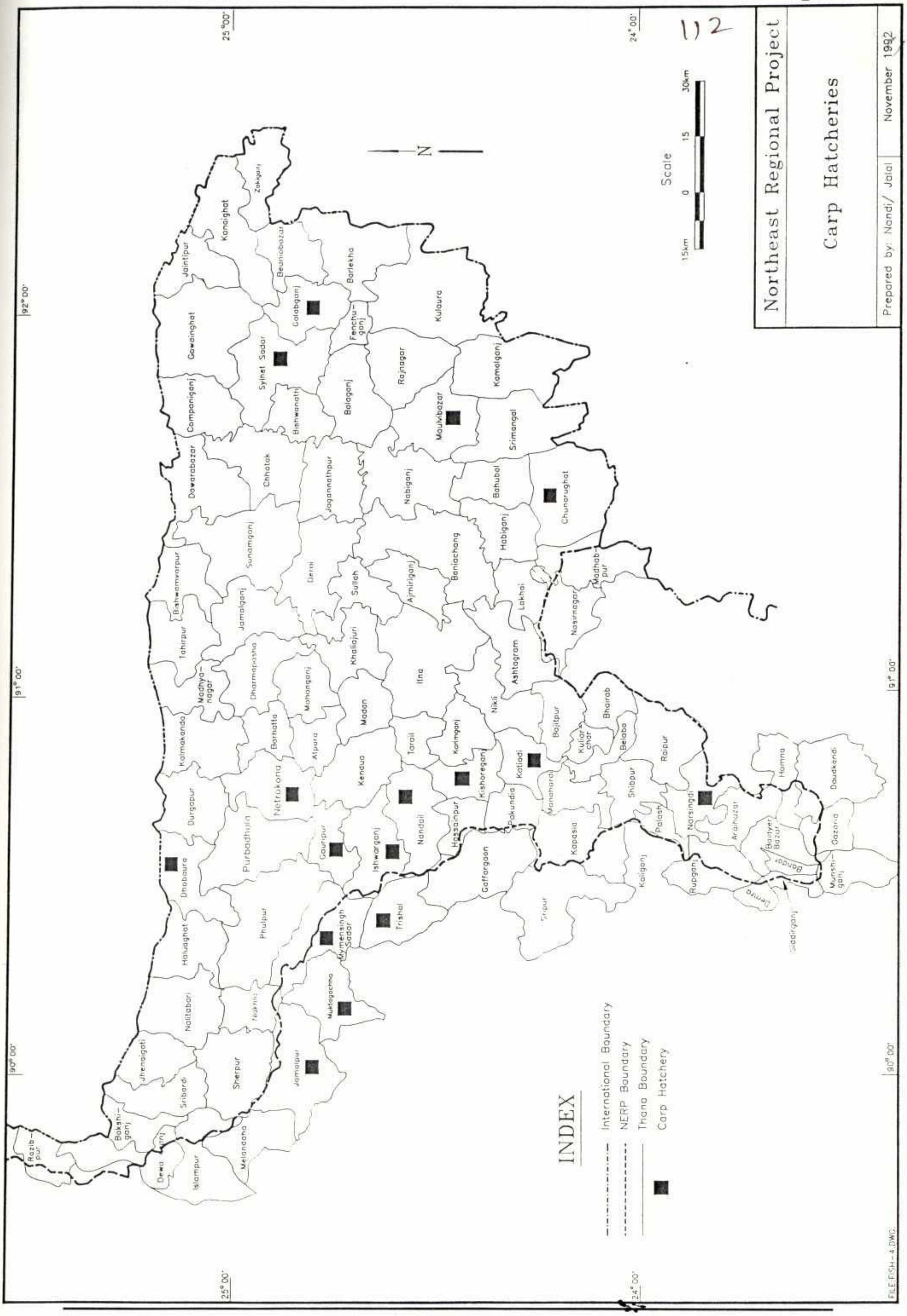
- High siltation rate in the river duars and major beels.
- Use of LLP for irrigation during the Boro crop season. As a result beels have dried up.
- Overfishing
- Deforestation within the beel area.
- Conversion of more land for agriculture, which resulted shorter water hectarage months.

Beel production has also suffered according to respondents. It is however difficult demonstrate any long-term trends based on statistical data. Recent production data from beels in Netrokona and Kishoreganj Districts are presented in Tables 2.16 through 2.18.

Table 2.16: Rajdhola Beel Production
Purbadhola, Netrokona District
Area: 32 ha

Species	Weight (kg)
Dec 1989 - Mar 1990	
Catla	246
Rui	260
Mrigel	117
Kalbasu	858
Ghonia	87
Boal	1210
Air	81
Shaol/gazar	87
Foli	167
Itcha	1059
miscellaneous	6490
Total	10662
Yield (kg/ha)	333

Species	Weight (kg)
Dec 1991 - Mar 1992	
Catla	357
Rui	468
Mrigel	275
Kalbasu	865
Ghonia	97
Boal	1,502
Air	169
Shoal/gazar	39
Foli	70
Itcha	580
miscellaneous	7,467
total (kg)	11,889
yield (kg/ha)	372


Northeast Regional Project
Carp Hatcheries
Prepared by: Nandi/ Jalal
November 1992
Scale
15km 0 15 30km
N
INDEX
International Boundary
NERP Boundary
Thana Boundary
Carp Hatchery
92°00'
91°00'
90°00'
25°00'
24°00'
Zakiganj
Kanaighat
Jaintiapur
Beanibazar
Barlekha
Golabganj
Gowainghat
Sylhet Sadar
Fenchuganj
Kulaura
Companiganj
Bishwanath
Balaganj
Rajnagar
Kamalganj
Moulvibazar
Srimangal
Dowarabazar
Chhatak
Jagannathpur
Nabiganj
Bahubal
Chunarughat
Sunamganj
Derai
Sullah
Ajmiriganj
Baniachang
Habiganj
Madhabpur
Lakhai
Bishwamvarpur
Jamalganj
Tahirpur
Dharmapasha
Khaliajuri
Nasirnagar
Madhyanagar
Mohanganj
Itna
Ashtagram
Nikli
Kalmakanda
Barhatta
Atpara
Madan
Tarail
Karimganj
Bajitpur
Bhairab
Kuliarchar
Belabo
Raipur
Durgapur
Netrakona
Kendua
Katiadi
Kishoreganj
Pakundia
Manohardi
Shibpur
Narsingdi
Homna
Daudkandi
Purbadhala
Gauripur
Ishwarganj
Nandail
Hossainpur
Kapasia
Palash
Araihazar
Gazaria
Dhobaura
Gaffargaon
Kaliganj
Rupganj
Baidyer Bazar
Bandar
Munshiganj
Haluaghat
Phulpur
Trishal
Sripur
Siddirganj
Mymensingh Sadar
Nalitabari
Nakhla
Muktagachha
Jhenaigati
Sherpur
Jamalpur
Sribardi
Bakshiganj
Melandaha
Razibpur
Dewanganj
Islampur
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113

Table 2.17: Fhalia Beel
Ishorganj, Mymensingh
Area: 16ha

Species	1990-91 Production (kg)	1991-92 Production (kg)
Catla	387	485
Rui	525	313
Mrigel	180	218
Kalbasu	977	1155
Ghonia	438	564
Boal	928	1214
Air	65	110
Shoal	56	212
Chital/Foli	33	46
Koi/Shingi Magur	15	33
Misc	3110	4203
Total (kg)	6713	8552
Yield (kg/ha)	420	535

Table 2.18: Nala Akamara Beel
Ishorganj, Mymensingh
Area: ha

Species	1990-91 Production (kgs)	1991-92 Production (kgs)
Catla	215	303
Rui	326	135
Mrigel	112	128
Kalbasu	684	713
Ghonia	353	307
Boal	613	768
Air	42	57
Shoal	15	25
Chital/Foli	10	30
Koi/Shingi/Magur	5	10
Misc	1014	1872
Total (kg)	3387	4346
Yield (kg/ha)		

BFRSS reports average yields of 582 kg/ha from all Sylhet District beels and 476 kg/ha for all Mymensingh District beels in 1989/90.

These yields (kg/ha) may be compared to those presented in MPO (1987) and Tsai and Ali (1987) and reproduced in Table 2.19.

Table 2.19: Yield of Beel Fisheries

Year	Beel	Location (District)	Fishery Type	Yield (kg/ha)
1967	Gacherdahor	Sylhet District	7 year pile	5,135
	Awara	Dharmapasha (Sylhet)	3 year pile	294
	Karchar	(Sunamganj)	3 year pile	354
	Bhogli	Itna, (Mymensingh)	3 year pile	240
	Sukchan (Chandina)	Itna, (Mymensingh)	3 year pile	1750
	Kawnai	Dharmapasha (Sylhet)	Annual	406
	Borokanglar	(Sunamganj)	Annual	1335
	Chotokanglar	(Sunamganj)	Annual	367
	Nagua Dhali	Kulaura, (Moulvibazar)	Annual	151
	Gurkuri	Kulaura, (Moulvibazar)	Annual	74
	Patia	Hail Haor, (Moulvibazar)	?	1945
1983-84	Noya	Hail Haor, (Moulvibazar)	?	1974
	Char	Hail Haor, (Moulvibazar)	?	1772

Source: MPO (1987)

The wide range of variation in yield statistics makes it difficult to draw any firm conclusions about beel production trends.

Some data for subsistence fish catches for Chardullava (Old Brahmaputra basin) is presented in Table 2.20. It is the average for 10 subsistence fishermen. The main reason for low production in 1988 and 1989 was ulcerative fish disease.

115

2.5.3 MSY and yield estimates

No estimates have previously been made of overall fish standing crop or potential yield for the region. Because fish stocks are on the whole not rigidly tied to any one major aquatic habitat and can still move relatively freely between rivers, floodlands and beels in much of the region, standing crop estimates for discrete habitats are limited in their usefulness from the prospectus of the entire floodplain (which still largely functions as a single holistic, dynamic and integrated system in the region). It is probably true to say that for many species any individual fish specimen represents a biological production composite originating from river, beel and floodplain habitats.

Table 2.20: Fish Catch for Chadullava

Month	Average Monthly Catch (kg per fisherman)			
	1988	**1989**	**1990**	**1991**
Jul	1.5	2.5	4.9	1.7
Aug	1.0	6.3	1.8	1.8
Sep	3.5	7.0	7.5	4.5
Oct	2.5	2.5	3.8	4.7
Nov	5.0	1.4	9.8	8.5
Dec	4.5	3.8	8.6	10.0
Total	18.0	23.5	36.4	31.2

An empirical approach to obtain a robust first approximation of MSY is to equate catch with maximum area flooded, or MAF (Welcomme, 1985). The relationship determined from catch and area data for 25 tropical floodplains exploited at a substantial level of intensity is:

$$C = 4.23\ A^{1.005}$$

where: C is catch in tons
A is area in sq km

The range of yields fall between 40 and 60 kg/ha/yr.

The area of the region occupied by flood prone landforms (see Section 2.1.4) is 21,710 sq km. Regional MSY is empirically predicted as 96,500 tons (yield of 45 kg/ha/yr). Nominal capture fishery production from the region is between 80,000 and 97,000 tons (nominal yield range of 37-45 kg/ha/yr). This encompasses the empirically predicted MSY, and would indicate that the region's fish stocks, according to BFRSS statistics, are being harvested at about the MSY level.

The unanimity of opinion that catches in the region are declining suggests that the real production level is probably significantly less than the empirically predicted MSY level. However, another interpretation is possible. If one accepts the World Bank assertion that subsistence catch statistics underestimate the real level of yield then the real overall regional yield may currently be in the range of 55-60 kg/ha/yr. If yield has indeed been declining over the last two decades, then yields several decades ago may have been as high as 70-100 kg/ha/yr before overfishing and environmental degradation from FCD/I and non-FCD/I factors began impacting the fish stocks.

It is interesting to note that, in general, year to year % changes in nominal river and flood land fish production are much greater than fluctuations in beel fish production. The average % change in any direction of the Upper Meghna is ±14.1%, other rivers ±15.8%, and flood lands ±20.5%. Beels in contrast vary only ± 4.6%. This is most probably due to a general difference in lotic and lentic habitats arising from hydrological variables driving fish production. Variation in catch of rivers is a function of river discharge, and flood land catch is a function of area flooded. Both of these hydrological indices can vary widely from year to year. Beel area, after flood recession, is probably more constant from year to year and the carrying capacity is probably fixed within a narrow range.

2.5.4 Effects of fishing effort on fish production

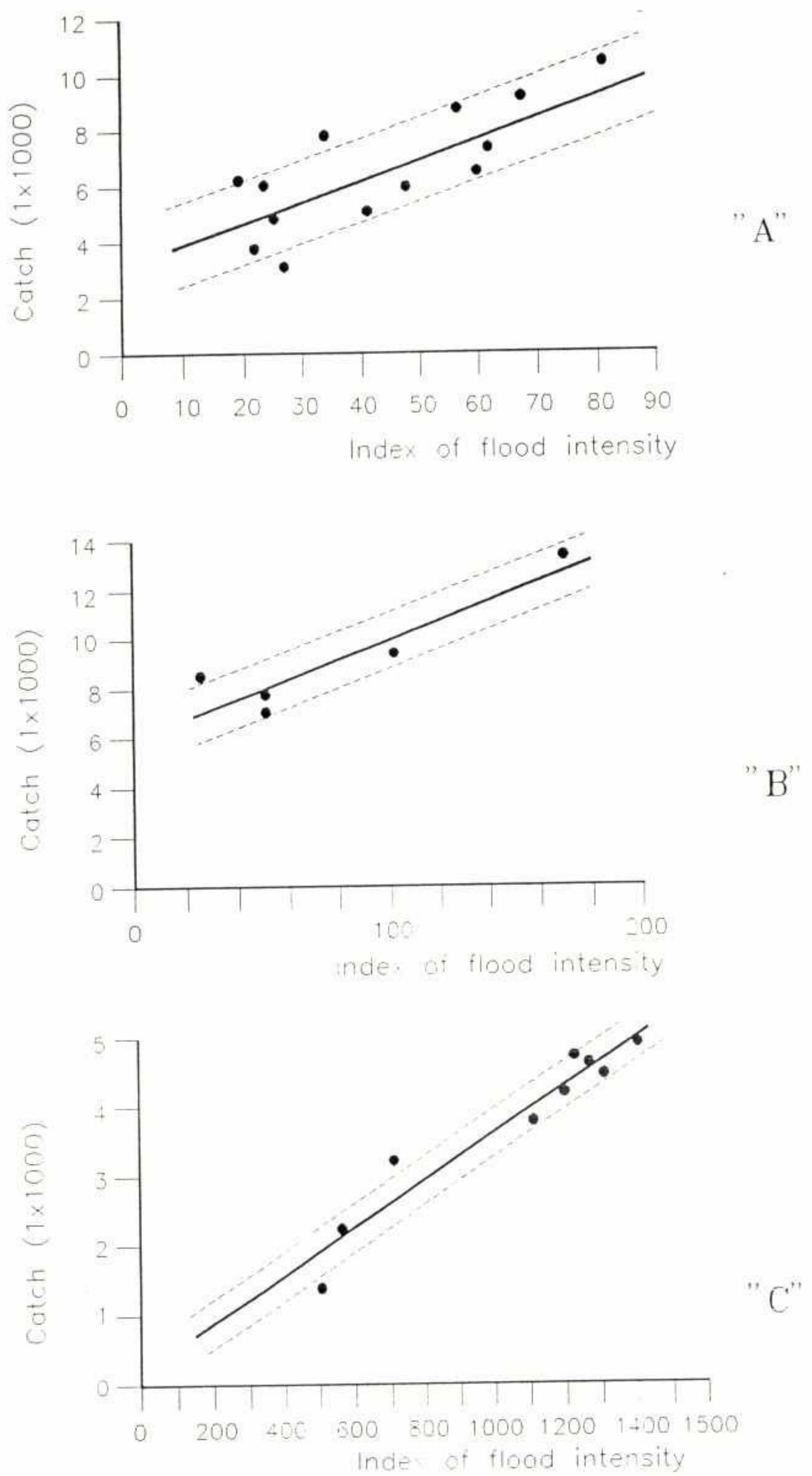
Welcomme's (1985) catch-versus-effort model of a multi-species floodplain fishery indicates that total catch reaches a broad plateau that is sustainable over a wide range of fishing effort before finally collapsing. The model would predict that the floodplain fisheries of the region will move beyond the plateau level of sustainability if the level of fishing effort increases beyond a critical threshold. Unfortunately, no reliable estimate of the level of fishing effort is available or can easily be developed for the region. It is not clear to what extent the current level of effort approaches the critical threshold, although population growth in the region certainly suggests that the situation may become critical within perhaps a decade.

The observed relative increase in proportion of miscellaneous species (which are mostly chotomaach) would appear to be in agreement with conventional wisdom which predicts that FCD/I will drive species composition towards small species. However, a change in the species composition from larger to smaller species is a normal feature of heavily exploited floodplain fisheries which is unrelated to FCD/I (except in cases where FCD/I increases the catchability of fish stocks). Tsai and Ali (1985, 1987) presented evidence that major carp stocks in beels in the region were being severely depleted by overfishing. "Fishing out" of larger slow growing species certainly appears to be taking place everywhere in the region and affects both predatory species (ie large catfish) and non-predators (ie major carps). This is likely due to intensification of beel harvesting by leaseholders (annual and biennial harvesting of katha) and general intensification of subsistence fishing due to the increase in population, rather than a direct FCD/I effect. The declines in carp and catfish production evident from the statistical data suggest that the high levels of fishing mortality on carp and large catfish exceed the level sustainable by the stocks. Removal of large species from the environment can be expected to create more "ecological space" for small species (which have a faster turnover rate).

2.5.5 Effects of environmental variables on fish production

Significant year to year variation in catch is a normal feature of floodplain fisheries. Studies on tropical floodplain fish production dynamics in other parts of the world have shown that a major part of this variation can be attributed to annual variation in flood intensity. In the region, lack of sufficient water on the floodplain during the 1992 monsoon resulted in a shorter grazing period and facilitated overfishing. Overall fish production in the Chamraghat area, for example, was at least 30-35% lower than the previous year. Most of the retailers in the ghat stated that fish were on average 30-40% smaller compared to the same time (September) in 1991. Similar slow growth was observed in Shanir Haor in 1992. AFI report low water levels and reduced fish production in 1992 for the Kaliajuri and Ajmiriganj areas. Further evidence of a causal relationship between flood intensity and fish production is the region-wide recovery of carp catches in 1988/89, which was probably due to the heavy flooding in 1987 and 1988. This implies that even if carp stocks and other fish stocks are over-harvested, they have a capacity to recover during periodic heavy flood years.

Figure 38



Northeast Regional Project

Best-fit regression lines for the relationship between catch and flood regaime for: (A) the Kafue Flats; (B) The Shire River;(C) the Central Delta of the Niger at Mopti (from Welcome-1985)

Prepared by BNP/Mamun | April 1993

FILE: FISH-56.DWG

The most general index of flood intensity in the region is the discharge of the Upper Meghna at Bhairab Bazar. Regression analysis was performed using DOF/BFRSS capture fisheries production data for the region (Appendix E) and AFI fish purchase and export data (Section 2.6.3 below). The best correlation of mean discharge from June to October was with AFI finfish exports of the same year plus the following year (0.02 > P > 0.01), highlighting the importance of both the rapid turnover of chotomaach production and the one or more year lag effect of slower growing boromaach. This is presented in Table 2.21.

Table 2.21: Correlation of Mean Discharge with Fish Production

Data Source	Fishery Statistics	Regression Coefficient r	Degrees of Freedom	Probability
AFI	Finfish purchased (year x)	0.588	5	P>0.1
	Finfish purchased (year x+1)	0.115	5	P>0.1
	Prawns exported (year x)	0.429	8	P>0.1
	Prawns exported (year x+1)	0.492	8	P>0.1
	Finfish exported (year x)	0.612	8	0.1>P>0.05
	Finfish exported (year x+1)	0.662	9	0.05>P>0.02
	Finfish exported mean of (years x and x+1)	0.743	8	0.02>P>0.01
DOF	Capture fisheries regional total (year x)	0.565	4	P>0.1
	Capture fisheries regional total (year x)	0.088	4	P>0.1

The analysis suggests that AFI data is of relatively higher quality compared to DOF/BFRSS data. The poor correlations with AFI finfish purchases and prawn exports may be due to market effects, rather than biological effects.

Several environmental factors of anthropomorphic origin have significant effects on floodplain fish production:

- Sewage: Population increase is leading to an increase in the production of domestic sewage. Almost all of the sewage enters the aquatic environment. This nutrient loading likely results in a general increase in primary and secondary production, and in turn fish production. This factor should therefore be generating a continuous increase in fish production, paralleling human population growth (1.8% per annum over the last 10 years).

११४

- Fertilizer: Intensification of agriculture is leading to increasing application of fertilizer in the region. A portion of this fertilizer enters the aquatic environment, either directly or as nutrients from decomposing or otherwise transformed crop wastes (more precisely, that portion of wastes representing the marginal increase in crop production due to the application of fertilizers). The increase in nutrients from fertilizers can be expected to result in increases in fish production. High rates of application of nitrogen fertilizers might however over-eutrophicate the aquatic environment, leading to a depression of fish production.

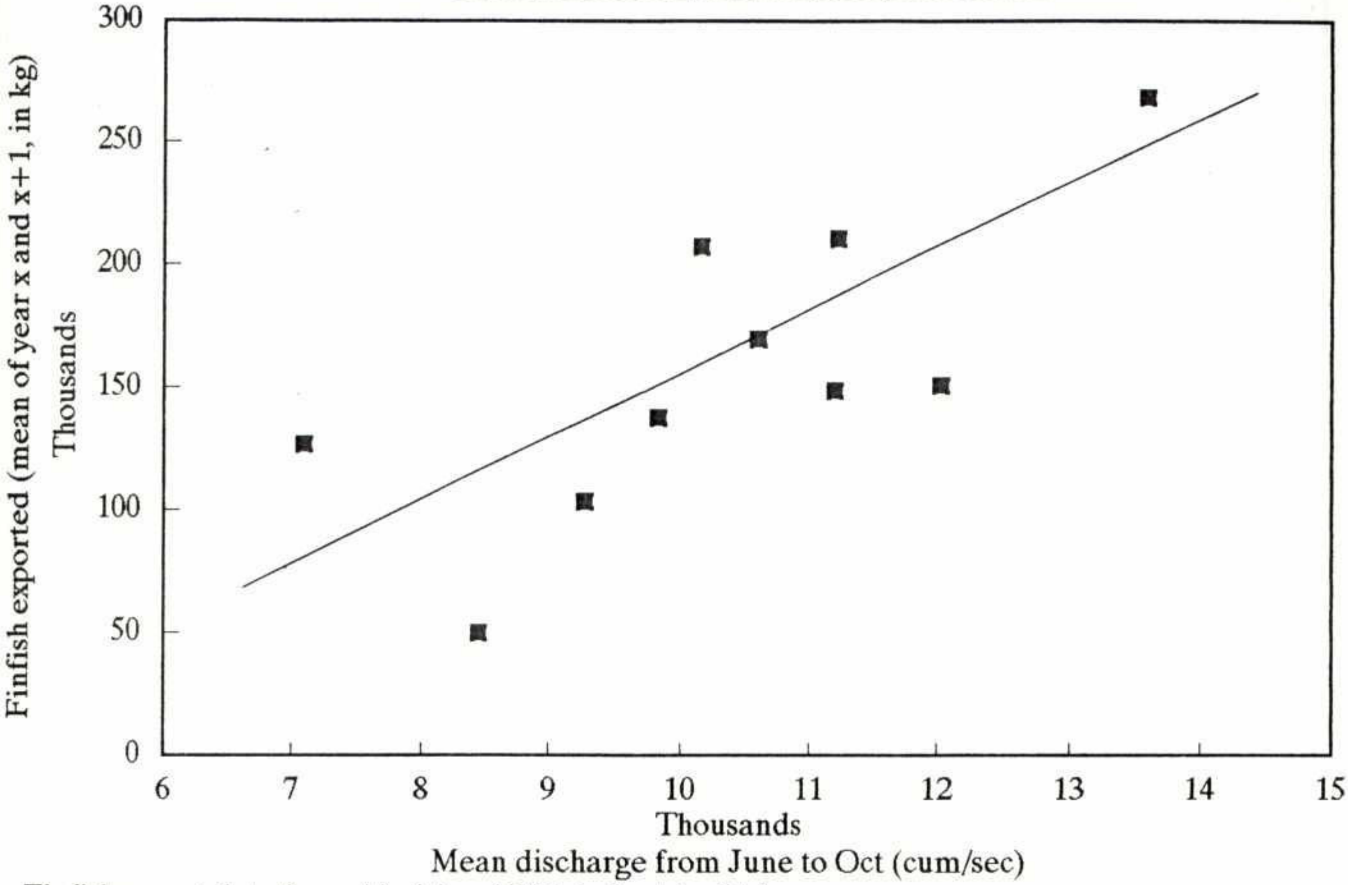
- Pesticides: Agricultural intensification invariably leads to increasing use of pesticides and residues in the environment. Lethal and sub-lethal impacts of pesticides will reduce fish production.

- FCD/I projects: When operating according to design, these major environmental engineering works alter the hectare-months of inundation to create an artificial environment conducive to agricultural production. Submersible embankments reduce flood duration but do not change area flooded. Full flood embankments significantly reduce area flooded and flood duration. In both cases, the result quasi-mimics natural variation in flood intensity caused by variations in river discharge and direct rainfall, but the effects are much more severe in the case of full flood embankments. The reduction in hectare-months of inundation can be expected to lead to a decrease in fish production. However, the inadequate level of operation and maintenance of projects and frequent public cuts of embankments act to mitigate some of the negative effects on fisheries production.

- Sedimentation: The high level of sedimentation in the region can be expected to have a negative effect on fish production. Increased sedimentation is the result of deforestation in the upland catchment. FCD/I projects alter the pattern of sediment deposition on the floodplain, and especially severely affect prime fish refuge habitat through infilling of river duars. High turbidity reduces primary production (photosynthesis) and deters fish migrations. Sedimentation has only come to be regarded as a significant problem in the last few decades. The trend has been towards increasing sedimentation, and this would result in a decreasing trend in fish production.

- Industrial effluent: Inadequately treated effluent discharges from the Chhatak pulp mill and the Fenchuganj fertilizer plant cause lethal and sublethal toxicity in fish in the Surma and Kushiyara Rivers, respectively. These losses in fish production began abruptly at start-up of each plant and will continue until such time as there is an improvement in effluent treatment or the plant(s) close.

CORRELATION BETWEEN FINFISH CATCH AND
UPPER MEGHNA RIVER DISCHARGE



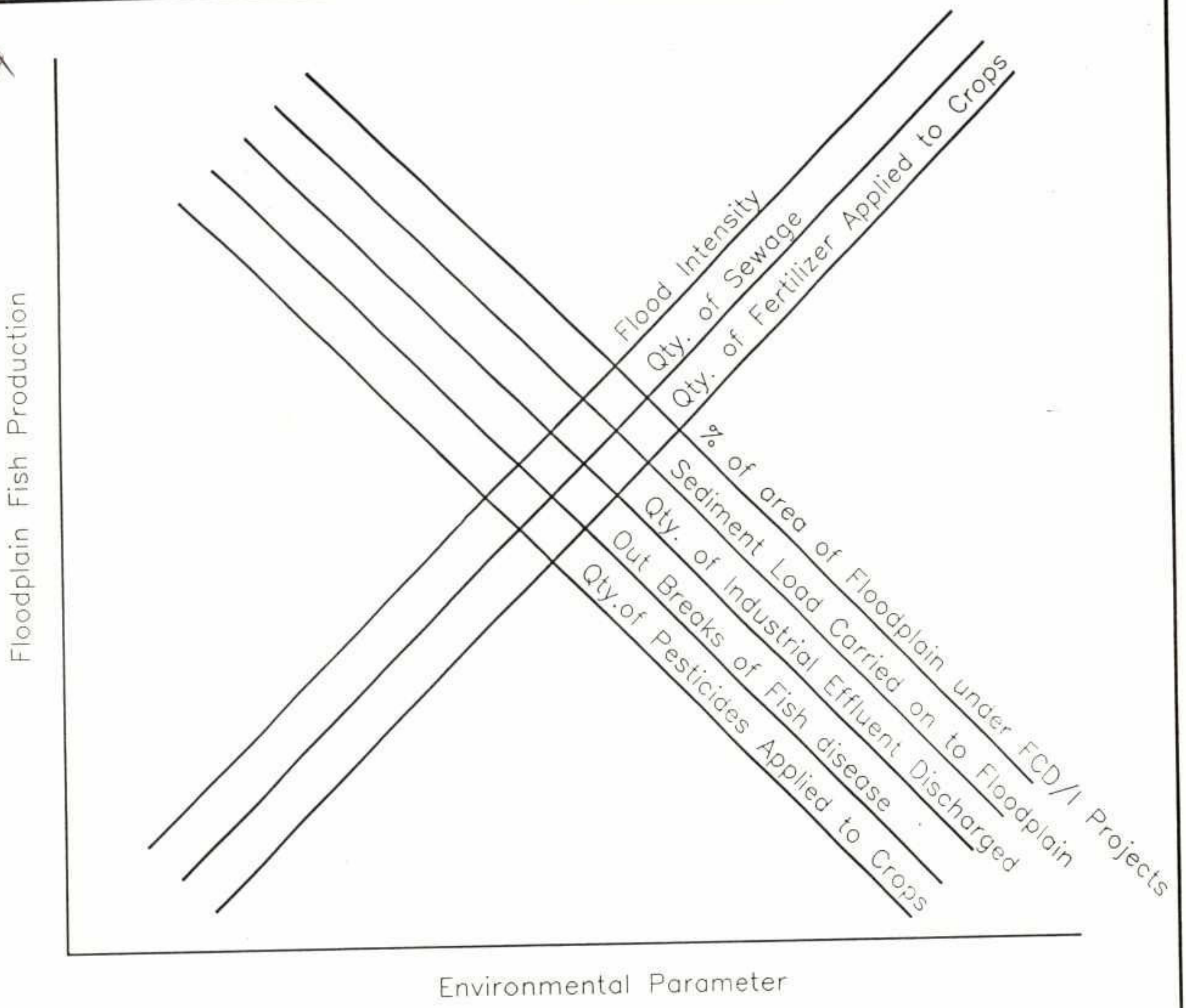
Finfish export data from Ajmiriganj Fish industries Ltd
$Y = 24.7X - 98{,}045 \quad r = 0.743 \quad df = 8 \quad 0.02 > P > 0.01$

- Fish disease: Severe outbreaks of epizootic ulcerative disease and massive fish mortalities appear to be induced by deteriorating water quality under stagnant water conditions in some beels, khals and borrow pits during the late monsoon and the dry season. This results in a loss of fish production. Deteriorating water quality is especially significant in full flood protection FCD/I project, and somewhat less so in partial flood protection FCD/I projects. Stagnant water conditions, coupled with increased fertilizer application, leads to massive proliferation of aquatic macrophytes. The subsequent death and decomposition of this heavy load of organic plant material leads to severe changes in water chemistry (acidification, oxygen depletion, heavy metals release from sediments) which weakens fish and reduce their ability to resist infection.

Construction of a predictive model which incorporates all eight of the above natural and man-made environmental parameters would be a difficult task because of the complexity of the interactions (many of which are not discreet but interdependent). The poor quality of the available data would introduce a very high statistical error which would likely reduce the efficacy of the model (or even invalidate it entirely). A predictive model of FCD/I impacts is formulated in Section 3.1.5 below for purpose of project pre-feasibility studies. However, comprehensive feasibility studies will have to take into account the non-FCD/I impacts which may come about as a result of an FCD/I project initiative and these cannot be readily evaluated by quantitative modelling.

Figure 40

121



NOTES: 1. End point effects on the left and right sides of the graph are not shown. In some cases, a reversal of directions of the relationship can be expected (i.e. very high rates of fertilizer application may deprese fish prodection).
2. In a predictive model a measure of industrial effluent would be developed which takes into account the different levels of toxicity of various effluent types.

Northeast Regional Project

Composite representation of the theoritical effects of eight important perameters on floodplain production

Prepared by:	BNP	April 1993
Drawn By:	Mamun	AutoCAD Drawing

FILE: FISH-60.DWG

2.5.6 Economic aspects of fish production

It is difficult to get real economic production data about river duar and beel fisheries. Some information was collected by interviews with fishermen and lessees during field visits in Ajmiriganj, Kaliajuri, Sylhet, Goyainghat, Companiganj and Dwarabazar areas. This information was used to make a preliminary estimate of the economic value of production.

Fisheries in river duars: Generally individual duars are not leased out separately for harvest. Instead, discreet river stretches are leased out as jalmohals and any existing duars are included in the stretches. (For example, the Kalni River section number 84/2 is 2 km long and contains two duars.) Katha are usually installed around the duars. Before starting the harvest, fishermen close off each end of the leased stretch with nets. These are gradually pulled up close to the katha. During that period they fish mainly by using Uthar jal. Harvesting continues for 1-2 months (depending upon water current and rainfall) from December to February.

Summarized economic production information for river duars is given in Table 2.22 below.

Table 2.22: Economic Production Data for River Duars

River Name	River Reach	Ave Yield* (Kg/reach)	Yield Value** (tk)
Surma	Chatak to Sunamganj	2500	1,50,000
Dhanu/Baulai	Jamalganj to Itna	8640	5,18,400
Piyain	Laipsa, Khaliajuri	13440	8,06,400
Kushiyara/Kalni	Sherpur to Ajmiriganj	9600	5,76,000
Ghorautra	Bajitpur	5760	3,45,600
Upper Meghna	Bhairab to Astagram	9600	5,76,000

* Yield for 1.5 - 2 km reach of river where duars exist.

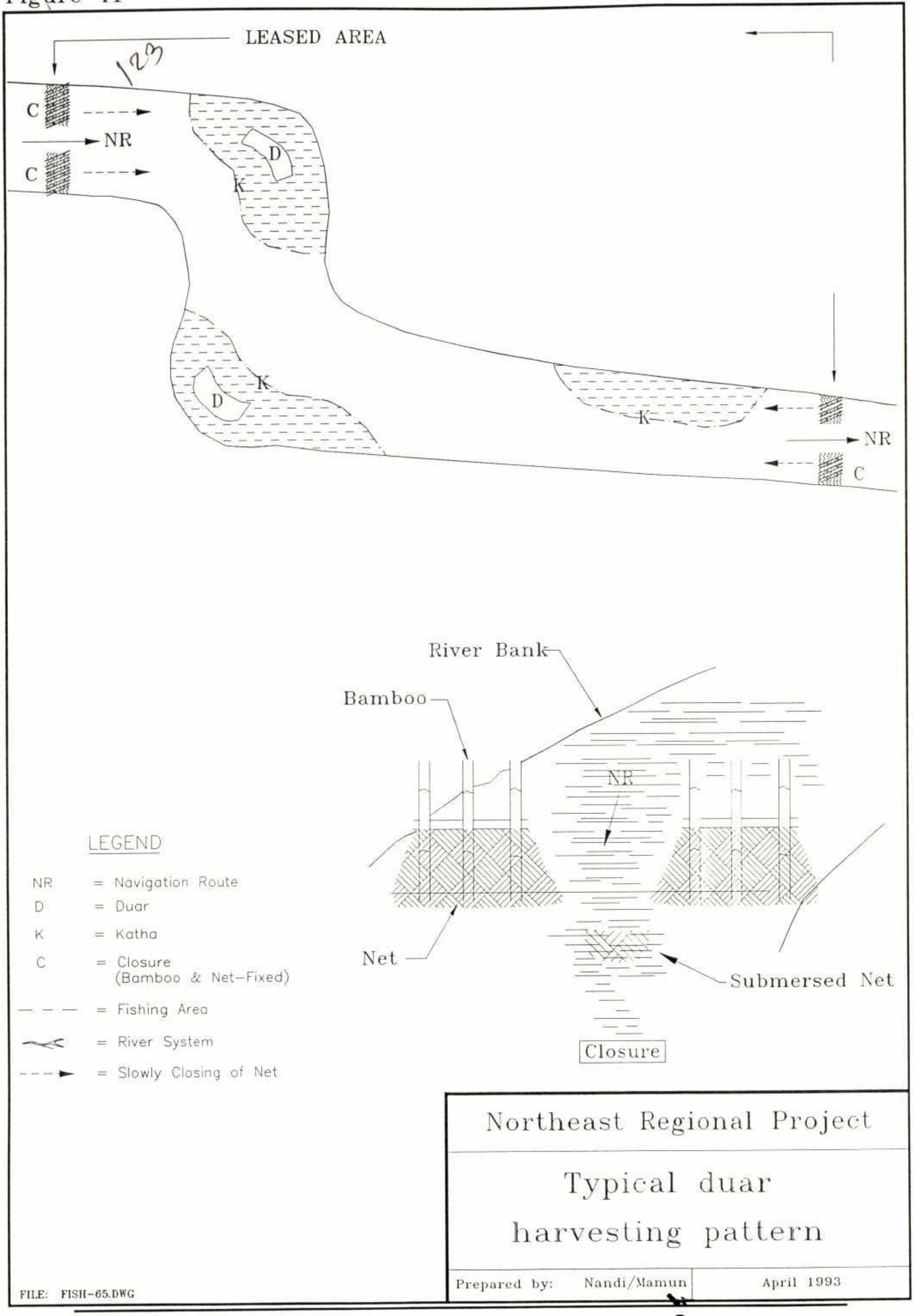
** Assuming an average fish price at the *Khola* of Tk 60/kg (average for *chotomaach* and *boromaach*).

River systems with duars are important overwintering grounds for brood fish. It is estimated that (based on fishermen's experience) *boromaach* constitute 50-60% of landed weight and *chotomaach* 40-50%. In value terms, *boromaach* constitute 70-80% of the total catch. Based upon this data it is possible to roughly estimate the overall production capability of a particular river system where important duars as well floodplains exist.

Actual fish production realized depends on a number of factors:

- The duar and the adjacent river need to be protected from poachers and mechanical disturbance.
- A nearby undisturbed floodplain is required for breeding and grazing.

Figure 41


LEASED AREA
C
NR
C
D
K
D
K
K
NR
C
River Bank
Bamboo
NR
Net
Submersed Net
Closure
LEGEND
NR = Navigation Route
D = Duar
K = Katha
C = Closure (Bamboo & Net-Fixed)
= Fishing Area
= River System
= Slowly Closing of Net
Northeast Regional Project
Typical duar harvesting pattern
Prepared by: Nandi/Mamun
April 1993
FILE: FISH-65.DWG

An example of the production capability of a river duar is Dwarabazar duar near Dwarabazar market in the Surma River (in the vicinity of Konoskai beel and Dekker haor floodplain - which is a breeding ground of many fish including carp):

- Average yield is 2500 kg fish (Boromaach 1500 kg and chotomaach 1000 kg).

- Production capacity: Assume 40% are female (600kg) and 60% are male (900kg) fish (boromaach). Also, assume, out of 600kg of female fish, 50% would be capable of breeding in the following year (which means 300 kg matured brood).

- Spawn production is 1 kg from an 8 kg female. Thus 300 kg active females yield about 37 kg spawn (0.2 million spawn = 1 kg; 37 kg = 7.4 million spawn).

Floodplain fish productivity (survival and production) may be calculated as follows:

- Spawn to fry (10%) = 0.74 m
- Fry to fingerling (30%) = 0.22 m
- Fingerling to adult fish (40%) = 0.08 m
- Expected average fish weight = 0.75 kg
- Total production = 66,600 kg
- Value of production = Tk 4,000,000 (at Tk 60/kg)

Thus, each river section having a good overwintering ground would be capable to produce about 66 mt fish valued at about Tk 4 million, as well as a large quantity of economically important *chotomaach*.

- Fish migration routes need to be protected particularly during the breeding (April-June) and overwintering (September-October) migration period.

- A ban on brood fish and immature fish harvesting using current *jal, kona jal* and *jam jal* needs to be enforced.

A case study of pile fishing was made in the upper stretch of the Baulai. The fishery is under NFMP with 84 licence holders. It consists of six small annually fished katha and two large piles fished once every two years. Fishermen managing the fishery are organized by Mr. Rhakhesh Das. They are financially supported by Md Ali Nur who has been involved in the fishery for the last 25 years. The base of operations is Ghuthir khola. The fishery was placed under NFMP in 1990. In early 1991 they harvested the fish from this area and then they installed piles of about 300 m length. *Hijal, Koroch, Barun, Sheora* and Mangosteen (*gab*) were used for the *katha*, with bamboos used to fix the katha in place. The total cost of the *katha* was about Tk 1,50,000 (Tk 100,000 for branches and Tk 50,000 for bamboo). The licence fee of the fishery is Tk 38,000 per year. Piles are installed for only two years. There are no other three year piles in the river, so the fishermen are afraid of losing fish to other fishermen who would harvest their *katha* annually. There is also a fear of poaching from fishing gangs, and three or four guards are recruited for each katha at a cost of Tk 1,000 per guard per month.

Table 2.23: Economic Data
Medhol and Rui Beels (1991/92)

Economic Parameter	Category	Amount (Tk)
Total Income		11,500,000
Production Cost	Lease fee to the Government	1,000,000
	Katha installation	500,000
	Guarding	1,000,000
	Fishing	1,000,000
	Sub-total	3,500,000
	Bank interest (12%)	420,000
Net Income		7,580,000

After erecting the *khola*, the *katha* are harvested within a matter of a few days. A *Chouhanda jal* is used to surround the *katha*, and *Ural jal* are set on bamboo poles above the water line to catch leaping carp. During the field visit, 15 *Rui* with a combined weight of 60 kg were caught in the *Ural jal* when they tried to jump out of the surrounded area during harvesting one of the *katha*. During the study, these were the only large fish observed. Fishermen estimated that the total value of the pile production would be more than Tk 1,500,000. Md. Ali Nur will get 40-50% of the total.

The fishermen were not confident that GOB policy would help them retain possession of the fishery. They requested that GOB take necessary measures to protect the natural fisheries resources. Considering the various forces driving fish stocks down, alternatives which impact positively on fish production and conservation such as provided by the pile fishing system should be encouraged. Unfortunately this fishing method is being replaced by annual fishing since the competition to exploit the resource is increasing. Presently, very few pile fisheries are operating in this area though it was a common fishing practice only a few years ago.

Table 2.24: Catch Composition
Medhol and Rui Beels (1991/92)

Species	**% of Total**	**Weight (kg)**
Carp	40%	78,419
Boal	20%	39,209
Air	10%	19,605
Misc	30%	58,814
Total	100%	1,96,047

Notes: Production Rate: 692 kg/ha/3 year pile
Rate of Return: 193%

Katha fisheries in beels: Medhol beel and Rui beel (total dry season area of 283 ha) are located on the Mehol Haor floodplain on the west side of the Sylhet-Jaintiapur road. Both beels are maintained under the pile fishery management system. Economic data provided by the lessee of the beels is presented in Table 2.23 and 2.24.

A case study of fishing in rivers around Itna showed that fishermen mainly operate *konaber jal*. To make one net (200 m x 170 m) costs about Tk 50,000. One boat is required with 8 persons working as a fishing team. The average daily income ranges from Tk 200 to Tk 1000. Usually fishermen can get a loan for the net, and the loan is repaid in instalments. In addition, fishermen also pay 50% of the daily catch to the money lender (*Matabbar*). By the time the net loan is fully paid off, the net has reached the end of its lifespan and needs to be replaced.

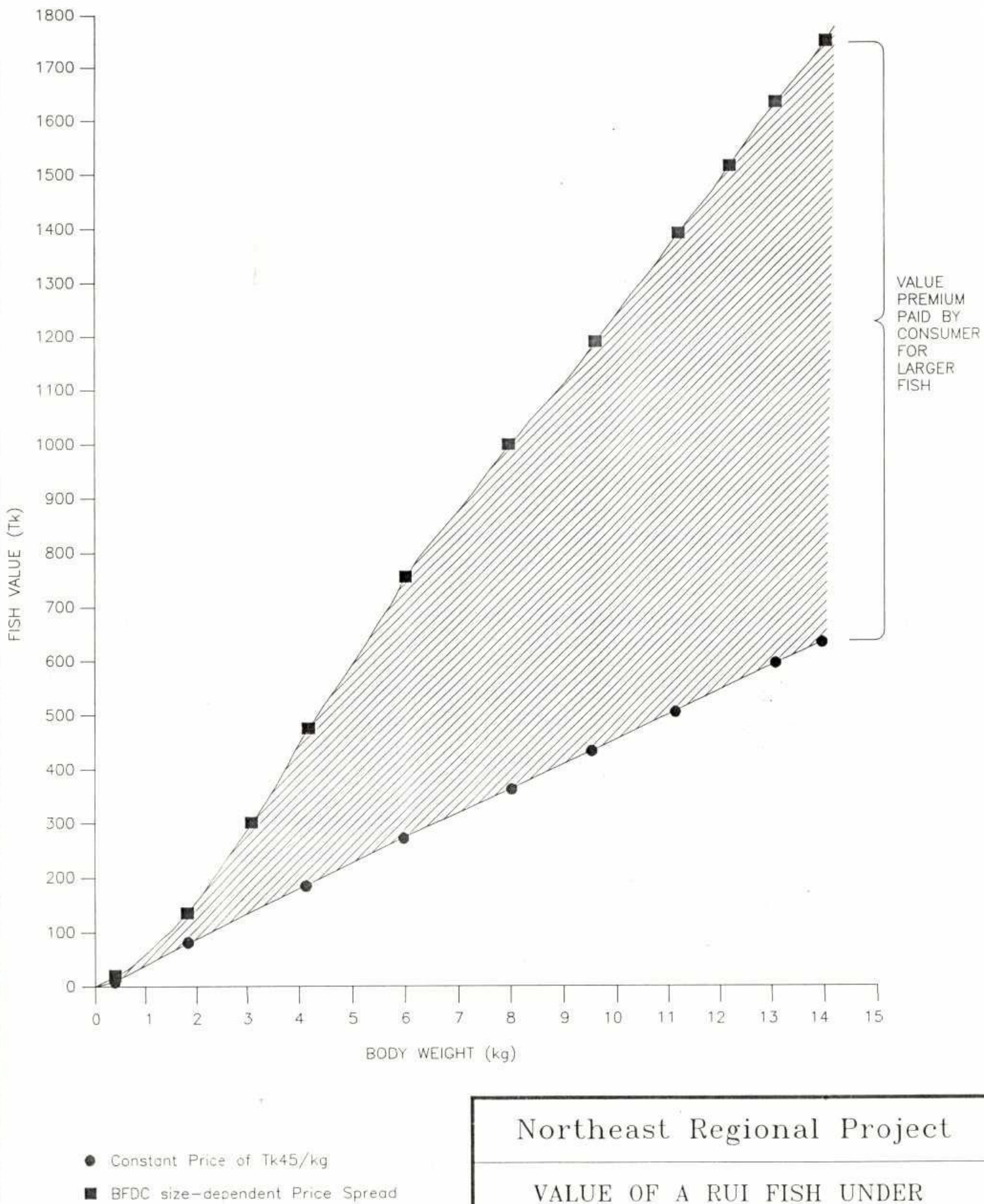
Fish price and harvesting regimes: A market factor which is of potential importance in management of boromaach fisheries is the progressivity of price structure. The price (Tk per kg) of a large individual of virtually any boromaach species is higher than that of a small individual of the same species. BFDC fish prices (see Appendix G, Section G.1.13) indicate that a 0.5 kg rui sells for Tk 23 (at Tk 45/kg), but a 4 kg rui sells for Tk 460 (at Tk 115/kg). The latter would only be worth Tk 180 if price were constant at Tk 45/kg over the whole size range. Thus the consumer pays a premium of Tk 280 over the constant value price for the larger fish (see Fig. 42). This is due to the perception that larger fish have a better taste and yield more flesh.
This price structure gives a clear market incentive to producers to harvest fish of larger size (and thus greater age), and would be expected to promote more rational fisheries management. An economically rational commercial fisherman would be expected to take advantage of this price spread and allow his fish to grow to some particular (optimal) size which maximizes their net value. Despite this market incentive to allow fish to grow larger, there is widespread harvesting of juvenile/undersized boromaach in the region. An analytic attempt was made to determine if there were any underlying driving forces responsible for the evident delinking of harvesting practices from market incentives.

Biological data from Khan and Jhingran (1975) and price data from BFDC was used to determine the optimal economic size of harvest for rui:

Table 2.25: Optional Economic Size of Harvest for Rui

AGE (years)	LENGTH (cm)	WEIGHT (kg)	GROSS VALUE in Tk (@Tk45/kg)	GROSS VALUE in Tk (BFDC prices)	% ANNUAL INCREASE (BFDC gross value)
0	0	0	1	1	-
1	31	0.38	17	17	1,600%
2	50	1.8	81	144	747%
3	65	4.1	185	472	228%
4	74	6.0	270	750	59%
5	80	7.9	356	988	32%
6	85	9.4	423	1,175	19%
7	89	11.0	495	1,375	17%
8	92	12.0	540	1,500	9%
9	94	12.9	581	1,613	8%
10	96	13.8	621	1,725	7%

Figure 42



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Northeast Regional Project

VALUE OF A RUI FISH UNDER TWO DIFFERENT PRICE STRUCTURES

Prepared by: GMB	June 1994
Computer Drafting by: Mamun	AutoCAD Drawing

As an individual rui ages, its annual increment in weight decreases somewhat. The annual increment in value also decreases, but gross value continues to increase every year. It is reasonable to assume that the decision to harvest the fish is not based on the maximum possible gross value it could potentially reach (although by age 20 years value increments will be less than 1%), but on the fisherman's need to convert his biological capital (ie the fish) into liquid assets (ie cash). The decision to harvest (or not to harvest, but to allow the fish to continue growing an additional year or more) would be based on a comparison of the fisherman's need for cash in the present (realizable as the current value of the fish) with the expected value of the fish in the following year (expressed as discounted net present value of the fish).

In order to gain an insight into the relationship between maximizing economic benefits and biologically rational harvesting of boromaach, a simple simulation model of a rui fishery was constructed. The simulation assumed that fish are being harvested for commercial sale, and there is no direct pressure for consumptive use by the fisherman (thus the simulation does not apply to a chotomaach subsistence fishery). All simulated fisheries start off in year 0 with 1000 fish, and undergo four different annual natural mortality rates: 0% as a benchmark; 10% for an extremely well managed fishery; 25% for a reasonably managed fishery; 50% for a poorly managed fishery; 75% for an ailing fishery. Fishing mortality is a total harvest once-only event (as for katha/pile fisheries), at the economic maximizing age.

Nine different discount rates were used. Rates of 5%, 8% and 10% might represent relatively secure and unstressed economic expectations, where the immediate consumption need is not overbearing and a certain rate of saving is possible. The discount rate used by the FPCO to evaluate public sector investments is 12%. Rates of 25% and 50% might represent stressed economic conditions, while 100%, 200% and 300% would represent severely stressed economies (giving rise possibly to excessive rent seeking).

The discounted present value[1] of discrete rui populations subjected to various natural mortality rates was calculated for various discount rates affecting the fisherman. The optimum age of harvest for economic maximization was determined as the age at which the current value exceeds the discounted present value, and are presented in Table 2.26:

[1] The simulation does not take into account fixed and variable costs (and the timing of the cost payments), and therefore does not examine net present value, but rather discounted gross present value of future benefit exclusive of cost. A second round of simulations was run which included fixed and variable costs, and this gave similar results to the first simulation run.

129

Table 2.26: Relationship between Discount and Mortality Rate

Discount Rate	Annual Natural Mortality Rate				
	0%	10%	25%	50%	75%
5%	infinite	7	4	3	2
8%	8	5	4	3	2
10%	7	5	4	3	2
12%	7	5	4	3	2
25%	5	4	3	3	2
50%	4	3	3	3	2
100%	3	3	3	2	2
200%	3	2	2	2	1
300%	2	2	2	2	1

The simulation indicates that natural mortality and discount rate strongly affect the age at which optimum economic value is realized. For example, in a rui fishery subjected to 25% natural mortality and operating in an economy with a discount rate of 10%, the rui stock will reach its maximum economic value at age 4 and should be harvested at that age. Harvesting at 3 years would give a lower value, while harvesting at 5 years would yield less than what the fisherman would be satisfied with.

A biologically inflexible (*senso lato*) criteria which must be incorporated into the analysis is the need for fish to breed at least once in order to replicate the population. Thus the economically optimum size of harvest must be reconciled with the age of first maturity of rui. As almost all rui are mature at age 3 years, biologically rational management would dictate that rui should only be harvested once they reach age 4 years (thus allowing each fish one breeding episode). Thus, harvesting fish aged 4 years or more is biologically acceptable and should result in sustainable production over the long term. Harvesting younger fish (ages 1-3 years, shaded cells) would be biologically unacceptable and would lead to over exploitation and eventual stock collapse. Comparing this inflexible biological criteria with the economic maximization simulations in the table above suggests the following hypotheses:

- Low discount rates (5% to 12%) should not normally lead to over-exploitation in healthy fisheries (0% to 25% natural mortality), but could lead to overexploitation in stressed fisheries (50% to 75% natural mortality).
- Medium discount rates (25% to 50%) can be expected to lead to overexploitation under normal conditions (25% or greater mortality).
- Very high discount rates (100% to 300%) lead to stock depletion regardless of the level of fishery management (0% to 75% mortality).

Generally, increasing the discount rate or increasing the mortality rate acts to decrease the age at which discounted present value peaks, and brings into existence an economic incentive to harvest at a biologically unsound age. Examples of factors which push up the discount rate into the 25%+ range (and lead to harvesting of rui less than age 4 years) are insecurity of tenure, short tenure periods, high credit interest rates, high government license fees and poor access to markets. Factors which would lower discount rates are secure tenure, long tenure periods, access to credit at bank interest rates, nominal licence fees and easy market access.

Two complementary approaches to bringing into existence a fisheries tenure and management regime (which would produce maximum economic benefits over the short run [because a new cohort of rui would reach 4 years of age each and every year] as well as the long run [because the stock will be able to keep replicating itself indefinitely]) are to bring the discount rate down to 12% or lower, and to provide a high quality fishery environment where annual natural mortality rates are less than 50%. Once achieved, there should in theory be little economic incentive or pressure to move away from a harvesting regime which is biologically sound. Conversely, any force exogenous to the fishery that either damages the economy and raises the discount rate, or damages the environment and raises the natural mortality rate, will automatically push the fishery out of equilibrium and into a state of disharmony between its economic and biological protocols, eventually resulting in depletion. Government could address the goal of maximizing the economic benefits of fisheries production in two ways: 1) 'cleaning up' and rehabilitating the aquatic environment to minimize natural mortality as far as possible, and 2) creating economic conditions which reduce costs and discount rates of fishermen. This needs to include access to credit at normal commercial bank rates, secure long term tenure of the boromaach fisheries and a major reduction in fixed cost (ie license fee) in favor of progressive taxation at post-production market level.

2.6 POST HARVEST SECTOR

2.6.1 Fish processing methods

It is estimated that over 90% of the fish production of the region is utilized in fresh or live form (although in more remote beels a large proportion of the catch may be processed). The main products are sun dried and semi-fermented fish. Smoking or salting is apparently not practised.

Typically, fresh fish is sold wholesale in ungutted form. Limited use of ice is made to preserve fish destined for local markets, but all fresh fish (except livefish) destined for distant markets is iced. Ice plants are numerous. Mohanganj has eight, Bhairab Bazar has 20 ice factories present near the retail market and eight ice plants are present in Kuliarchar, Shibpur and Monohordi thana. Due to poor catches in 1992, many ice plants were forced to close and hundreds of workers became unemployed. In the Mohanganj area, transportation of iced fresh fish is done by train. The eight ice factories in Mohanganj are insufficient to meet the demand for ice during the peak season (January to March). About 60-70 kg of ice are used to pack 76 kg (2 md) of fresh fish. The ice plants by district are provided in Table 2.27. There are about 40 cold stores in the region.

METHOD OF PREPARATION OF SEMI-FERMENTED FISH

Shidal (semi-fermented fish) is a widely accepted fish product in the region. It is not only taken on festivals and other occasions but it is possibly one of the main sources of animal protein for most landless and marginal people in the area. It is appreciated for its special flavour and taste. *Shidal* is prepared from *Puti* (Puntius, Chola , P. sorhore etc), *Pabda* (Ompak pabda), *Bashpata* (Danio devario) and *Chanda* (Chanda nama).

Shidal is mainly prepared in winter month during the period of annual harvesting. The step-by-step processing method is given below:

- The fish are degutted and dried in the sun (usually on the bamboo mats) for 10-15 days. Sometimes the dried fish is exposed to fog at night to improve the color of the product.
- The viscera, head and lips of the fish are washed and boiled in water to extract the oil which floats to the surface of the water and is collected with a spoon.
- 40-50 kg capacity earthen pitchers are prepared by continuously soaking the innerside with the fish oil. The soaking process takes up to 10-15 days.
- When the pitcher is ready, the dried fish are washed in clean water and placed in the pitcher in layer pressed by hand.
- After completion of filling, the mouth of the pitcher is blocked by rice straw and then sealed with clay (to make it air tights). The pitchers are stored in any dark place (preferably in the house).
- It takes about a month of fermentation to produce the edible *shidal*. It can be preserved for 6-7 months without deteriorating in quality.

Sun-dried fish *(shutki)* is the most common form of processed fish product. Sun drying is mainly done by women. Typically the fish is laid out on mats on the ground, or on raised bamboo platforms. The area is protected from birds with small mesh nets or fishing line. Occasionally fish are dried on tarmac road surfaces. Sun drying is typically used for large catches of chotomaach, as occurs when a beel is harvested. Some species (for example *puti, kaikka, kachki*) are not considered to be very tasty in their fresh form, and also spoil rapidly. Hence they are sold in a dried form. Other species which may be sold sun-dried are *pabda, boal, baim, itcha, tengra, chanda, bailla, chapila, gonia, tepa* and *cheka*. Fish are also sun-dried and stockpiled for future sale when traders and fishermen cannot agree on the price of the fresh product. Most urban retail fish markets have vendors selling sun-dried fish and people of all classes buy them. Product quality is variable but is often poor as sun-drying imparts no preservative into the product (unlike salt or smoke drying). The organoleptic properties of sun-dried fish are said to be appreciated by consumers.

In the Mohanganj area, *Shutki* is a widely accepted fish product. It is not only taken on special occasions, but may be one of the main source of protein for most landless and economically marginal people. Mohanganj is an important dried fish marketing centre in the region. On average 57,000 kg of *shutki* are exported weekly to Dhaka, Chittagong, Mymensingh and other parts of the country from November to May. *Shutk*i is produced only during the dry season. The most commonly used species are *itcha, mola, chela, chanda, baashpata, bojori, chapila, batashi* and *kechki*. Also used are *tengra, shilon, pabda, kaikka, shoal, gazar, lati* and *bheda*.

Fermented fish *(shital)*, is produced in low lying beel areas of Kishorganj and Netrokona.

Both *shukti* and *shital* are produced by women in the *kholas* (temporary seasonal fishing camps). For example, at the Khaliajurigoona *Khola* in the Kaliajuri area, about 2500 kg of dry fish and about 2000 kg of semi-fermented fish were produced in the 1991 fishing season. The species used for *shutki* were *batashi, boal, tengra, gulsa, kaski, along, chapila, air* and others. The species used for *shidal* were *puti, pabda, bashpata, along* and *chanda*. For dried product, 40 kg of fresh fish yields about 10 kg of dry fish (about a 75% weight loss). For semi-fermented fish, 40 kg of fresh fish yields about 50 kg of product (about a 25% weight increase).

There is scope for further development in artisanal level fish processing in the following areas:

- Better quality control (processing facilities are sometimes unhygienic, and washing and gutting is not properly done);
- New processing methods and products (salted fish, marinated fish);
- More employment and income for women.

Table 2.27: Ice Plants by District

District	Ice Plants
Sunamganj	12
Moulvibazar	12
Kishorganj	36
Sherpur	3
Narsingdi	9
Sylhet	17
Habiganj	6
Netrokona	22
Gazipur	5
Mymensingh	9

A small portion of the catch (large prawns, major carp, large catfish, Chital, some chotomaach) is destined for export and undergoes high quality processing in factories. There are three such export processing plant situated in the region (see Section 2.6.4 below):

- Ajmiriganj Fish Industries Ltd, Ajmiriganj
- Kuliarchar Cold Storage Ltd, Kuliarchar
- Saidowla (PVT) Enterprise Ltd, Sunamganj

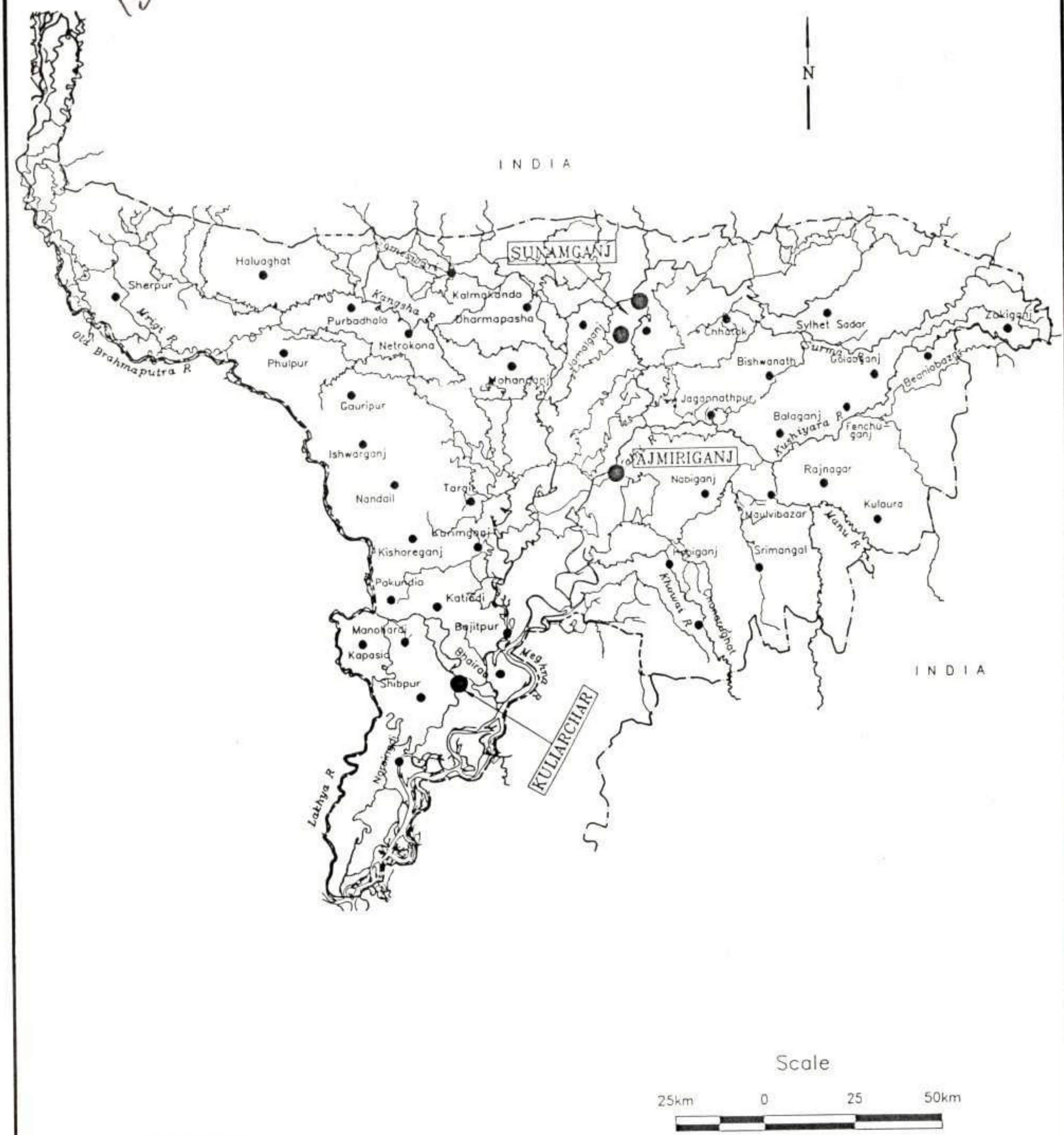
A fourth large fish receiving facility (owned by the BFDC) is at Dabor, but this plant is not functional at present (see next Section).

2.6.2 Fish marketing

Fish marketing is relatively well organized in the region, as elsewhere in Bangladesh. There are three levels of traders:

- *Nikari,* who are a Muslim caste of small scale fish traders (wholesale and retail);
- *Aratdars,* who are large-scale well capitalized wholesale fish traders;
- *Paiker*, who are small-scale urban fish retailers.

Figure 43



INDEX

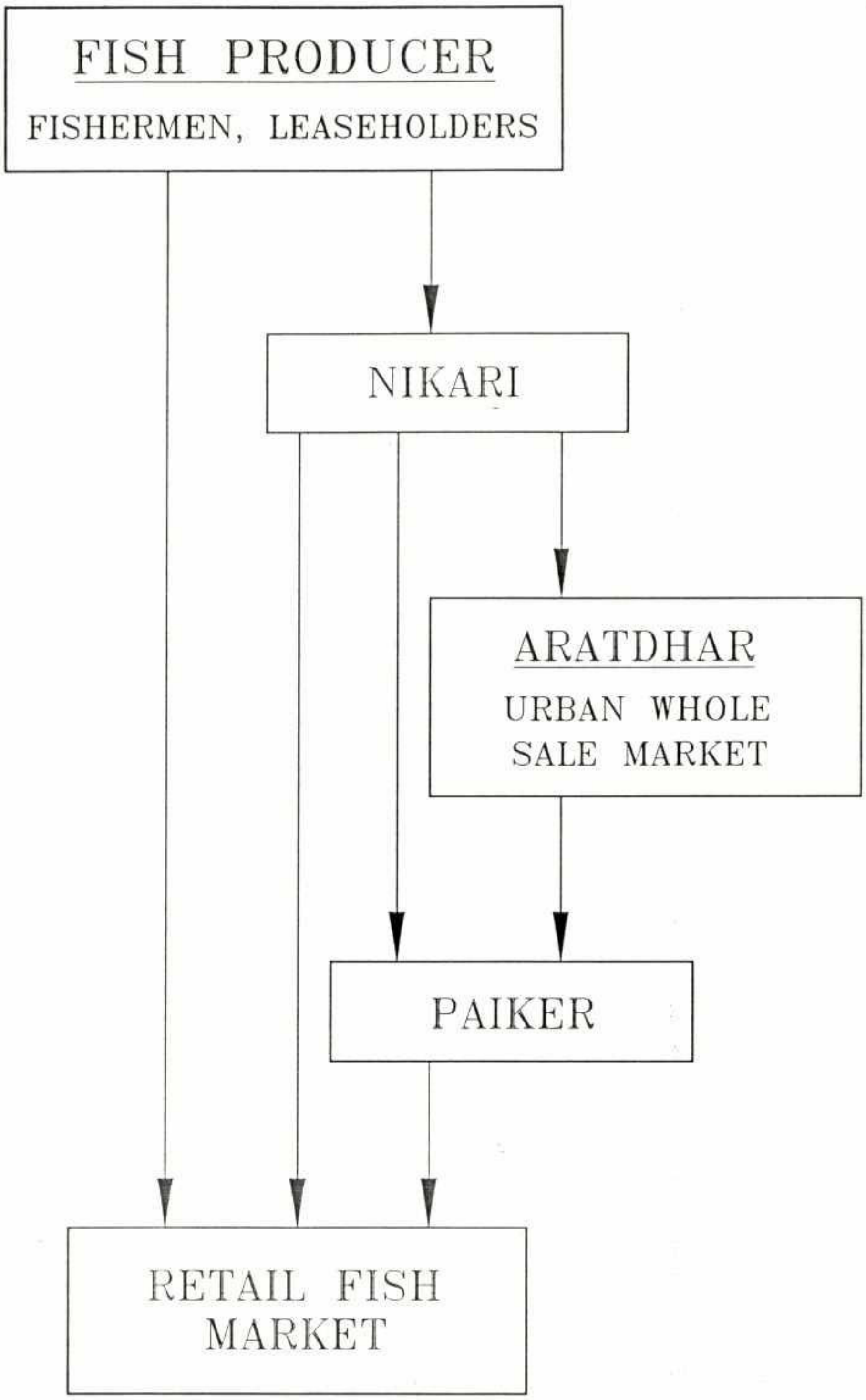
- International Boundary
- NERP Boundary
- Thana Boundary
- Fish Procesing Plants and Ice Plant
- Ice plant only

Northeast Regional Project

Fish Processing Plants and Ice Plants

Prepared by:	BNP/Jalal	April 1993

FILE: FISH-131.DWG



Northeast Regional Project

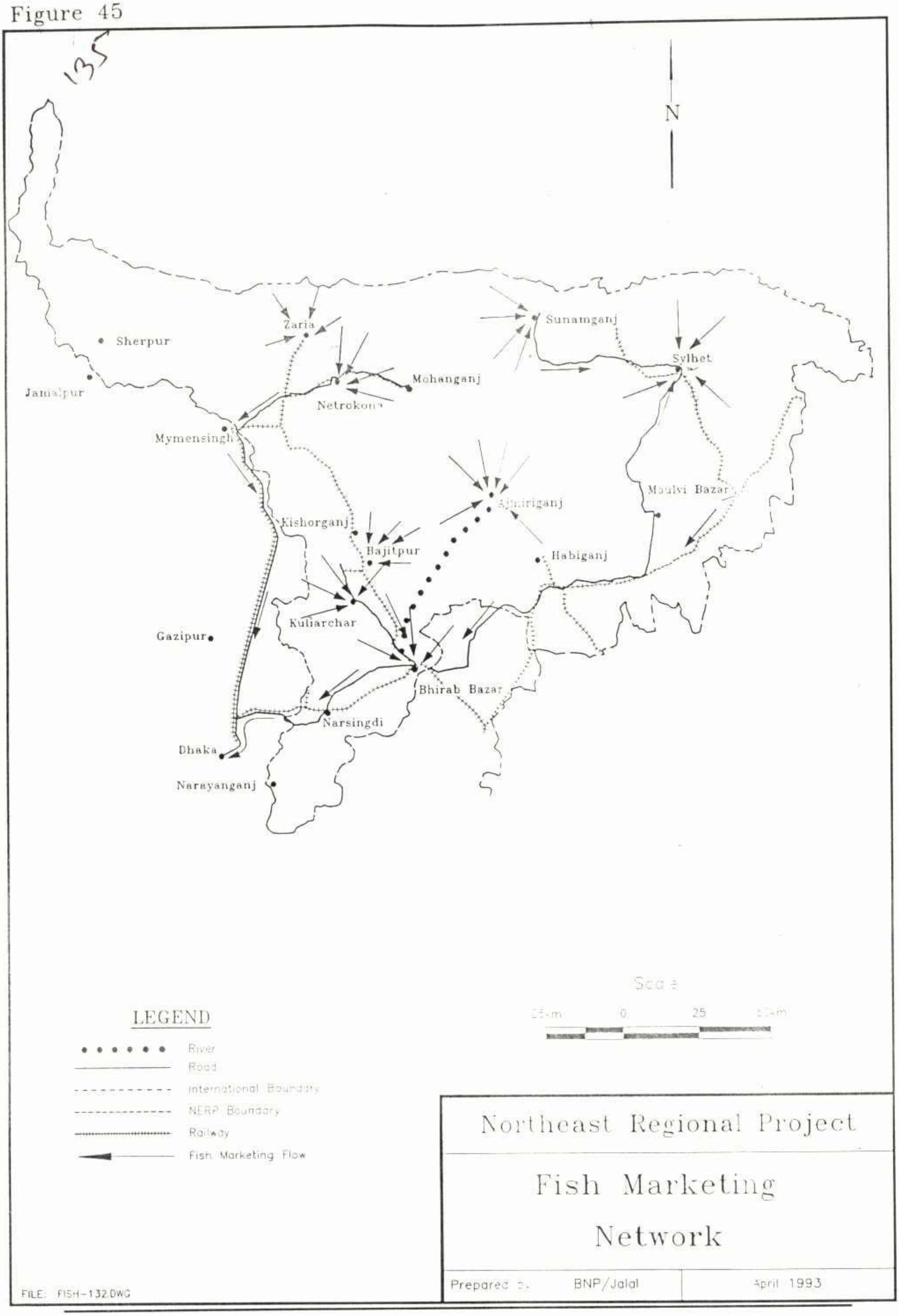
ORGANOGRAM OF

FISH MARKETING IN THE REGION

Prepared by: BNP/Mamun | April 1993

FILE: FISH-53.DWG

Figure 45



N
Zaria
Sunamganj
Sherpur
Sylhet
Jamalpur
Mohanganj
Mymensingh
Moulvi Bazar
Kishorganj
Bajitpur
Habiganj
Kuliarchar
Gazipur
Bhirab Bazar
Narsingdi
Dhaka
Narayanganj
Scale
LEGEND
River
Road
International Boundary
NERP Boundary
Railway
Fish Marketing Flow
Northeast Regional Project
Fish Marketing
Network
Prepared by
BNP/Jalal
April 1993
FILE: FISH-132.DWG

In general *Nikari* are active in directly buying fish from the fishermen. Typically, they go to a *khola* (fishing camp) or *ghat* (fish landing or assembly place) and buy fish from the fishermen or *jalmohal* leaseholders, either by auction or bargaining. Sometimes the competition between *Nikari* is so intense that they wait in boats near the fishing grounds and buy catches almost as soon as the fish are netted from the water (or "floating fish markets"). If the *Nikari* has purchased the fish from his own capital, or has borrowed capital without a sales contract, he has two main options: 1) transport the fish to a local retail market *(maach* bazar) and sell it himself, or 2) transport the fish to a local wholesale market *(arat)* and sell to an *aratdar* or *paiker*.

Historically, the *aratdar* profession arose as a response to the large seasonal landings of *ilish* from major rivers (Jamuna, Padma) in June to September. These caused gluts on the local market and led to the establishment of marketing networks to transport iced *ilish* to remote areas. *Aratdars* now deal in all species of fish. Most have contracts with jalmohal leaseholders to purchase their fish production. They often finance *Nikaris* to go to the *kholas* to procure fish and transport it back to the *arat*. Assembly (or *arat*) boats are used to collect fish from the fishermen. The fish are packed in baskets with ice. The *aratdar* then puts the fish up for sale at the wholesale market, where it is bought by *paikers*. The latter transport the fish to retail markets for sale to consumers. *Nikari* and *paiker* traders are sometimes related to professional fishermen.

Large consignments of high value fish destined for Dhaka may pass through a hierarchy of traders before reaching the consumer, with most of the finance put up by large fish wholesalers in Dhaka working in cooperation with district wholesalers and jalmohal leaseholders. Fish are transported by road or rail to Dhaka.

Fishermen may on occasion themselves take their catch to wholesale or retail markets in order to realize a better price. They used to be taxed by middlemen at ghats. Sometimes there are several ghats along a stretch of road. Under NFMP genuine fishermen cannot be subjected to a ghat toll. They can, in theory, now go directly to markets and sell their catch for higher net income.

Women do not work as fish vendors in markets.

Much of the fish coming out of the haors of the Sylhet Depression from the Sunamganj side goes to Dhaka. Also, it seems to be common knowledge in the area that a substantial proportion (possibly as much as 25%) finds its way to India.

The most important commercial wholesale fish markets in the region are as follows:

> Kazibazar, Sylhet: Kazibazar is the most important regional wholesale fish market in greater Sylhet.
>
> Kuliarchar: Typically most of the retailers (Aratdar) and the cold storage owners advance large sums of money to the lease holders (bel fishery) and the individual fishermen (subsistence) to meet the cost of katha, nets, etc. In return they receive all of the production harvested. This is sold through open auction (generally people come from Dhaka and elsewhere for the auction) from which they get a 5% commission. *Aratdars* recover their invested money from the sale and also from a 5% auction commission. At the Kuliarchar landing centre, it is estimated that the total value of traded fish is between

Tk 100 and 200 million per annum. The important prawn catch of the Baulai River is also marketed through Kuliarchar. There are a number of private investors within the area. During the period of May-June, they give loans to the prawn fishermen of Tk 1000-3000 per person. During harvesting, the investors collected the daily catch and pay Tk 80- 90 per kg (with the head on). After collecting the prawns, investors sell the catch at the local *arat* (Bajitpur) for about Tk 100 per kg. The *aratdars* decapitate the prawns and sell the products to the Kuliarchar freezing plant. Prawn prices at Kuliarchar are given in Appendix G).

Table 2.28: Species and Availability in Ajmiriganj

Species	Period of Maximum Abundance
Catla, Rui, Mrigel, Chitol, Air, Boal, Batashi, Keski, Chapila, Puti, Shingi, magur	Nov - Feb
Baim, Cirka, Bailla, Tengra, Gulsha, Chanda	July - Oct
Golda chingri	June - Sept

Ajmiriganj. There are a number of fish traders in the Ajmiriganj area. In most cases, they lend money to traditional or non-traditional fishermen. Commercially important finfish and prawns are mainly purchased by Ajmiriganj Fish Industries Ltd for export. About 30% of the fish are transported to either Kuliarchar cold storage or to Chittagong for export. As a result, the fish supply in local markets is low. The seasonal abundance of fish in the Ajmiriganj area is shown in Table 2.28. The period of lean fishing is April/May, when only *keski* is abundant.

Purbadhala: Jaria and Thakukona are the two main fish landing and marketing centres for the Kangsha. Based on discussions with *aratdars*, it is estimated that on average 1000 kg of fish are exported to Dhaka and other places every day. Kalmakanda, Purbadhala and Durgapur are the main source of fish for the *arats*. Fish are preserved and transported with ice. In Jaria, Purbadhala and Thakurkona there are eight ice factories (total ice production capacity averages about 400 kg blocked ice per day) and about 80% of the ice produced is used in fish processing.

Mohanganj: Dharmapasha and Kaliajuri are the two most important fish producing areas in the Sylhet Depression, and Mohanganj is the most important fish outlet to Dhaka and elsewhere. The Mohanganj wholesale market receives its supply from Dharmapasha, Jamalganj, Kaliajuri, Madan, Atpara and Borohatta areas. Mohanganj has a railhead, and iced fish from the western part of the Sylhet Depression is transported by rail to Dhaka during the winter months. Mohanganj has 55 *arats*. The average daily ranges from 3800-4200 kg, and the peak season daily export is 38,400 kg. Seasonal variation of fish landings are provided in Table 2.29.

Table 2.29: Seasonal Variations of Fish Landings in Mohanganj

Average Daily Landings	Period	Major Species
High (7000 kg)	Mid-Dec - Feb	*Major carp, Large catfish, Chital, Pabda, Shingi, Magur, Shoal, Taki, Gazar, Batashi, Bacha, Laso, Baim, Chapila, Tengra, Gulsha.*
Medium (3000 kg)	Jun - Aug; Nov - mid-Dec	*Tengra, Gulsha, Kalibaus (s), Chapila, Laso, Ghonia, Rita, Kechki, Chela, Shingi, Magur, Icha*
Low (400 kg)	Mar - May; Sep - Oct	*Koi, Shingi, Magur, Tengra, Baim, Shoal, Gazar.*

Dharmapasha: About 90% of the Dharmapasha fish landings are exported to Dhaka and Chittagong via Mohanganj, Kuliarchar and Bhairab Bazar. As a result most of the commercially important fish are not available in the local market. Seasonal abundance of fish in Dharmapasha fish market are shown in Table 2.30.

Table 2.30: Seasonal Fish Abundance in Dharmapasha

Abundance level	**Period**	**Remarks**
Maximum	Dec-Feb	All species and large size fish are available, which are harvested from the beels and the rivers.
Low	Mar-Apr	Particularly smaller species like *keski* are available which are harvested from the rivers and canals.
Medium	May-Nov	Most of the species are available, of which *Tengra, Chapila* and other smaller catfish are dominant (smaller size), harvested mainly from the floodplain.

Mymensingh. *Maach* bazar is the wholesale fish market in Mymensingh. It handles a lot of pond carp production.

BFDC Fish Marketing Centre at Dabor. The BFDC opened a large fish marketing center at Dabor in May 1991, which is complete with auction hall, 50 ton cold store (*himagar*) and 20 ton per day ice plant (*boraf kal*). The objective was to buy local fish caught in beels, rivers and floodlands during the dry season from November to March and transport them to retail markets in Dhaka, as well as export a portion. During the rainy season from April to September, it was planned to bring *Ilish* from the coast to sell locally. Fish auctioning would be an "open market", but contradictorily this meant that

139

prices would be fixed by GOB. The Dabor center is still far from meeting its objectives because it has been unable to buy fish locally. Fishermen borrow money from the moneylenders and *aratdars* in Sylhet. These *aratdars* are organized into a close cartel to keep prices low. Fishermen sell their fish to the *aratdars* and not to the BFDC. Furthermore, local wholesalers take loans from Dhaka wholesalers and are bound to sell to them. Seven *aratdars* have been appointed by BFCD to carry on auction business at the Dabor center, but they have shown no desire to leave the Kazir Bazar Wholesale Market at Sylhet. The result has been that the center has been unable to buy any substantial quantity of floodplain fish locally. Except for 10 tons of iced *Ilish* brought up from the coast, no other fish has passed through the center. GOB is even reluctant to license the procurement of *Ilish* because it is feared that the fish will be smuggled to India. The sale of ice has however been good (1,000 tons since mid-August 1991), showing that at least this operation meets a real local need. The BFDC is attempting a "new solution" to its raw material supply problem. They have submitted a proposal to the Ministry of Revenue to obtain 10 beels for a 10 year lease period. These would be operated as a joint venture with local influential *Jalmohans*. The latter are to "supply" genuine fishermen who will work as daily wage labourers.

Local fish prices are high, and *rui* of 4 kg size sell for Tk 90-110 per kg. In the Sylhet market it sells for Tk 100 per kg. But BFDC cannot pay more than Tk 80-85 per kg if it is to make a profit transporting the fish to Dhaka. So BFDC cannot buy fish on the local market, hence the proposal to vertically integrate production with marketing. The complete incompatibility of this BFDC proposal with the NFMP is rather stunning.

The most important retail markets in the region are:

- Bandar Bazar in Sylhet
- Sherpur roadside fish market
- Central Market in Moulvibazar
- Chota Bazar in Netrokona
- Purantana Fish Market in Kishorganj

Market supply varies seasonally:

- Lean: April-May (livefish and other small species)
- Medium: June-November (all small species)
- Maximum: November-March (all species)

Urban retail fish market facilities are often very poor: cramped, overcrowded, unhygienic, and lacking tables and sun shades. Lack of space results in fish also being sold on the roadside next to markets (ie Moulvibazar Central Fish Market). If the trend to increasing commercialization of fish continues, expansion and improvement of retail fish markets in all urban centres in the region will be needed. Retail fish traders usually pay a small market stall/position fee to the town market committee. In Moulvibazar this is Tk 10 for fresh fish (plus a Tk 5 fine to the police for traders overflowing on to the roadside) and Tk 5 for a dry fish stall. Retail fish markets are usually well supplied with local produce. Apart from fresh fish, sun-dried fish is usually available and iced *Ilish* from the coast is often offered. Large fish such as *rui* and *catla* may be sold whole, or by the piece. Mostly middle class people buy major carp and large catfish. Canned tuna and mackerel is sometimes available in shops at higher prices for wealthy consumers. A constraint on retail market development is the general poverty of the population, which lacks ready disposable cash to buy fish. Also, many rich people have their own ponds and have less need to buy fish from local markets. Thus the quantity of fish seen to pass through retail markets in the region is not especially large compared to overall production in the region.

Table 2.31: Indicative Fish Prices (Dhaka)

Species	Price (Tk)
Pangas	150
Catla	125
Hilsa	70
Icha	100
Golda Chingri	130

Local fish prices are highly stratified (see Appendix G). The major carps, large catfish, *chital* and *Golda chingri* are usually the most expensive, although some *chotomaach* such as *Rani* and *koi* can command high prices. Prices in the region are somewhat lower than Dhaka prices. Some indicative fish prices (per kg) in Dhaka in March 1992 are provided in Table 2.31.

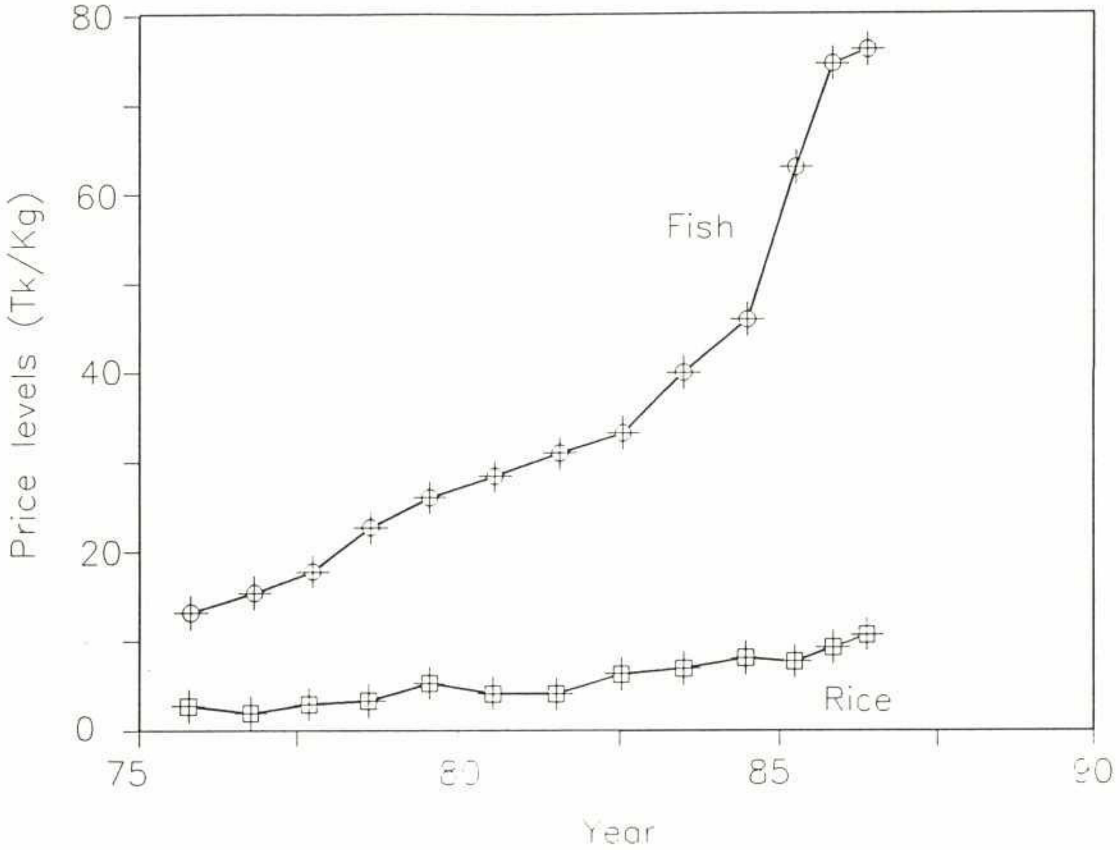
According to wholesale marketers in Srimangal, the price of fish has increased by 400% over the last 10 years. This is due to:

- Higher income levels due to increased employment abroad during the last decade;
- Increased demand due to high population growth;
- Reduced fish abundance due to overfishing, fish disease, reduced fish grazing area because of increased paddy cultivation lands (HYV) and siltation of river beds;
- Indiscriminate use of insecticides in paddy fields which may sometimes cause large losses of fish and spawn particularly at the time of early rains (as many paddy fields are adjacent to beels and rivers).

Dry fish is expensive on a dry product weight basis, but cheap on an equivalent wet weight basis. Fishermen thus suffer a loss if they are unable to sell their catch in fresh form and have to resort to drying it. Another factor affecting the price of some species is fish size. Thus small *rui* sell for about Tk 40 per kg, while large adult *rui* sell for Tk 100 to 150 per kg. Retailer trade margins vary between 6% and 33% which is not especially large compared to other developing countries.

Figure 46

(141)



Source: World Bank (1991)

Northeast Regional Project

Growth in Retail prices for Fish and Rice in Bangladesh

Prepared by: BNP/Mamun | April 1993

FILE: FISH-64.DWG

2.6.3 Fish festivals

An important fish marketing festival (*Machher Mela*) has been held annually at Monumuk for the past 100+ years. It is based on the Hindu cultural holiday *Poush Sangkranti* (last day of the Bengali month *Poush*). This is the most important fisheries festival in Bangladesh. A substantial number of large fish are brought here to display as well as sell. During the British period, a landlord named Mr Mothura Babu organized the mela to have the largest fish for his family during the *Poush Sangkranti* festival. As Monumuk was an important place for business and fisheries resources this Mela became a historical festival for all classes and people of different religions living in the area. Every year, it is customary for several thousand people of the area to purchase their largest fish of the year from this Mela.

In 1993, the *mela* started on 12 January afternoon and closed on 14 January morning. It was organized in two places due to conflicts between two *maimol* groups. As a result the original site (Monumuk) is losing its importance while another site near Sherpur Ghat (Brammangram) adjacent to the Kushiyara has increased in importance over the last 20 years. Many other consumer goods, including furniture, are also offered for sale at the mela. Thus the *mela* committee divides the *mela* into four parts:

- Fish market,
- Furniture market,
- General Market, and
- Amusement site.

The permit to hold the *mela* is auctioned each year by GOB. The auction is managed by the Thana Nirbahi Officer for Moulvibazar Sadar. Four groups of people are responsible for stall fee collection from vendors who pay the mela permit fee. In 1993 the permit fee was Tk 80,000, while in the previous year it was Tk 36,000. It was reported that the 1993 permit fee was so high because of the submission of a complaint to the office of the Deputy Commissioner, Moulvibazar by a non-fisherman. The permit had initially been auctioned for Tk 42,000. This individual wanted to win the *mela* permit and was willing to pay Tk 65,000. He stated that GOB would lose revenue. As a result, a second auction was held after cancelling the first auction agreement. The *Maimol* group which had won the first auction became angry but they participated in the second auction. They were defeated when the concerned individual bid Tk 80,000 and won.

Examples of the size of fish sold at this fair in 1993 are:

- Two *Bagair* (33 and 70 kg)
- Six *Catal* (20-25 kg)
- Eight *Rui* (6- 10kg)

Large individuals of most other species occurring in the region were also brought. The price of large fish was high at the *Mela*. The owner of the large *Bagair* asked Tk 13,000 (it had been purchased by him for Tk 9,100). One *Catal* weighting about 20 Kg was purchased for Tk 2,200. There were two types of fish marketing arrangement at the mela:

- Direct sale by local fishermen (70% of total volume)

- Sales through *Aratdars* by outside fishermen (30% of total volume)

Local fishermen and *nikery* do not require the *aratdar* for marketing. They sell their fish directly to the consumer. Fishermen, *nikery*, and *paiker* who come from a distance (Chandpur district, Jamalganj, Netrokona, Dhirai, Khaliajuri etc.) need *aratdars* for marketing their fish because of the large quantities of fish involved. There were seven *aratdars* who earned in total about Tk 60,000 (or 5% of the total sales through *Aratdars* of Tk 1.2 million). It is estimated that the total value of fish sold in the *Mela* was about Tk 4 million and the total weight that was sold about 57 t (an average price of Tk 70 per kg). GOB does not have any responsibility except auctioning the *mela* permit. DOF does not provide any inputs to the *mela* or collect market data.

In 1994, the mela started on 13 January. That day, around 600 retail fish traders had 30-35kg fish each (total around 20tons) for sale. Temporary stalls of 7 arats (Sapla, Kushiyara, Janata, Surma, Shahjalal, Angur, Bismillah) of Sherpurghat controlled the major outside supply to the market. Three quarters (55-60 tons) of fish were sold either in retail or to paikers from Srimongal, Hobiganj, Maulavibazar, Sylhet, Balaganj, Kulaura, Fenchhuganj and Nabiganj. The fish supply was unexpectedly less due to change in the Bengali date which caused confusion among the fishermen. It was observed no fish came from Chandpur and BhairabBazar unlike the previous year.

Observed fish prices were as follows:

Table 2.32: Fish Prices in the Fish Festival

Fish	Weight (kg/fish)	Price Tk/kg
Catal	10-12	100-110
Rui	07-10	110-125
Boal	03-25	60-70
Ghagot	2.5-6	110-120
Baghair	10-70/75	80-100

Average fish price was 20-30% less compared with the previous year. One buyer purchased about Tk 15,000 of fish to send to relatives living abroad.

Discussions with mela organizers revealed that though the government earns a lot of revenue (current year Tk 1,04,000; last year Tk 80,000; year before last year Tk 36,000) from auctioning the mela permit it has never spent any money to develop the festival. The mela venue is on private land, and the mela is an initiative of the fishing community which is part of their social identity. However the Government uses it as an opportunity to collect revenue, and attaches rules and regulations to its holding. Such action may in future destroy the communal harmony of this locality, because it is calls into question the prestige of the Maimol people (who are leading community with the largest population in the area). Proposals for improving the mela are:

- Mela site should be demarcated.
- The mela permit should be auctioned within the fishermen community.
- The mela should be organised by the fishermen community.
- A portion of revenue should be spent for Mela development.
- Sufficient announcement /advertisement should be ensured.

Aratders of Sherpurghat fish landing center realized the following mela sales (total Tk 1,102,000):

• Kushiyara Arat	Tk	140,000
• Shapla Arat	Tk	107,000
• Bismillah Arat	Tk	40,000
• Janata Arat	Tk	248,000
• Surma Arat	Tk	160,000
• Angur Arat	Tk	170,000
• Shahjalal Arat	Tk	237,000

The average price of fish was around Tk 50/kg while it was about Tk 70/kg last year. The weight of fish sold through the aaratders was 22.04 ton. Most of the fish originated from distant areas. Local origin fish were not marketed through arats, and were estimated to be 43 tons. The estimated total amount of fish in the festival was 65 tons. Over 100 tons had been expected but was not realized because of confusion about the date.

In the Netrokona area, *Shauk* or *Baish* fishing is a well known community beel fishing festival in the winter. During the British and Pakistan period (and right up to the present in some areas) some of the beels and jalmohals were maintained without a lease. Once or twice a year local people would gather early in the morning around the jalmohal and start fishing with *Polo, Shib jal, Thaki jal, Vor jal* and *Pati ban*. Normally the fishing festival date was announced about two weeks in advance. In some areas, prizes were awarded for the largest catch.

2.6.4 Fish imports and exports

International fish trading is of importance to the Bangladesh economy. Available data at national level is presented in Appendix F. Aside from very small quantities of highly priced canned fish, there is no significant retailing of imported fish products. However, the export of fish commodities is a major foreign exchange earner. The most important export commodity is frozen shrimp from the coast. There are 106 fish processing plants in Bangladesh. Half have closed permanently and will not reopen because machinery is deteriorated beyond repair. Only 10-12 plants are operating at a profit.

Exports from the region are:

- Frozen prawns (only about 2% of total Bangladesh crustacean exports);
- Frozen *boromaach* and *chotomaach* (about 10% of total Bangladesh finfish exports, including marine fish);
- Frog legs (although this commodity is now proscribed).

The international export of high value prawns and *boromaach* from the region is important to the regional economy. Grey market exports of beel fish and *Ilish* to India (Assam) appears to be well established, although not viewed with enthusiasm by GOB. Quantities may be substantial (ie as much as 25% of beel production from around Sunamganj). It is claimed that bigger size food fish from Moulvibazar area are smuggled to India during the months of December through February. It is very difficult to estimate how much fish actually enters India, but a figure of about 30-40% may represent the upper range during the beel harvesting period.

There are two functioning fish processing factories in the region which target export markets: Ajmiriganj Fish Industries Ltd and Kuliarchar Cold Storage Ltd. A third plant, Saidowla (PVT) Enterprises Ltd of Sunamganj, went bankrupt in 1989, and is at present attempting to start up again. It is however not in a financially healthy position. It has to offer too high a price for raw material in order to compete with the Sylhet market.

Table 2.33: AFI Financial Statement

Cost Statement	Amount
Loans Received	
Industrial Bank ICB Directors' equity	9,250,000 2,500,000 2,500,000
Total	14,250,000
Other Costs	
Land value Buildings Machinery Other- Refer van, Refer vessel, Equipment, Fishery, Bank interests etc.	305,615 3,040,631 5,885,886 5,017,862
Total	14,249,994
Repayments	
Industrial Bank ICB	1,425,0677 5,680,621
Total	19,931,298

Ajmiriganj Fish Industries Ltd: This is a substantial fish processing plant. Freezing capacity (per day) are:

- Plate freezer: 2 mt
- Air blast freezer: 2 mt

The ice plant has a capability of 10 mt per day. The cold storage capacity is 150 mt (in two rooms). The plants financial statement is provided in Table 2.33.

Of the total supply of raw material, about 55% is harvested from their own leased jalmohals (for example: Kaliajuri fishery), about 15% is purchased from the open water fishermen in the Kaliajuri and Ajmiriganj areas and about 30% is purchased from fishermen in the Sylhet area. These proportions however vary from year to year. It is stated that the plant can handle only 15% of the area's total production (Kaliajuri, Ajmiriganj, Sullah, Derai and Baniachong thanas). The plant requires quality fish (usually the larger size of a particular species) and before purchasing, fish are carefully checked.

The floodplains of Kaliajuri, Ajmiriganj, Sullah, and Itna serve as a grazing ground for giant fresh water prawn during the monsoon period. Pangasiar haor of Kaliajuri is one of the important fish and shrimp producing areas in the region. Most of the renowned *jalmohals* of the Kaliajuri fishery are located within that haor, of which Rangchapur, Dhalimati, Chunai and Faridpurar duar are the most important. *Golda chingri* are caught from the floodplain between May and September. In addition, a few prawns are also caught from *duar's* and *katha's* during the period of winter fish harvesting. Up to 200 fishing units work on that floodplain (around the Laipsa bazar area) to catch prawn. Each fishing unit consists of 150-200 *chai* (basket traps). One fishing unit can catch up to 65 kg of prawns in a season (based upon 1992 data for 11 units) which suggests that 9100 kg of prawns were harvested from the Pangasiar haor floodplain (Laipsa area) in 1992. Rough economics of these chai operations are provided below:

Table 2.34: AFI *Golda Chingri* Purchase Records

Year	Prawns Purchased (kg)
1985	137,964
1986	105,067
1987	76,085
1988	193,642
1989	121,750
1990	180,525
1991	201,334

- Cost of *chai*: 175 *chai* units at Tk25/*chai* = Tk 4375
- Cost of bamboo stick: Tk 350
- Total costs: Tk 4725
- Sale of the product: at Tk 175/kg x 52 kg = Tk 9100

Golda chingri purchase records of the industry during the period 1985-1991 are provided in Table 2.34.

Purchases of finfish and exported quantities and values for the period 1982 to 1992 are provided in Tables 2.35, 2.36 and 2.37.

Table 2.35: Fish Purchased by Species by Year (kg)
Ajmiriganj Fish Industries Ltd.

Species	1985	1986	1987	1988	1989	1990	1991
Ruhu	3122	17930	41621	61035	42635	46254	12942
Katal	2983	2979	4055	10650	12336	3818	330
Ayre	32060	45967	26069	70172	24897	14682	18805
Boal	68445	77261	37519	102636	71277	21964	30384
Chital	4062	1669	2477	3614	793	633	802
Pabda	46124	15652	6669	21570	49179	11026	27448
Tengra	4930	2078	249	1500	875	1847	3364
Keski	8699	2718	12983	17180	2042	8474	12491
Chapila	85	240	147	902	1155	1416	4380
Batshi	5124	1439	7010	8193	4273	4828	1082
Rani	42	-	3348	6428	2224	6036	4219
Pangash	1123	08	06	1248	-	-	20
K.Boush	136	4749	6183	15736	14884	940	1372
Bacha	486	540	610	6608	4361	721	1002
Meni	384	-	4670	1112	235	08	55
Gazar	753	2441	194	2150	-	279	185
Shoal	619	223	1719	5425	-	158	2034
Koi	81	1263	8420	1751	120	2884	1300
Kaikka	559	43	1405	3190	-	-	332
L.Baim	456	856	8222	6545	2058	4142	3789
Puti	96	728	-	2769	-	-	-
Taki	237	29	1542	2958	-	-	11
Magur	07	205	980	4294	14	-	770
Ghonia	-	-	2452	3494	-	-	-
Baashpata	-	-	497	1124	-	146	04
Garua	-	-	-	27	-	-	-
Lacho	-	-	2640	1584	433	-	1430
Shilon	-	-	205	101	91	-	-
T.Baim	-	-	1495	9770	-	-	-
Mrigel	-	-	313	38	-	-	-
Mola	-	-	225	2701	-	50	737
Shingi	-	-	-	521	-	-	-
Chela	-	-	-	161	-	160	-
Puti (small)	-	-	6979	2557	-	21	573
Kanla	-	-	-	574	-	490	-
Gutum	-	-	161	845	2808	1622	-
Kaguli	-	-	-	1574	748	3561	2125
Chanda	-	-	-	103	-	-	-
Total	180613	179018	191065	382840	237438	136160	131986

Table 2.36: AFI Exports and Value

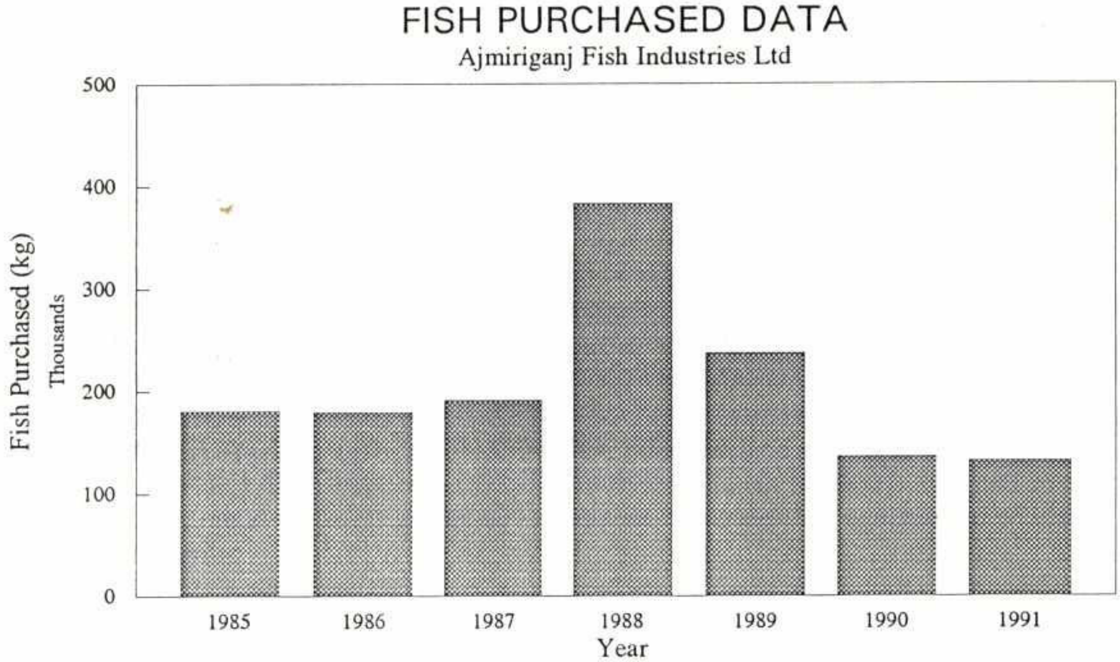
Year	Products Exported	Quantity (kg)	Value (Tk)
1983	Prawn	107,136	18508300
	Fish	68,122	17,80,500
	Total	175,258	2,02,88,800
1984	Prawn	93,147	1,78,75,200
	Fish	229,402	2,02,41,300
	Total	322,549	3,81,16,500
1985	Prawn	116,045	1,81,20,300
	Fish	110,784	61,46,300
	Frog legs	33,677	42,59,500
	Total	260,506	2,85,26,100
1986	Prawn	113,280	1,80,64,200
	Fish	96,192	58,92,300
	Frog legs	101,030	1,10,55,000
	Total	310,502	3,50,11,,500
1987	Prawn	46,618	97,09,300
	Fish	157,325	1,18,39,100
	Frog legs	90,470	1,44,,09,000
	Total	294,413	3,59,57,400
1988	Prawn	158,861	3,87,58,800
	Fish	257,280	2,20,59,400
	Frog legs	91,046	1,86,89,000
	Total	507,187	7,95,07,200
1989	Prawn	108,058	2,26,32,592
	Fish	279,091	1,26,63,317
	Frog legs	65,779	1,12,15,632
	Total	452,928	5,65,11,541
1990	Prawn	168,960	4,29,31,324
	Fish	141,850	1,18,31,449
	Total	310,810	5,47,62,773
1991	Prawn	159,590	5,01,66,147
	Fish	133,824	1,29,81,304
	Frog legs	81,216	1,90,74,900
	Total	374,630	8,22,22,351
1992	Prawn	94,272	2,37,44,138
	Fish	168,077	1,91,03,260
	Total	262,349	4,28,47,418

Source: Ajmiriganj Fish Industries Ltd., Dhaka, 1993

149

Table 2.37: Export Quantity and Value

Product Form (Species)	Master Cartons (Number)	Total Weight (kg)	Total Value (Tk '000)	Price per kg (cif)	
				Tk	Pound Sterling
Block Frozen					
Pabda	150	2730	325	119	1.98
Rui	30	546	80	147	2.42
Air	65	1183	174	147	2.42
Boal	92	1674	179	107	1.76
Keski	37	673	45	67	1.10
Lacho	1	18	1	80	1.32
Sarputi	1	18	2	87	1.43
Kajali	2	36	3	80	1.32
Bacha	24	437	47	107	1.76
Chapila	3	55	4	67	1.10
Batashi	22	400	27	67	1.10
Tengra	80	1456	137	94	1.54
Kaika	92	1674	146	87	1.43
Individual Quick Frozen					
Rui	117	2129	313	147	2.42
Boal	126	2293	245	107	1.76
Air	142	2584	380	147	2.42
Katla	2	36	4	107	1.76
Kalibaus	20	364	39	107	1.76
Gonia	1	18	2	94	1.54
Ilish					
1.2-1.5 kg	463	8427	733	87	1.43
1.5+ kg	52	946	82	87	1.43
Total/average	1523	27719	2968	107	1.76



With reference to Table 2.33, the exchange rates used are:

Pounds Sterling = Tk 60.8
USA Dollar = Tk 39
Indian Rupee = Tk 1.33

The total value of this particular shipment of 27.7 tons of mixed freshwater fish is Tk 29,68,000 (= Pound Sterling 48,816, or US$ 76,102).

AFI requested export prices of freshwater fish on 28 January 1993, shipment cif from Chittagong, are given in Table 2.37. These prices were accepted by the buyer. Product is packed in standard size 40 lb (18.2 kg) master cartons.

Prawns (reference Table 2.36) are exported to USA, Japan, Canada, UK, Italy, France, Belgium, Germany, etc. Freshwater fish (Rui, Boal, etc) go mainly to the UK. There is very good demand in the UK from the expatriate Bangladeshi community.

Despite good market demand, finfish exports have declined. In 1990, 150 containers of freshwater fish (each container weighs 18 tons, thus a total weight of 2250 t) were exported. In 1991, only 85 containers (1530 t) were exported. In 1992 not more than 50 containers (900 t) went out. The decline in exports of freshwater fish is due to the decline in raw material. In 1992 there was very little water in the haor area. Normally water levels are about 4.5-5.0 m, but in 1992 the level was only 1.0-1.3 m. This depressed fish production. *Golda chingri* production is also down, from 130 containers (2340 t) in 1991 to 80 containers (1440 t) in 1992. AFI and Bangladesh cannot fully supply the UK market. UK importers need at least 50

151

containers from Bangladesh each year. There are 5-6 importers in the UK and 3-4 new importers in the USA as well. In 1991, 10 containers (180 t) were exported to the USA. In 1992, 25 containers (450 t) went to the USA. The Gulf States (Kuwait) and Saudi Arabia also have good demand from mainly their Bangladesh and Indian (West Bengal) expatriate communities.

Aside from raw material shortage, another problem affecting fish exporters is that internationally standard packing material (laminated duplex board, LDB) is not available in Bangladesh. The locally produced packing material (simple printed and waxed duplex board) is of very poor quality. If the product was better packed it would get a better price. It would be too expensive to produce LDB locally because of the high price of the machinery. So next year AFI will introduce a new packing material into Bangladesh by starting to import LDB from Thailand. Importation of equipment and supplies (plastic fish boxes, rubber gloves, etc) has a high duty on it. Locally produced items do not meet international standards. Sea freight costs from Bangladesh are high. A 40 ft container with destination London or New York costs US$6000. Out of Bangkok the same container costs only US$3000. Export of fresh (=chilled) fish on ice would be interesting, but the cost of air freight (Tk 50 per kg) is too high.

The Export Promotion Bureau do not have sufficient information about the international fish market. Bangladesh has to compete with India, Philippines, Thailand and Malaysia in the prawn market. The price of finfish exported from Bangladesh is too high compared to regional competitors. Bangladesh *Magur* is priced at Pounds Sterling 1.20 per lb, while Thailand is selling *Magur* at only Pounds Sterling 0.65 per lb. A UK importer will buy from India because the fish are cheaper. India sells *Rui* at Rupees 45 per kg (equivalent to Tk 60 at an exchange rate of 1.33). However AFI has to purchase *Rui* raw material at Tk 50 per kg from fishermen for a fish weighing 3 kg or more. As a result, AFI is currently exporting at a loss. There is no profit in freshwater fish because the price of raw material is too high. They are producing right now just to stay in the market. He predicts that over the next two years Bangladesh will probably get squeezed out of this market. About 60% of all *Ilish* caught in Bangladesh is exported (mostly clandestinely) to India. *Ilish* caught near Chandpur exits the country via Comilla. This aggravates the supply shortage and dietary protein deficiency. The high domestic fish price is due to declining production. Many species are now in very short supply or locally extinct: for example, star *Baim, Rani, Bheda, Sarputi, Nandina, Mohashol, Gutum.*

Since AFI is presently running at a loss, the owners are thinking of relocating from Ajmiriganj to Chittagong. After 1996, it is anticipated that large scale shrimp culture will begin in the coastal area. The logistics of loading transport boats at Ajmiriganj are not good. Because of sedimentation, the plant is now one km from the river. The containers warm up too much while being carried from the plant to the river. Intense sedimentation of the river bed has resulted in very shallow water depths. This has reduced the allowable draught of transport boats. While the boats should carry up to 30 tons of cargo, they now carry only two tons. The carrying cost to Chittagong (where the containers are transhipped) is now higher than the product value. In 1979-80 when the factory was built, the water depth was 13-15 m in front of the factory (because there was a duar there). Only country boats can pass there now. River excavation is badly needed in the area. In 1984-85 the plant was receiving 15-18.75 tons of raw material per day during the dry season (January to March). The raw material bought at Ajmiriganj is sometimes tainted by pollution from Chhatak and Fenchuganj. Fish from the Surma all the way down to Kaliajuri have a bad smell. Species affected are *Boal, Air, Rui* and *Chital.* Kushiyara fish as far downstream as Ajmiriganj also have a bad smell because of the Fenchuganj fertilizer plant effluent.

Because of the shortage of fish supply in Bangladesh and high domestic prices, it is more lucrative to import cheap fish from outside. But the 70% customs tariff is preventing fish imports from expanding. The tariff is a protective tariff designed to support BFDC fishing operations and marketing. Over the next 3 to 5 years, AFI predicts that Bangladesh will have to start importing fish from India to meet food requirements. Bangladeshis generally do not prefer frozen fish, although of course expatriate Bangladeshis in the UK and elsewhere are quite prepared to accept frozen fish from Bangladesh and pay high prices.

Kuliarchar Cold Storage. The capacity of the cold store is 300 mt. Exports in 1991 were Tk 281 million. The major export items are prawns (65%) and table fish (35%). Purchasing prices are prawns (headless) Tk 270-594 per kg, and for table fish (dressed) Tk 80-135 per kg. The areas of origin of prawns are Bajitpur, Bhairab, Astagram, Nikli, Itna, Kaliajuri and Kuliarchar. In 1992, 3,371 kg of prawns (headless) were purchased. Export prices for prawns are US$ 8.00-8.50 per lb and for table fish US$ 0.75-0.95 per lb. The peak season for prawns is late May to early November, and for table fish November to February.

2.6.5 Fish consumption

The role of fish in the Bangladesh diet is substantial. Approximately half of all dietary animal protein is derived from fish. The current national per person supply is calculated by FAO [Laureti (1991) Appendix M] as 7.2 kg per year. However the accuracy of the FAO estimate is not clear as there are two major possible sources of error:

- Subsistence production may be much higher than nominal BFRSS statistics suggest;
- Substantial grey market exports of *Ilish* and other species are not taken into account.

It is of course possible that these two errors might approximately cancel each other out.

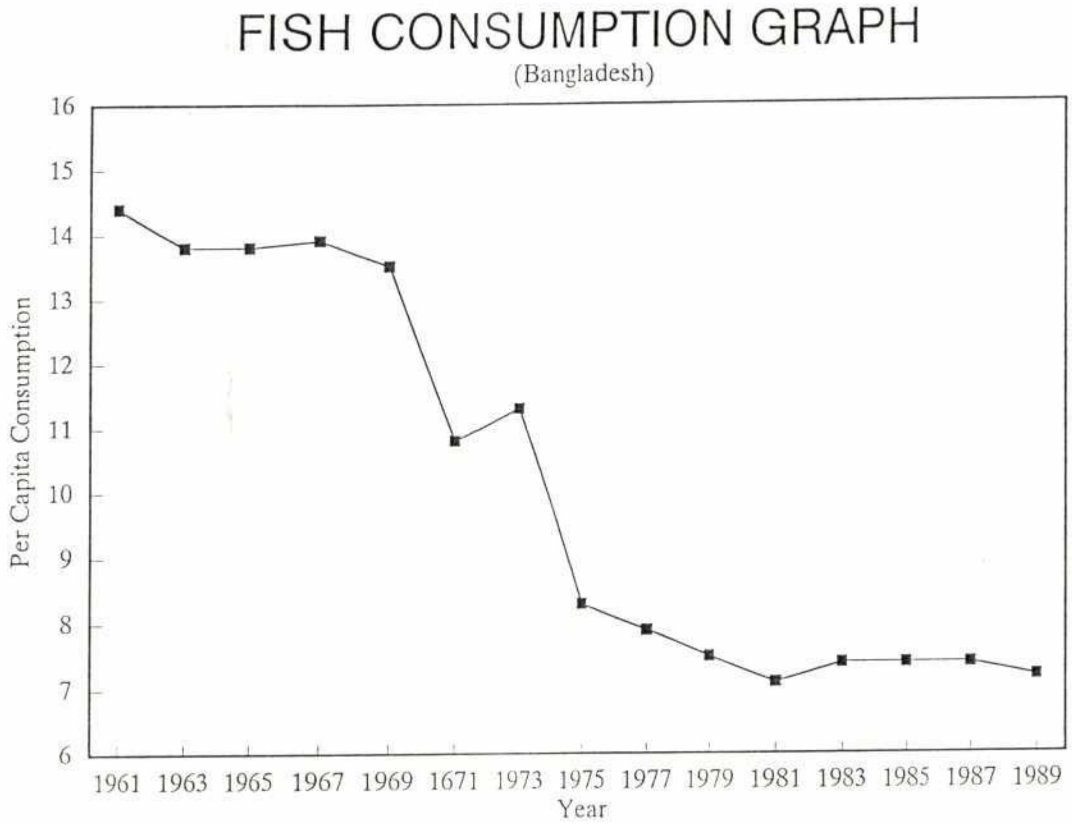
Only a rough approximation can be made of the quantity of fish consumed in the region. For the year 1988/89, it may be assumed that of the total regional production of 114,273 t about 85% is consumed within the region. A per caput supply of about 6 kg per annum is estimated for the region.

BFRSS data indicate that 1.4 million households carried out subsistence fishing in the region in 1988/89, catching 18.42 kg per household. Assuming that the average household consists of 5 persons, the estimated per caput supply from subsistence fishing is only 3.7 kg per annum, or about half of the estimated mean regional supply of 6 kg. This suggests an unequal distribution of fish among consumers, with the bias in favour of non-subsistence households (ie wealthy rural households, urban populations). However, if the subsistence catch is underestimated in BFRSS statistics (as the World Bank [1991] suggests), actual subsistence consumption should be higher.

The historical trend in fish consumption for Bangladesh as a whole has been one of decline. In 1961, per caput supply was a respectable 14.4 kg/yr (compared to 9.1 kg/yr for the world) But this had decreased by 50% to 7.2 kg/yr by 1989 (while world supply grew to 13.4 kg/yr). Given that the region has a net outflow of fish (to Dhaka, other larger Bangladesh urban areas, India and international markets), an increasing population and declining production (according to most sources) it is quite probable that regional per caput consumption is also declining.

Figure 48

153



2.7 EMPLOYMENT, INCOME AND WELFARE

2.7.1 Employment within the fisheries sector

Four general occupational categories within the production sector are recognizable (apart from caste/ethnic groupings):

- Professional fishermen, who earn their livelihood entirely from fishing. Under the NFMP, these are called "genuine fishermen".

- Part-time fishermen, who fish for only part of the year to supplement their income, and are engaged in other employment (ie agriculture, etc) during the rest of the year.

- Occasional fishermen, who fish irregularly, and mainly for subsistence rather than income.

- Fish farmers, who own ponds and operate at various levels of production intensity.

There are several castes of highly experienced Hindu fishermen, the most important being the *Koibarta*. Muslim fishermen are not caste defined (*Maimol* being an exception). Many enter fisheries as a "last resort" because they are landless. Because of their marginal economic situation, their fishing practices are short-run, income-maximizing in nature, and not conservationistic.

Production support industries include boat building and net making (artisanal hand weaving, factory mechanized weaving). In the post harvest sector employment categories include fish vendors/traders (wholesale and retail), processors (artisanal sun-drying, export factories), and transporters (collector boats, insulated trucks). Business investment interests include jalmohal leaseholders and moneylenders.

The role of women in fisheries is limited. They are employed mainly in processing and net weaving/repair, and may also carry out pond feeding. Girls often participate in fish harvesting in rice fields and borrow pits. Unlike in many other countries, women do not work as fish vendors/traders because of Muslim rules forbidding women to handle money. Because they rarely receive any money for their efforts, women never achieve a position of economic strength or capital accumulation within the fisheries sector. Hindu women tend to be somewhat more active in the fisheries sector.

During the dry season when there is no free access to fishery resources, many genuine fishermen have to work as fisheries wage labourers. In Hakaluki Haor, the fishermen work for leaseholders as wage labourers, getting paid Tk 20-25 per day. Fishermen receive no share of the catch. But this employment is only during the dry season. Sometimes the leaseholder brings fishermen labourers from far away villages (possibly to undermine any strengthening of local labour organizational power). During the rainy season, when the entire haor is flooded out, the fishermen are free to fish anywhere on the floodplain. They prefer the rainy season because they are independent and can sell their catch directly at the market. It is during the flood months of June and October that seasonal labour absorption capacity peaks in fisheries. During 4 months of flood season, a fisherman can earn about Tk 40-50 per day selling his fish. During the dry season which lasts 6 months, fishery wage earning work for leaseholders is not continuous and pays only Tk 20-25 per day.

No reliable data exists on the numbers of persons employed in the fisheries sector in the region. Studies of many artisanal inland fisheries in different parts of the world has shown that limitations on the physical capacity of individual artisanal fishermen to handle their catch, as well as lack of efficient gear and adequate infrastructure, restrict output per commercial fisherman to about 1 to 4 tons per year. Assuming the lower value to be appropriate for the region (given the high intensity of exploitation), the overall production of 1987/88 (115,402 tons) suggests that the number of fishermen, in terms of equivalents to commercial fishermen units, might be 115,000. The actual number of persons involved in fishing activity is however much greater as 24% of overall production results from occasional subsistence fishing. Over 70% of all households in the region participate in some type of fishing activity. Furthermore, the production sector creates employment both upstream (boat building and net making) and downstream in post harvest (processing, transport, marketing). Studies elsewhere indicate that for every job in the production sector 2 to 3 jobs are automatically created in the post harvest sector. Direct employment in fisheries in the region might be in the order of 345,000 - 460,000 persons (or 6.8% to 9.0% of the regional labour force of 5.1 million). Self-provisioning subsistence fishing might be carried out by several million individuals in the region.

Expansion of the labour force will increase the demand for employment. The regional population is expected to increase by about 66% in the two decades between 1990 and 2010. The labour force could increase by an additional 3.4 million persons. If the fisheries sector is to maintain its current share, an additional 340,000 jobs will have to be created in fisheries over the next 20 years.

There is also increasing incidence of landlessness among the poor because small holders are going broke and selling out. This increases the supply of agricultural wage labourers. Because they have a low opportunity cost, many are drawn into fishing, which puts even more pressure on the fish resources.

Potential areas for creation of new jobs are:

- processing
- marketing and transport
- net making and repair
- boat building and repair
- construction works supporting fisheries (such as embankments around beels, excavation of borrow pits and ponds, and fish passes)
- pond culture production

2.7.2 Income from production and post harvest sectors

Little direct information is available on income levels within the fisheries sector of the region. At an estimated average current retail price of Tk 60 per kg, the total value of fish production from the region is about Tk 6.9 billion. Assuming that 76% of this pertains to commercially marketed produce (the remaining 24% is an equivalent market value for subsistence produce), a total of Tk 5.2 billion is shared out among the 500,000 persons guestimated to be directly employed in the fisheries sector. Mean per caput income is therefore Tk 10,400. However, jalmohal lease holders, money lenders and government taxation capture a large share of total income, leading to severe inequality of income distribution in the fisheries sector. Actual hands-on "genuine" fishermen and artisanal and factory processing labour undoubtedly earn considerably less than the mean income.

BBS (1991) gives data from the 1988/89 household expenditure survey for all of Bangladesh. Average monthly income per rural households are:

- 39.3% are farming households, Tk 3,129
  - owner farming, Tk 3,696
  - owner-cum-tenant, Tk 2,737
  - pure tenant, Tk 1,968

- 21.1% are agricultural wage labour households, Tk 1,565

- 1.6% are fishing households, Tk 2,068

Although these figures may not be accurate for the region, they do indicate that fishing is more remunerative than agricultural wage labouring or tenant farming.

Genuine fishermen are apparently now better off than before NFMP. In Habiganj, NFMP fishermen are said to earn up to Tk 4,000 per year, whereas before they earned less under the jalmohal lease system. Implicit daily wage rates determined by BCAS (1989) for NFMP fisheries range between Tk 57 and Tk 167, but these are high season averages, not annual means.

Given the range of retail trader markups, the retail prices of fish and the quantities of fish sold per trader, it would seem likely that a small fish trader's income might exceed that of a fishermen by a modest margin.

2.7.3 Living standards of fishing communities

Fishermen live in three types of community situations:

- Permanent fishing villages, where most or all of the inhabitants are involved in fishing;
- Permanent agricultural villages, where only a minor proportion of inhabitants are involved in commercial fishing (although many more may carry out occasional subsistence fishing);
- Temporary fishing camps *(Khola)* situated near beels in haors and in deeply flooded areas. Typically fishermen live here for only five months during the dry season, and move back to permanent villages during the rainy season. The temporary buildings are re-erected each year after the flood recedes using materials brought in from outside.

Most Muslim fishing families own their own homestead, and have a small amount of agricultural land (garden plot). This plot is however too small to yield an economic return. Movable properties are productive assets (fishing gear, boats). Professional Hindu fishermen are mostly poor, low caste and absolutely landless (no plot).

From the available evidence it is not clear that permanent fishing villages differ substantially from agricultural villages and general rural norms in terms of quality of life/living conditions (ie health services, potable water, energy, roads, transport, housing, electrification, child mortality, nutrition, life expectancy). Hygienic conditions in *Kholas* appear to be better than in permanent villages, possibly because of the shortage of time for accumulation of refuse, annual flood flushing of the site and greater care because of the need to reduce the vulnerability of the fish drying operations to rodents and other pests.

In general however, fishing communities are extremely poor. Illiteracy is almost total among fishermen. Fishermen often do not want their sons to become fishermen. But they have no money to send their boys to school. The value of education for getting better jobs is clearly recognized.

Low incomes prevent capital accumulation or expenditure on human development (ie education for children). Unless there are concrete and significant shifts in fisheries resource allocation and tenure in favour of genuine fishermen/producers, backed up by institutional support in technology, marketing and finance, no change in the living conditions of fishing communities can be expected in the foreseeable future.

2.8 FISHERIES INSTITUTIONS AND CURRENT DEVELOPMENT POLICIES AND PROJECTS

2.8.1 Department of Fisheries

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

Hotta (1990) notes that the DOF suffers from shortcomings in planning, project implementation, design of extension activities and inter-agency coordination. With regard to the latter, the absence of a clear mandate for the DOF results in "confusing and/or overlapping divisions of responsibility" between DOF and MIWDFC, MLGRDC, FRI, BFDC and thana administrations. Key persons are usually delegated to projects, thus perpetuating weaknesses of the DOF's main structure. Insufficient staff are trained in planning, economics, social sciences, financial management, and accounting. The DOF staff and resources are definitely overextended. All funds available for development projects cannot be spent. The absorption capacity of the DOF for more external assistance is not great, and committed assistance cannot be fully utilized.

2.8.2 Fisheries Research Institute

The FRI was established in 1984. It operates four research stations:

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

There are 59 scientific staff and 105 supporting staff. The FRI is involved in some 26 research projects, including borrow pits and Ilish (Chandpur Station). There is a need for involvement of DOF in programme prioritization of FRI research activities.

2.8.3 Bangladesh Fisheries Development Corporation

Established in 1964, the BFDC is concerned with developing marine fisheries, Kaptai Lake and fish processing/marketing. A number of fish landing centres have been built around the country and are intended to operate as commercial enterprises. Only those in Chittagong and Cox's Bazar are functioning properly. Another 9 (including the Dabor center near Sunamganj) are practically lying idle. Contracts were awarded for the construction of these often poorly planned centres. The BFDC's financial performance is poor. Reportedly they lose Tk 5 crore every year. Opinion has been expressed that most of BFDC holdings should be sold off to the private sector as soon as possible. Given the generally efficient marketing system for fish which exists in Bangladesh, it appears that BFDC should not enter into fish marketing and compete with the private sector. Clearly, if BFDC is to play a useful role in the future development of fisheries in Bangladesh a re-evaluation of its mandate is needed.

2.8.4 Other institutions and NGOs

Other public institutions involved in inland fisheries are:

- MOL: administration and leasing of jalmohals over 8 ha;
- Thana Parishads: administration and leasing of jalmohals of 1 - 8 ha. Most of their development finance is spent on agricultural projects and there is little investment in fisheries;
- MIWDFC: leasing of borrow pits resulting from FCDI construction;
- DRH: leasing of borrow pits resulting from road embankment construction;
- Ministry of Commerce: export of frozen fish commodities;
- Ministry of Finance: budget and administration of externally funded fisheries projects;
- Nationalized banks (Krishi, Agrani, Rupali): provision of credit for fisheries;
- Planning Commission: planning for fisheries sector within national economic planning;
- Universities, whose staff members carry out fisheries related research.

More than 100 local, national and international NGOs are involved in fisheries in Bangladesh. In the region work is carried out by BRAC, IDEA, CARITAS, FIDVB and PROSHIKA MUK, among others. Some NGOs lack competency in administering fisheries management projects.

2.8.5 Current fisheries development policies

The Fourth Five Year Plan (1990-95) describes the objectives, targets, strategies and policies adopted by GOB for the management and development of the fisheries sector (see Appendix I). The Plan sets as its objectives increasing fish production for domestic consumption, improving socio-economic conditions of fishing communities, creation of additional employment opportunities, enhancing fish production and management technology, training manpower, increasing foreign exchange earnings from exports and improving the environment and public health.

At the strategic and policy levels, the Plan considers fisheries as a priority sector to generate additional employment opportunities and alleviate poverty of the rural community. A well-defined land and water utilization policy is to be framed on the basis of land topography, monsoon and tidal inundations, water salinity, soil quality and other environmental and economic factors for optimum utilization of resources. Guided by this policy, the low-lying areas, riverine and coastal areas, sweet and brackish water areas including khas lands are to be optimally used for culture of shrimp and suitable fish species. The yearly leasing of inland open waters will be replaced with the licensing system under the New Fisheries Management Policy. Simultaneously, an investment and management oriented leasing system covering at least 4 years or more is to be adopted to ensure higher production and resource conservation.

A set of 12 strategy and policy measures are put forward to achieve the Plan objectives. Of particular importance to the floodplain fisheries of the region are the following measures:

(ii) Biological management of jalmohals by providing fishing rights to the genuine fishermen and gradual replacement of existing leasing system,

(iii) Large-scale stocking of inland open waters, inundating flood lands with rigid enforcement of fish and fish habitat conservation practices,

(iv) Community-based integrated development approach for artisanal fisheries with improvements in technology, processing, marketing and distribution facilities,

(xi) Formulation and implementation of a well-defined land/water policy to avoid wasteful resource conflicts, along with effective measures against dumping of industrial and other wastes into the open water system and use of agricultural biocides of long residual effects.

The Plan lays out a framework of activities based on these strategy/policy measures:

Environment: Coordination among water resources development agencies in planning and designing of water projects for properly managed fisheries would be stressed. This would involve adequate provisions in such projects for losses in fishery sub-sector in arriving at economic viability and justification. In addition, enforcement of laws relating to treatment of wastes would be emphasized for regulation of harmful discharge of agrochemicals and industrial effluents into the water systems.

Fisheries Management: In order to initiate proper management of fisheries resources, emphasis is to be given on promulgation and proper execution of adequate fish conservation laws through revision of existing laws on the basis of biological studies of commercial fish species. With a view to ensuring benefit to the fishing communities and licensed fishermen, two systems of management — licensing system as per New Fisheries Management Policy (NFMP) and modified leasing system — will function simultaneously. The existing yearly lease system will be replaced by a longer term of at least 4 year period to encourage appropriate investment, better management and higher production and to allow the fish sufficient time to grow to maturity and breed. Subject to successful implementation, the NFMP will gradually replace the leasing system.

Inland Fisheries Development: Inland open water fisheries will be developed through effective management and conservation measures of riverine fisheries and floodplains. Massive artificial stocking of open waters such as rivers, flood lands, beels, and lakes with fish fingerlings will be done and biological management and fish habitat conservation practices would be strictly observed. Selected species to be stocked will include Chinese and Indian carps as well as Magur, Koi, Punti, Golda prawn, etc. Short time stocking with miscellaneous species of small fish in the sluices, dykes, floodplains, reservoirs etc. will also be encouraged during the monsoon seasons. For development of floodplain fisheries the selected areas would be Rajshahi, Khulna and Dhaka Divisions including Sylhet and Mymensingh floodplains. More floodplain areas will be taken up for development during the Fourth Five Year Plan through improved management and conservation practices. The protection and conservation measures will include:

(i) rigorous implementation of fish protection and conservation act,

(ii) establishment of fish sanctuaries,

(iii) exploitation of non-sanctuary perennial beels,

(iv) strict enforcement of the ban on jatka (Ilish fingerling) catch during February-April,

(v) heavy penalization to the users of current jal,

(vi) imposition of penalty on the industrial dumping of untreated and harmful industrial wastes into any open water system,

(vii) fisheries development and conservation in flood control, drainage and irrigation projects etc.

The Plan sets the following targets for the fisheries sector:

- Increase fish production from 847,000 tons in 1989/90 to 1,200,000 tons in 1994/95. Inland capture fisheries production in 1994/955 would increase to 523,000 tons, and inland culture fisheries production to 415,999 tons.

- To export 45,000 tons of prawns and shrimp (head on), 17,000 tons of fish and fish products and 2,000 tons of other aquatic organisms,

- To generate fulltime and part time employment opportunities for about 1,000,000 people by 1994/95.

Evaluation of the efficacy and realism of the Plan strategies and policies is given throughout this report.

2.8.6 Current fisheries development projects

Five DOF managed fisheries development projects are currently being executed in the region:

2nd Aquaculture Development Project. This project is financed by the ADB. It started up in June 1987, and presently extends up to June 1995. The DOF have requested that the project be extended to June 1996. There are four major project components:

- culture-based floodplain fisheries (ie stocking of native and exotic major carp in selected beels in the Northeast Region);

- carp culture extension (ie purchase of seed, fertilizer, feed for fish farmers, training and demonstration, credit, in Sylhet, Habiganj and Kishorganj Districts);

- construction of 6 major government-owned hatcheries (of which 3 will be in the Northeast);

- shrimp culture extension in coastal districts.

Table 2.38: 2nd Aquaculture Project Budget

Component	Original (Million Tk)	Revised (Million Tk)
DOF Portion	727.5	990.2
Credit	980.1	1147.0
TOTAL	1707.6	2137.2

The project budget has undergone revision as shown in Table 2.38.

The project finance has been procured from the ADB as a soft loan to the Government of Bangladesh, at 0.75% service charge and 40 year maturity. Credit lines of the project are administered by the Bank of Bangladesh and disbursed through three commercial banks (Krishi, Agrani and Rupali).

According to project personnel, the beels selected as nurseries are connected with the most important fishery areas. Haor generally contain several beels and other water bodies (khals, ponds, borrow pits). Among those only one shallow beel is selected for the nursery (for poisoning and spawn release). Compared with the total area of the haor, the poisoning of one beel is considered very negligible from the viewpoint of species extinction due to rotenone poisoning. The haor area was surveyed in 1991 and the following important fisheries were identified for stocking:

Sylhet District:
Meder haor (Pile fishery)
Medhal beel
Rohila beel
Aral beel (Golapganj)
Rajibari Chapra beel
Chatol-Patachatol beel (Balaganj)
Varua beel (Fenchuganj)

Sunamganj District:
Danchapra beel (Chatak)
Dabor beel
Barol beel
Jaor haor
Tangua haor (Taherpur)

Moulvibazar District:
Ainpur Beri beel (Sherpur point)
Hakaluki haor system

The rotenone poisoning of about 1600 ha of beels has reportedly been completed. Hail Haor was stocked in 1991. Hail Haor was stocked in 1991 with *rui, catla, mrigel*, Silver carp and Common carp. Local fishermen say catches are increasing. However, 0+ and I+ year classes are not showing up in local markets, and may be going to Dhaka or India.

Realizing the problems associated with hatchling stocking in the beel areas, the project authority has now proposed that larger size fry/fingerlings be stocked in 1995. This proposal is being reviewed by the ADB.

Comments on the project from various sources include:

- It diverts hatchery production away from pond production, and has resulted in scarcity of fry for aquaculture (thus leading to a decrease in pond production);

- Rotenoning of beels for carp nursery purpose kills miscellaneous chotomaach subsistence fish, and disrupts the food chain and life cycle of the environment. There is also evidence that other animals are killed.

- Subsidizing jalmohal leaseholders and rewarding bad management practices (ie benefits go to rich not poor fishermen). It is said that middlemen are benefitting and not fishing communities, as the stocked carp go into the katha of leaseholders.

- In the long term, stocking is unlikely to be financially sustainable. Unless very strict management of fishing effort on natural brood stock overwintering in beels and duars is implemented, any rehabilitation of the carp stock which the project may be successful in achieving will be defeated within 2 or 3 years by uncontrolled beel and duar harvesting by jalmohal leaseholders.

- Large government owned hatcheries take up to 7 years to build, and furthermore do not operate in an economically efficient manner. Hatcheries should be smaller, more numerous and entirely under private sector ownership.

Some impact information was collected at Ainpur Beri beel. The nursery is connected with Berry beel. Before stocking, project personnel applied rotenone to kill all fish. Although a large quantity of fish was killed (even the leaseholder was surprised at the magnitude of the standing crop), many fish including predators were able to escape poisoning by swimming into marginal aquatic plant stands. Local people assume that they will catch less small fish in the coming year. About 1000 people reside in the area and about 90% of them customarily caught their subsistence fish from the beel. Before rotenoning the beel for nursery purposes, people caught 20-25 kg of fish per year per family for their own consumption. Some of the young people believe that this stocking system may increase the production of carp, but decrease the subsistence fishing in the area. The leaseholder said that because the rotenone had killed much of the *chotomaach* local people were now catching carp fingerlings/juveniles for subsistence.

Integrated Fisheries Development Project. This project is financed by the GOB. It was intended as a time gap filling pilot project prior to start-up of the current 2nd Aquaculture Project. Several of its components are of importance to fisheries in the region:

- establishment of mini hatcheries at the thana level;

- establishment of fish sanctuaries;

- implementation of NFMP in borrow pits belonging to the BWDB;

- survey of public water bodies in urban centres.

Total value of the project is Tk 177.3 million.

Mini hatcheries are being established in Moulvibazar (Kulaura), Sherpur and Narsingdi Districts. BWDB borrow pit development is being done to gain experience in development of FCD/I-impacted jalmohals. No project sites are in the region, but a planned second phase will have a site in the Manu River Irrigation Project near Moulvibazar.

The following fish sanctuaries are being established in the region:

- Sari River, Sylhet District, from Sarighat to the Bangladesh border;
- Luba River, near Kanaighat in Sylhet District, 1,000 ha total area (to protect migrating *rui, catla, gonia,* and *kalibaus*);
- Surma River, at Sunamganj, 1,000 ha area;
- Ublakha River and Hogla Beel, in Khaliajuri thana of Netrokona District, 500 ha total area;
- Kali River, in Kuliachar thana of Kishorganj District, 500 ha area.

Uniformed "fish guards" have been appointed to prevent fishing for migrating or overwintering carp and other stocks in sanctuary areas. Fish guards have at their disposal mechanized country boats. The system is new and not yet very effective.

There are numerous derelict government khas ponds and reservoirs in urban centres. All districts are being surveyed in order to bring these jalmohals into productive use.

A successor project is being planned, entitled "Integrated Aquaculture Development in FCDI Project Areas". This will focus on fisheries in BWDB borrow pits. Re-excavation of pits will be carried out under a food for work arrangement supported by WFP. Project expenditures will be met by the GOB, at least initially.

Improved Management of Open Water Fisheries Project. This is a follow-up project to an earlier experimental management project (BCAS, 1989). It is financed by Ford Foundation and has a budget of Tk 11.2 million. The project seeks to improve socioeconomic conditions of NFMP fishing communities. It supplies boats, gear and credit, and is concerned with community development. For example, it attempts to introduce handicrafts as a new source of income. An important aim is of the project is to try to transfer authority for management to the fishermen themselves (ie community-based fisheries management). The project works in association with NGOs (BRAC, CARITAS, FIDVB, PROSHIKA MUK), but does not provide them with finance. The project's beneficiary *jalmohals* are all under NFMP. These are:

- Rivers in Netrokona and Kishorganj, Kanglir Haor near Sunamganj,
- Beels in Habiganj and Netrokona, and
- A dead river *(baor)* in Sherpur.

The project budget has provisions for holding two workshops, foreign training for DOF staff and computer training.

Aquaculture Extension Project. This project is financed by DANIDA and GOB. It operates only in Mymensingh District (half of which falls within the NERP area). The current project is nearing completion and will likely go into a second phase. The project targets primarily small scale pond owners. The total project budget is Tk 69.4, of which DANIDA contributed Tk 62.9 million and the GOB contributes Tk 6.5 million.

The project has 3 main components:

- credit for those who qualify;
- demonstration for those who don't qualify for credit;
- contact farming advisory service.

The project aims to promote pond production through intensive extension support to the farmers. At present it is working in six thana's in Mymensingh. Work will be expanded over the four new districts (Kishorganj, Netrokona, Jamalpur and Gazipur) in the second phase which is expected to be start from 1993. During the first phase, the project was successful in increasing aquaculture production and incomes. In addition to carp fingerling and food fish production, the project has initiated production of giant fresh water prawn by established a prawn hatchery at the FSMF, Mymensingh. The hatchery is now successfully producing prawn post-larvae for stocking in farmers' ponds. It is expected that the overall pond production in the area will be substantially increased after the execution of the second phase of the project.

Institutional Strengthening in the Fisheries Sector Project. This project is financed by UNDP and executed by FAO. In the region it provides some support to aquaculture extension in Netrokona and Kishorganj.

3. FISHERIES ENVIRONMENT ISSUES AND PROBLEMS

3.1 IMPACTS OF FCD/I PROJECTS ON FISHERIES

3.1.1 Status of fisheries in areas without FCD/I projects

As a basis for the evaluation of impacts of FCD/I projects on fishery resources and the supporting aquatic environment of the region, as well as for assessing the overall status of the fisheries sector in the region and formulating a strategy for regional fisheries rehabilitation and development, 16 field case studies were carried out at well defined fisheries areas not directly enclosed or impacted by FCD/I projects. The areas were selected based on their importance and relative contribution to the overall fish production of the region. Full accounts of the findings are reported in Appendix K. Summaries of production trends and non-FCD/I factor impacts at ten fisheries are presented below:

Mother Fisheries

Hakaluki Haor: Over the last few years, fish production in the haor has declined due to several reasons:

- Use of current jal and chat jal;
- Disease infestation;
- Siltation, mainly in the Juri river and some important beels (Barang beel, Tamshakuri beel, Malam beel, Hingjuri beel, Chatal beel, Tural beel, Guala beel);
- Effect of Fenchuganj Fertilizer factory pollution, which not only restricts migration, but by discharging ammonia gases, causes air pollution;
- Decomposition of paddy roots/stems, which has created water quality problems during the breeding season (April/May) when water volume is low;
- Complete de-watering of annual beels results in capture of all species;
- Deforestation within the haor (wood used for fuel and katha);
- Reduction of bird populations due to deforestation, as birds droppings are an important source of nutrients to produce natural fish food organism.

Local people maintain that there are occasional massive fish mortalities in the Juri river which are attributed to the appearance of toxic plants (*Bishlat*) coming from India.

Tangua Haor. In spite of the high level of environmental quality and human inputs such as tree plantations, the production level is gradually declining. The main natural threat to Tangua Haor is sedimentation of the Jadukata River, which carries large quantities of sand and stones from the Indian hills. The river bed is gradually raising which reduces the water storage capacity of the river. Due to low carrying capacity of the Jadukata River, flash flood water is diverted to the Maharam River, which now carries a large quantity of sand to Tangua haor area. As a result, the Alam *duar* of Tangua haor is gradually silting up. The Pachasloal beel has already been destroyed due to siltation. Re-excavation of the old Jadukata River is recommended by the local fishermen to keep the haor as it was.

167

Kaliajuri area: Over the last 5 years the total catch has reportedly declined by 70%. Local people identified the following problems:

- Overfishing as a result of the population increase and no other alternate employment opportunities after the paddy harvest in April;

- Rapid deforestation because of a domestic fuel shortage. No massive plantation program has been initiated by any agency. Recently some of the medium and large farmers have begun small scale plantations of *hijal, koroch, borun* and *mera* trees around their houses;

- Annual beel fishing as a result of insecurity of leases as well as widespread poaching and intergroup conflict for dominance among the rich people;

- Shortage of water resulting from siltation, use of water for irrigation and draining wetlands to create more land for rice cultivation;

- No supervision over the pile fishery. There are some sanctuary piles in the area, but no one is maintaining these piles. As a result brood fish are decreasing rapidly.

Gunga Beel near Ballavpur, Khaliajuri, was famous for *Nandin* (which is now extinct). The species does not like to reside in areas which are silted and always prefers deep areas with clayey soil. This may well lead to its extinction.

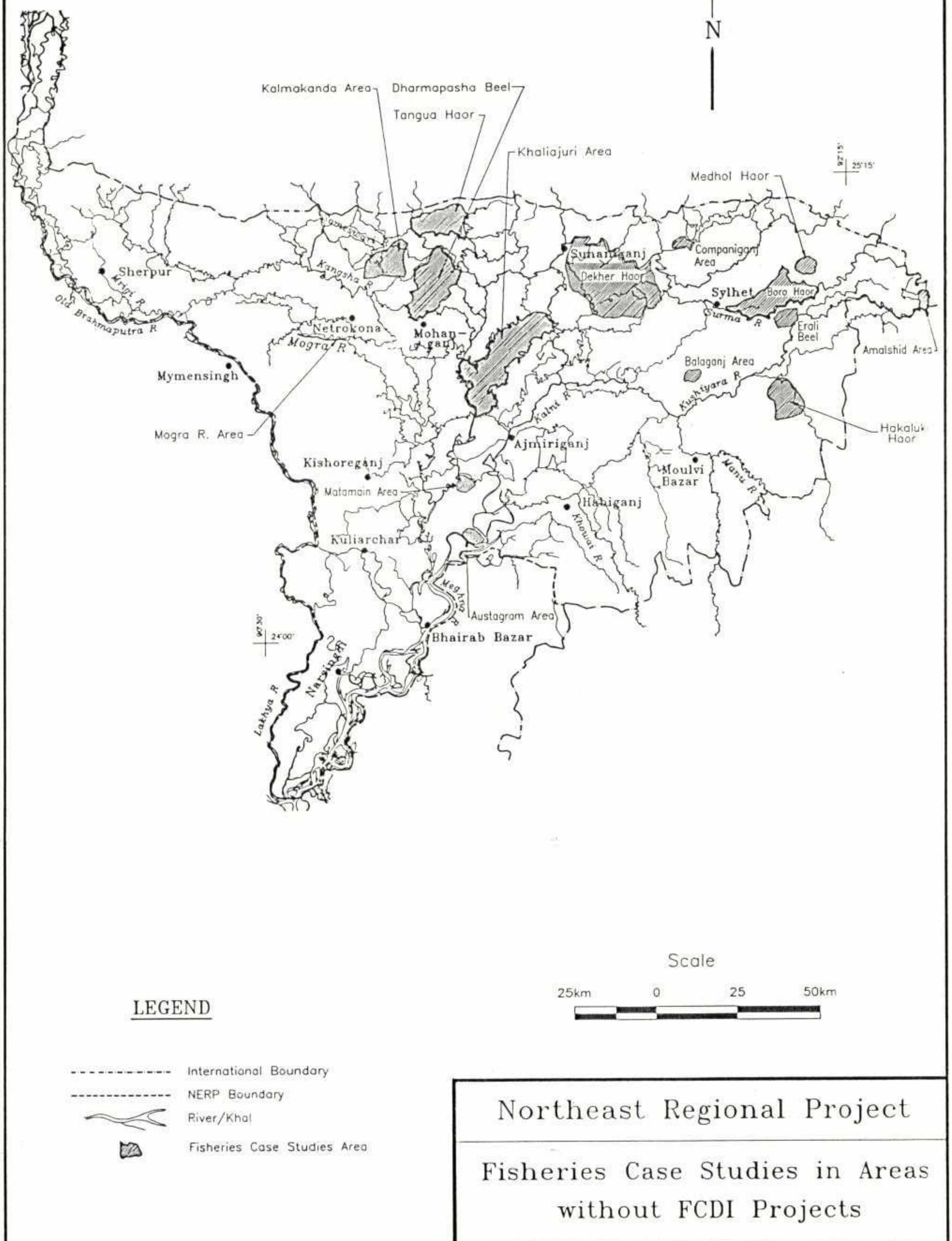
Companiganj area: This mother fishery is in relatively good condition. Stone quarrying is the main business in the area. As a result fishing pressure is less on the adjacent water bodies as most of the working class people are engaged in this highly profitable business. Removal of sand and stone from the river bed deepens it and probably enhances the quality of the environment by counteracting sedimentation.

Other Fisheries

Kalmakanda area: In the past, the area was famous for *Mohashol, Koi, Boal, Air, Rui, Nandin* and other fish. However, fish production has reportedly declined by about 70-80% over the last five years. The following reasons for this decline were given by one *nitimala* fishermen group:

- excessive siltation
- rapid deforestation
- annual harvesting of the fishery by complete de-watering
- overfishing and use of current jal and chat ber jal

168



Northeast Regional Project

Fisheries Case Studies in Areas without FCDI Projects

Prepared by: BNP	November 1994
Computer Drafting by: Jalal/Mamun	AutoCAD Drawing

XREF:NERP-075.DWG
FILE: NERP-140.DWG

U69

Dharmapasha area: Fishermen and other people maintain that the overall production of the area has declined by 30-35% over the last five years due to the following causes:

- Siltation of the perennial water bodies
- Excessive fishing pressure on the jalmohals
- Short term leasing and annual fishing by complete de-watering of the *jalmohals*
- Deforestation within the haor area
- Use of current *jal* and *kona ber jal* on the floodplain
- Fish disease
- Lack of mother/reserve/pile fishery in the area

Extinct species in the area are: *Nandin, Mohashol, Koral (Berkul)*.

Astagram area: People in the area maintain that a new type of net (*Vim jal*) which has recently been introduced is a major reason for a decrease in the areas fish population since it catches almost all fish including broodstock and fry. However, the main problem in the Astagram area is siltation of the Upper Meghna. People from Astagram and Bangaalpara maintain that rapid siltation is the result of excess use of *katha* and *jaak*. In the river stretch from Bhairab bazar to Ajmiriganj, about 0.5 million bamboo stakes are placed in the river, which reduce the current velocity and induce siltation.

Erali beel: Three to five years ago, the floodplain areas of Erali beel was renowned for producing large Singi, Magur and Koi. However, at present these species are more or less extinct due to the introduction of current jal, which is the main factor for the declining fish production in the area. It is reported that the overall production has declined by 75% over the last 5 years.

Balaganj area: The Thana Fishery Officer, fishermen and the lessee identify the following factors as responsible for the decline in fish production in the area:

- Siltation caused by the Kushiyara River water;
- Use of current jal and kapri jal in the open water;
- Immediate leasing of the partially silted lands for agriculture;
- Industrial effluent of Fenchuganj fertilizer plant.

Due to the high sedimentation rate, most of the jalmohals are now becoming silted up. People of the area maintain that the high rate of sedimentation started after the construction of the Manu River Irrigation project on the opposite bank.

Boro Haor: Mass mortality of fish occurs occasionally in the river and it is suspected that poisonous plants are thrown into the water in the Indian catchment.

Production trends are summarized in Table 3.1. Except for the Companiganj mother fishery, all the other fisheries studied have suffered production declines ranging from 30% to 80% (where quantitative estimates were put forward by interviewees). These figures should not be interpreted literally but as indicating the existence of significant problems at many non-FCD/I fisheries which require attention (mother fisheries in particular).

Table 3.1: Production Trends by Fishery

Code	Fishery	Production Trends (Reported)
1	Hakaluki haor	Declining
2	Tangua Haor	Gradually declining
3	Kaliajuri area	70% decline over last 5 years
4	Companiganj area	Stable
5	Kalmakanda area	70-80% decline over last 5 years
6	Dharmapasha area	30-35% decline over last 5 years
7	Astagram area	Declining
8	Erali beel	75% decline over last 5 years
9	Balaganj area	Declining
10	Boro haor	Occasional shock

The factors responsible for declining production are summarized in Table 3.2. The most common region-wide factors responsible for declining fish production are:

- Overfishing from use of current *jal* and other illegal nets;
- Siltation of beels and rivers;
- De-watering of beels for agriculture;
- Annual harvesting of *katha*;
- Deforestation.

Other factors contributing to declining catches are:

- Fish disease;
- Industrial water pollution;
- Plant poisons;
- Decomposition of rice plant residue;
- Dynamite fishing (one case: Luba River);
- Short term *jalmohal* tenure (ie leasing);
- Reduced bird population;
- Poaching and conflicts between lessees.

These factors are discussed in greater detail in the relevant sections of this report below. These factors also affect many fisheries inside FCD/I projects (see Appendix L).

Table 3.2: Factors Responsible for Declining Fish Production

Factor	Fishery (codes are those defined in Table 3.1)									
	1	2	3	4	5	6	7	8	9	10
Current jal Over-fishing	●		●		●	●	●	●	●	
Disease	●					●				
Siltation	●	●	●		●	●	●		●	
Industrial effluent	●								●	
Decomposition of rice waste	●									
De-watering	●		●		●	●			●	
Annual fishing	●		●		●	●				
Deforestation	●		●		●	●				
Reduced bird population	●									
Toxic plants	●									●
Poaching, conflict			●							

All of these factors in combination can be regarded as a non-FCD/I factor complex which negatively affects fisheries. It might be possible to quantify the losses due to individual non-FCD/I factors, but it would be difficult to separate the effects of two or more factors operating simultaneously. Few fisheries in the region appear to under only a single stress factor. Typically, most non-FCD/I fisheries are being impacted by several factors simultaneously.

An additional complication to evaluating the fisheries of non-FCD/I areas is the importance of remote effects of both nearby and distant FCD/I projects (singly and in combination). For example, an FCD/I project such as the Manu River Irrigation Project which damaged a carp spawning locality would exert a negative influence on all downstream non-FCD/I fisheries which depended on that carp spawning area for fry. Another remote effect of FCD/I projects is to 'channelize' boromaach broodstock during their spawning migrations. Thus the 15+ partial flood protection FCD/I projects in the northern part of the Sylhet Basin (ie Shanir Haor, Halir Haor, Matian Haor, etc) prevent broodstock that are swimming up rivers during the premonsoon from moving laterally on to the floodplains prior to circa 16 May. The broodstock presumably continue to swim upstream, past the embanked haors, until they reach unembanked haors/floodplains near the Indian border, such as Tangua Haor and the Companiganj area. A high density of FCD/I projects/embankments thus transforms rivers into corridors which 'lead' migrating fish to remote unembanked areas further upstream. FCD/I projects also induce sedimentation in non-FCD/I fisheries, both upstream (through ponding) and downstream (through aggradation).

3.1.2 Monitoring of fisheries in Shanir Haor FCD and Manu River FCDI Projects

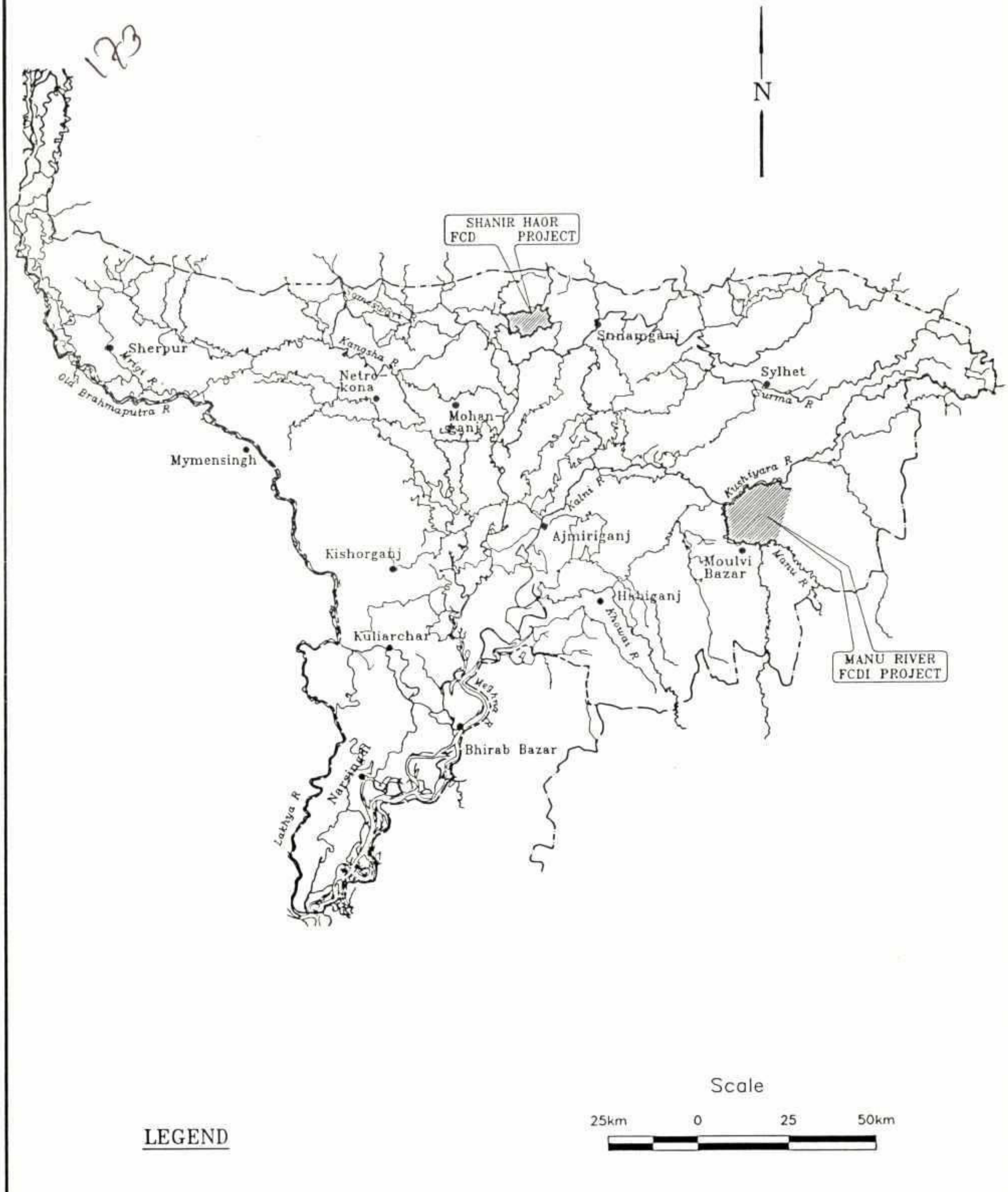
Long term monitoring of fisheries was carried out at:

- Shanir Haor FCD Project, a partial flood protection (submersible embankment) project situated in the northern part of the Sylhet Depression,
- Manu River FCDI Project, a full flood protection project with pumped drainage and irrigation situated in the southeastern part of the region on the Kushiyara floodplain.

The monitoring studies were components of a larger multidisciplinary NERP activity termed the Project Monitoring Programme (PMP). This programme focused on understanding the livelihood pattern of the people of the area, and the impact of the project on it, and hence determine the needs for, and means of achieving, institutional and technical improvements in FCD/I projects at the planning, design, construction, operation and maintenance phases. The general objective of the PMP is to create a basis for improved water resources planning and design through better understanding of the real impacts of actual FCD/I projects on agriculture, fisheries, environment, human welfare and economic development. Specific objectives are:

- Social. To evaluate the impacts of the project on human development and standard of living (employment and disposable income; literacy and education; health, nutrition and life expectancy; public empowerment, economic equity, gender equality and freedom).
- Economic. To evaluate the impacts of the project on production sectors (agriculture, fisheries, forestry), services (navigation, health, education, communications) and infrastructure (roads, domestic water supply, energy supply, etc);
- Physical. To evaluate the physical performance and physical impact of the project inside and outside of the project area;
- Financial. To assess the economic efficiency of the investment of the project in terms of internal rate of return, benefit/cost ratio and net present value.
- Planning. To formulate practical recommendations to solve FCD/I-induced and related problems at Shanir Haor and Manu River.

Figure 50



Northeast Regional Project

Project Monitoring
Programme Sites :
Shanir Haor & Manu River

Prepared by: BNP/Jalal	April 1993

XREF:FISH-121.DWG
FILE: FISH-110.DWG

Full reports of findings of fisheries monitoring are presented in the two PMP reports prepared by NERP and entitled 1) Shanir Haor 2) Manu River. Brief summaries are given below.

Shanir Haor FCD Project

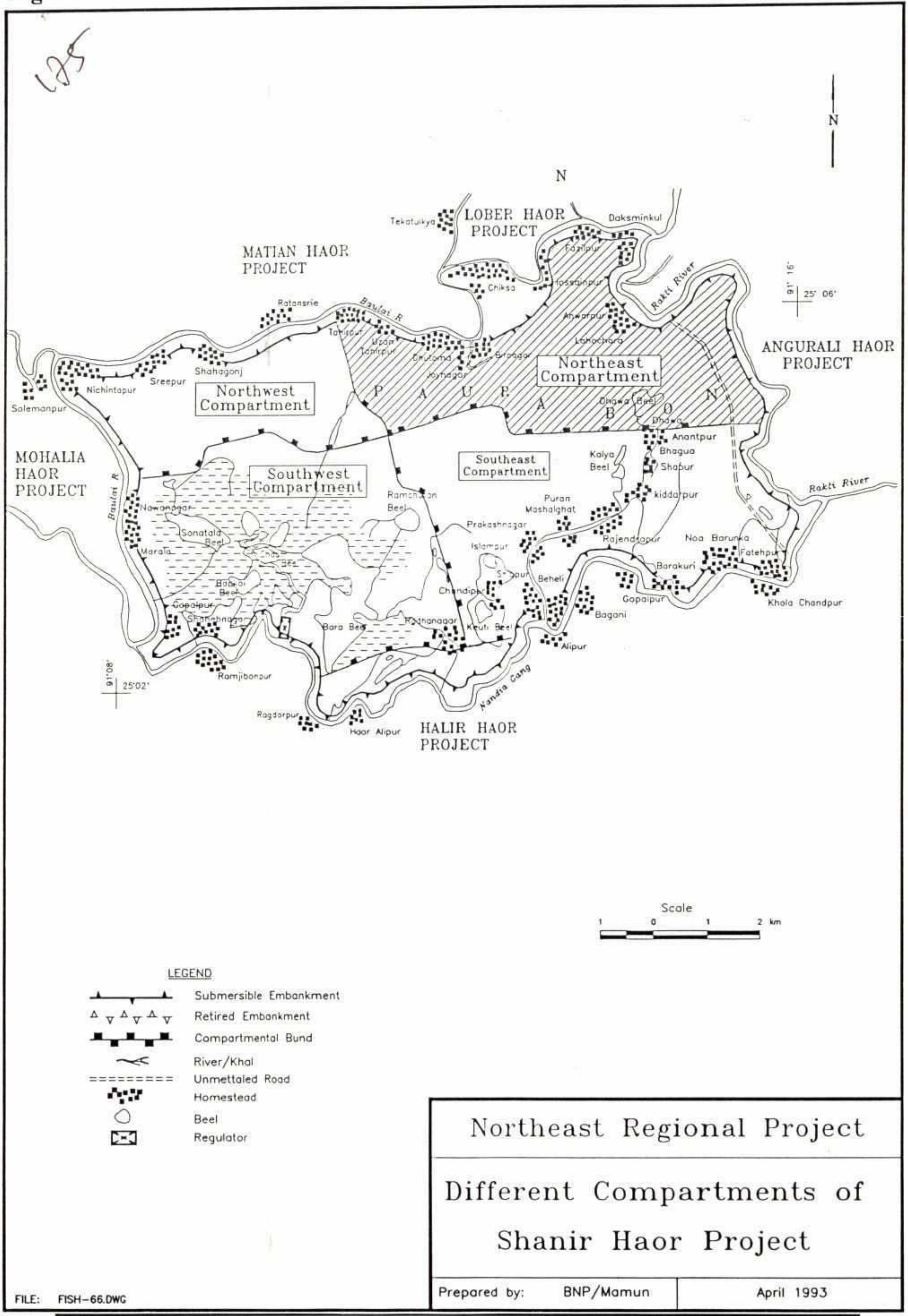
Monitoring work began in March 1992 and ended in May 1994. The PMP base camp was situated at Beheli, an old village with some historical background situated by the bank of the Abbua (Nandia) River. Twenty five field trips were made to the locality: Twelve field visits were made during year 1 and thirteen during the year 2. The average length of each field trip was around ten days.

Project location and general data: The project is located in the deeply flooded area of the Sylhet depression, in Taherpur, Biswambarpur and Jamalganj thana under the district of Sunamganj. It is a partial flood control project covering about 7010 ha of land. The project was begun by the local jaminder in 1920 and completed by BWDB in 1986. The embankment around the project delays inundation of the haor, resulting in reduced fish production. Some 88 species were identified in and around the Shanir Haor area.

Physiography and Hydrology: Shanir Haor is located in the midst of several other important haors (Matians, Anguurali, Halir and Gurmar) and the project area is bordered to the north and west by the Baulai River, to the east by the Rakti River and to the south by the Nandia Gang. At the northeast corner of the area, the Baulai and the Rakti branch off the Jadukata River. The Baulai eventually discharges into the Surma River below Jamalganj. Recent sedimentation of the Baulai and Rakti increase the dry season water levels of Nandia Gang, which tends to delay post-monsoon drainage of the project area. Also as a result of the sedimentation, Baulai and Rakti monsoon flood flows have decreased. Local people believe that water levels in the rivers surrounding the project have risen due to sediment deposition, causing flooding and post-monsoon drainage congestion in the area, and increasing the incidence of embankment breaching and overtopping. The project area contains the important Boigani beel group Fishery, which has an area of 44 km^2. There are a number of duars within and around the Shanir haor area in the Abbua/Putia River.

Project concept: The project objective is to protect the *boro* crop from pre-monsoon flash floods by constructing 48 kilometres of submersible embankments, 9 kilometres of compartmental bunds, and one six-vent flushing/drainage regulator. The area experiences deep monsoon flooding of 3.0-6.0 meter depth. The area is mostly single-cropped; local *boro* is the main crop. Fisheries was not taken in consideration as an important economical resource during project planning.

Figure 51


N
N
LOBER HAOR PROJECT
MATIAN HAOR PROJECT
ANGURALI HAOR PROJECT
MOHALIA HAOR PROJECT
HALIR HAOR PROJECT
Northwest Compartment
Northeast Compartment
Southwest Compartment
Southeast Compartment
P A U R A B O N
Baulai R
Rakti River
Nandia Gang
Tekatukya
Daksminkul
Chiksa
Ratonsrie
Shahagonj
Sreepur
Nichintapur
Solemanpur
Nawanagar
Marala
Sonatala Beel
Gopalpur
Ramjibanpur
Ragdarpur
Haor Alipur
Bara Beel
Chandipur
Keuti Beel
Alipur
Bagani
Beheli
Gopalpur
Barakuri
Khola Chandpur
Fatehpur
Noa Barunka
Rajendrapur
Prakashnagar
Islampur
Puran Mashalghat
Kalya Beel
Anantpur
Bhagua
Shapur
Kiddarpur
Dhawa Beel
Dhawa
25° 06'
25°02'
Scale
1 0 1 2 km
LEGEND
Submersible Embankment
Retired Embankment
Compartmental Bund
River/Khal
Unmettaled Road
Homestead
Beel
Regulator
Northeast Regional Project
Different Compartments of Shanir Haor Project
Prepared by: BNP/Mamun
April 1993
FILE: FISH-66.DWG

Hydrology : Hydrological changes during the two study years in Shanir haor resulted in a significant difference in fish production. NERP hydrographs indicate that the project area was inundated at least one month earlier in 1993 than in 1992, and water level during the 1993 monsoon was on average one metre higher. The water level remained above the 7 m level for 80 days in 1993, compared to only 15 days in 1992. The flood intensity was 1,468 MCM-months in 1993 while it was only 1,195 MCM-months in 1992.

Water quality: Water in the permanent beel area was clear in both monitoring years. During the early monsoon, water become turbid in shallower region as the river overtopped the embankment. Heavy waves in June - July 1993 created turbidity throughout the project area.

Aquatic plants: The northeast compartment of the project was observed to be densely populated by Paura bon in 1992, but not in 1993. The northeast compartment band could not be drained, and the stagnant water allowed densel growth of aquatic plants.

Fish abundance based on catch assessment surveys : Shanir haor was once one of the most productive fisheries in the region, but has lost productivity due to natural factors and human interventions. Local old people (including fishermen) maintain that fish abundance has suffered a major decline (90%) over the last 20-25 years. Siltation in the Baulai river located in the north and south side of the haor is increasing and depresses fish production. The surrounding embankments have only a single inlet/outlet structure (Boigani regulator) which does not allow migrating fish (broodstock, juveniles, fry) to get in during the early monsoon. Public cuts in the embankment result in heavy fishing mortality of brood fish during the breeding migration (*uzaia utha*) in April/May in the shallower beel area. Delayed migration is also due to the embankment.

It was observed that large numbers of migratory species were caught in 1993, compared to only a very few migratory species in 1992 when inundation took place one month later. The efficiency of Kona jal was reduced by 50% in 1993 compared with 1992 because of higher water levels. More intense flooding in 1993 allowed migrating Mohashoal, Sarpunti, Silver carp, Mrigel, Catal etc. to enter the haor area. These species were not found in 1992, and are generally rare in the area.

Total estimated flood plain production increased from 510 tons (76 kg/ha) in 1992 to 590 tons (88 kg/ha) in 1993. Beel production was 78 tons (165 kg/ha) in 1993 compared to 60 tons (122 kg/ha) in 1992.

Fish abundance based on NERP sampling: The standing crop estimated by kona jal and ber jar shows a significant change between the two study years. Standing crop of Kona jal was observed to decline from June (70 kg/ha) to September (13 kg/ha) in 1992 while it was observed to increase from May (11 kg/ha) to September (28 kg/ha) in 1993. Same patterns were observed for Ber jal.

The changes in stock abundance over the two years (in 1993, production increased 17.3% by weight and 46% by value, compared with 1992) resulted in the selection of more efficient fishing gears compatible with the changing hydrological conditions and species composition. The efficiency of different gears during different periods of the monsoon play an important role in fish production in the haor.

177

Fish disease: Hydrological conditions appear to play significant role in outbreaks of fish disease. Prevention of stagnation and excessive aquatic macrophyte growth by flushing appears to reduce the fish disease in the haor. The incidence of diseased fish in 1993 was estimated to be only about 25% of the previous year.

Fishing communities: About 30,000 people live within the haor, among which about 4,000 (13%) earn a livelihood from fishing. During the monsoon, most poor people go fishing as there is no other employment option. Some poor people (including fishermen) migrate out of the haor because of lack of opportunity to earn a living. Better hydrological conditions in 1993 yielded an improved livelihood as their earnings from fishing increased.

The population of fishermen in the haor fluctuated with the fish abundance as well as access to fishing grounds. It was observed that the people residing near the water bodies fish either for their family consumption or for marketing. If deprived of access to fishing grounds, fishermen would sometimes form large gangs in order to raid fish from privately leased jalmohals (ie gang fishing).

Interyear Comparison of Annual production : Comparison of production, yields and flood intensity between years 1 and 2 are given in the following table:

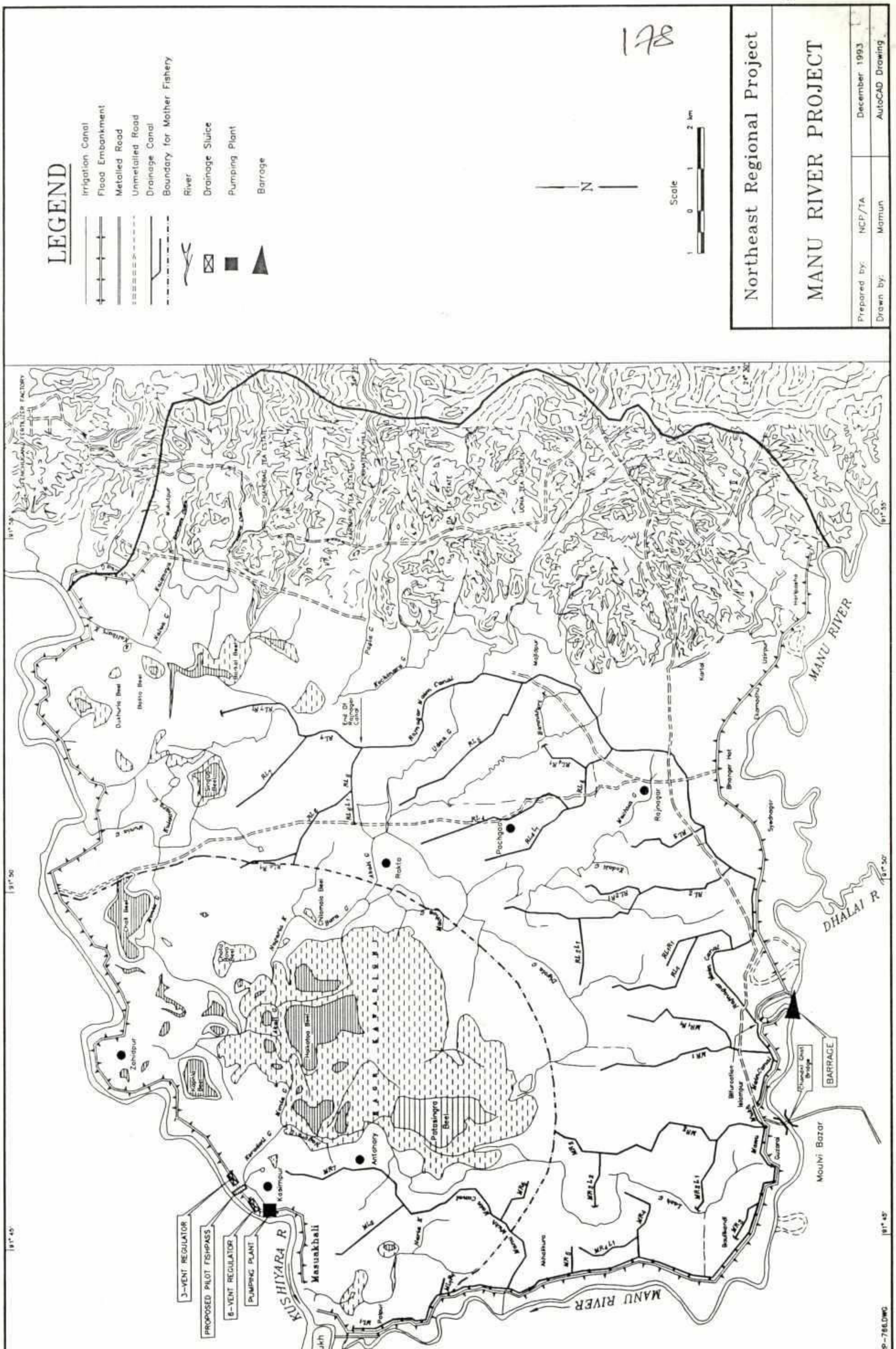
Table 3.3: Inter Year Comparison of Annual Production

	SEASON & HABITAT	YEAR 1 (Jun92-May93)	YEAR 2 (Jun93-May94)	% CHANGE
PRODUCTION	Monsoon Floodplain	510.0 t	589.9 t	+ 15.7%
	Dry season beels	59.8 t	78.4 t	+ 31.1%
	TOTAL =	569.8 t	668.3 t	+ 17.3%
YIELD	Monsoon Floodplain	76.4 kg/ha	88.3 kg/ha	+ 15.6%
	Dry season beels	121.8 kg/ha	164.6 kg/ha	+ 35.1%
FLOOD INTENSITY	Entire haor	1,195 mcm-months	1,469 mcm-months	+ 22.9%

Manu River FCDI Project

Monitoring work began in June 1992 and ended in May 1994. Twenty-two field trips were made to the locality: ten field visits were made during year 1 and twelve during year 2.

The full flood control structures around Kawadighi Haor create a large difference in abundance of species between the inside and outside of the haor area. Some 79 fish species were identified in and around the Manu Project area.


178
LEGEND
Irrigation Canal
Flood Embankment
Metalled Road
Unmetalled Road
Drainage Canal
Boundary for Mother Fishery
River
Drainage Sluice
Pumping Plant
Barrage
N
Scale
Northeast Regional Project
MANU RIVER PROJECT
Prepared by: NCP/TA
December 1993
Drawn by: Mamun
AutoCAD Drawing
3-VENT REGULATOR
PROPOSED PILOT FISHPASS
8-VENT REGULATOR
PUMPING PLANT
BARRAGE
KUSHIYARA R
MANU RIVER
DHALAI R
Manumukh
Masuakhali
Kasimpur
Antonary
Zahidpur
Rakta
Pachgaon
Rajnagar
Moulvi Bazar
Hakaloo Beel
Patasingra Beel
FILE: NERP-788.DWG

179

Project location and general data: The project is located in Moulvibazar and Rajnagar thana under the district of Moulvibazar. It is a full flood control, drainage, and irrigation project covering about 22,580 ha of land. It was declared completed in 1983.

Physiography and hydrology: The project is located just above the confluence of the Kushiyara and the Manu rivers at Manumukh. The Kushiyara flows west along the Project's northern boundary. The Manu flows northwest along the project's western boundary. The Bhatera Hills lie to the east; their rainfall runoff drains into the project via eleven streams. The project area contains the outstandingly important wetland Kawadighi Haor, which has an area of 85 km^2.

Project concept: The project objective is to increase crop production by providing full flood protection, passive and pumped drainage, and dry season and supplemental monsoon surface water irrigation. It includes 145 km of canals and 42 regulators and sluices, 59 km of full flood embankments along the Manu and Kushiyara Rivers with 27 pipe inlets (48 cm diameter) for irrigation, one six-vent and one three-vent drainage regulator, and a 35 m^3/s capacity electric pumping station on the left bank of Kushiyara River which is designed to partially remove local rainfall runoff. Fisheries was not taken into consideration as an important economical resource during project planning.

Hydrology: Hydrological events differed radically between the two study years. The hydrograph indicates that the water level of the Kushiyara river remained higher than the level inside the haor up to early August during 1992. However in 1993 water levels were equal in the river and the haor already in early June. The water level in the haor was on average one meter higher during year 2. The water level remained above the 8 m level for 130 days in 1993, compared to only 80 days in 1992. In 1993, water level was above the 9 m mark for 75 days, while in 1992 the maximum water level was about 8.5 meter. Breaches in the embankment in 1993 coupled with heavier rainfall resulted in more intense flooding during year 2, and equalization of hydrological conditions between haor and river side. The local catchment area (Bhattera Hills) of Manu project area helps to maintain high water levels in the haor area.

Water quality: Haor water was clear through out the year 1992 which allowed dense growth of aquatic plants throughout the haor. Water logging and stagnation in the western side resulted in a marked deterioration in water quality. In 1993, breaches in the embankment allowed flushing of stagnant areas and conditions generally improved. However, the water remained turbid throughout the monsoon. Regular water flow through the haor improves ecological conditions and promotes increased fish production.

Aquatic plants: Most of the beels of the project were full of rooted aquatic weeds in 1992, while only a very few aquatic weeds were observed during 1993. Rooted aquatic plants reduce the quantity of dissolved nutrients in the water column and thus limit the growth of plankton.

Fish abundance based on catch assessment surveys: Prior to project construction, Kawadighi haor was a mother fishery and one of the 'fish mines' of greater Sylhet area. The project however completely destroyed the mother fishery. When the full flood control embankments are intact, only closed water fishes species are present inside the project area. Any breaching in the embankment improves haor fish production several fold. There was opportunity to observed the both situations in 1992 and 1993. This is analogous to with and without FCDI project situations, with the added bonus of the situations occurring at the same locality (thus, the only difference in fish production in the two years being the result of the embankment breaches). Embankment breaches at Macchuakhali in June 1993 resulted in about a 60% increase in fish abundance compared to 1992 when the embankment was intact. Large rui, catal, air, boal, ilish and rita were caught from the project area during 1993 while these species was not found during the monsoon of 1992. As a result, the average daily income of the fishermen was increased by 8 to 10 times compared to 1992. Use of Gill nets, Uther jal, Bheshal jal and Thela jal increased by 80%, 1000%, 500% and 450%, respectively.

Total estimated floodplain production was increased from 275 tons in 1992 to 572 tons in 1993. The yield in Patasingra beel increased about 10 times (28 kg/ha in year 1 compared to 275 kg/ha in year 2. The average beel production increased even more (i.e to 355 kg/ha) through out the project area. Estimated fish price was observed to be decreased by 20% during 1993 (Tk 36/kg) compared to 1992 (Tk 45/kg).

Fish abundance based on NERP sampling: The estimated standing crop of Kona jal during the two years shows the important effect of hydrology on open water fish production. Standing crop increased 280% from 1992 (10 kg/ha) to 1993 (28 kg/ha) during the same time period.

Fish disease: Hydrological conditions appear to play an important role in outbreaks of fish disease. Poor hydrological flushing and heavy aquatic plant growth in year 1 (along with colder water temperature) might have led to the observed high incidence of disease mortality. The improved hydrological conditions during year 2 resulted in only minor disease incidence (ie about 20% of the mortality observed during the previous year).

Fishing communities: The Manu River FCDI Project has had major negative impacts on the genuine fishermen living in 21 fishing villages around Khawadighi Haor. About 20,000 fishermen people have suffered either partial or complete disruption of their livelihood due to establishment of the project. A large number of the social elite including political leaders comes from the fishing community. After construction of the Manu Project many economically insolvent fishermen had to change their profession due to destruction of the fishery resources. At present only the very poorest people who have no other sources of income in the area attempt to earn a living by fishing. The only relief is when breaches in the embankment increase stock abundance temporarily. Thus in 1993 it was observed that 4340 fishermen were directly engaged in fishing, while in the 1992 monsoon it was only around 2640.

Interyear Comparison of Annual Production: Comparison of production, yields and flood intensity between years 1 and 2 are given in the following table:

Table 3.4: Inter Year Comparison of Annual Production

	SEASON & HABITAT	YEAR 1 (Jun92-May93)	YEAR 2 (Jun93-May94)	% CHANGE
PRODUCTION	Monsoon Floodplain	313.5 t	571.9 t	+ 82.4%
	Dry season beels	23.3 t	229.1 t	+ 883.3%
	TOTAL =	336.7 t	801.0 t	+ 137.9%
YIELD	Monsoon Floodplain	30.7 kg/ha	56.1 kg/ha	+ 82.7 %
	Dry season beels	28.0 kg/ha	275 kg/ha	+ 882.1%
FLOOD INTENSITY	Entire floodplain	1,237 mcm-months	2,066 mcm-months	+ 67.0%

181

3.1.3 Case studies of other FCD/I projects

Short duration field studies were undertaken to examine the impacts on fisheries of the other 65 BWDB FCD/I projects in the region. The findings are presented in Appendix L. FCD/I project were separated into 6 main types:

- Partial flood protection (30 projects, excluding Shanir Haor Project)
- Full flood protection, without pumped drainage or irrigation (20 projects)
- Full flood protection, with pumped drainage and irrigation (1 project, excluding Manu River Irrigation Project)
- River channelization (5 projects)
- River and khal re-excavation (6 projects)
- Water retention structures (3 projects)

These categories are not completely distinct from each other, as any one project may include elements of another category. For example, some full flood protection projects include khal re-excavation to improve drainage. The impacts of each of these project types are discussed below.

Partial Flood Protection Projects

These projects typically consist of submersible embankments surrounding a haor, and one or more hydrological regulators. Their purpose is to protect boro crop from pre-monsoon flooding by delaying haor flooding until 16 May. There are two major clusters of projects in the north/central and east Sylhet Depression, and outliers at Kalnar Haor, Chhatak area, Hail Haor, the Upper Kushiyara and the lower Baulai. Summaries of production trends and FCD/I impacts for 19 projects are presented below:

North/Central Sylhet Depression Group

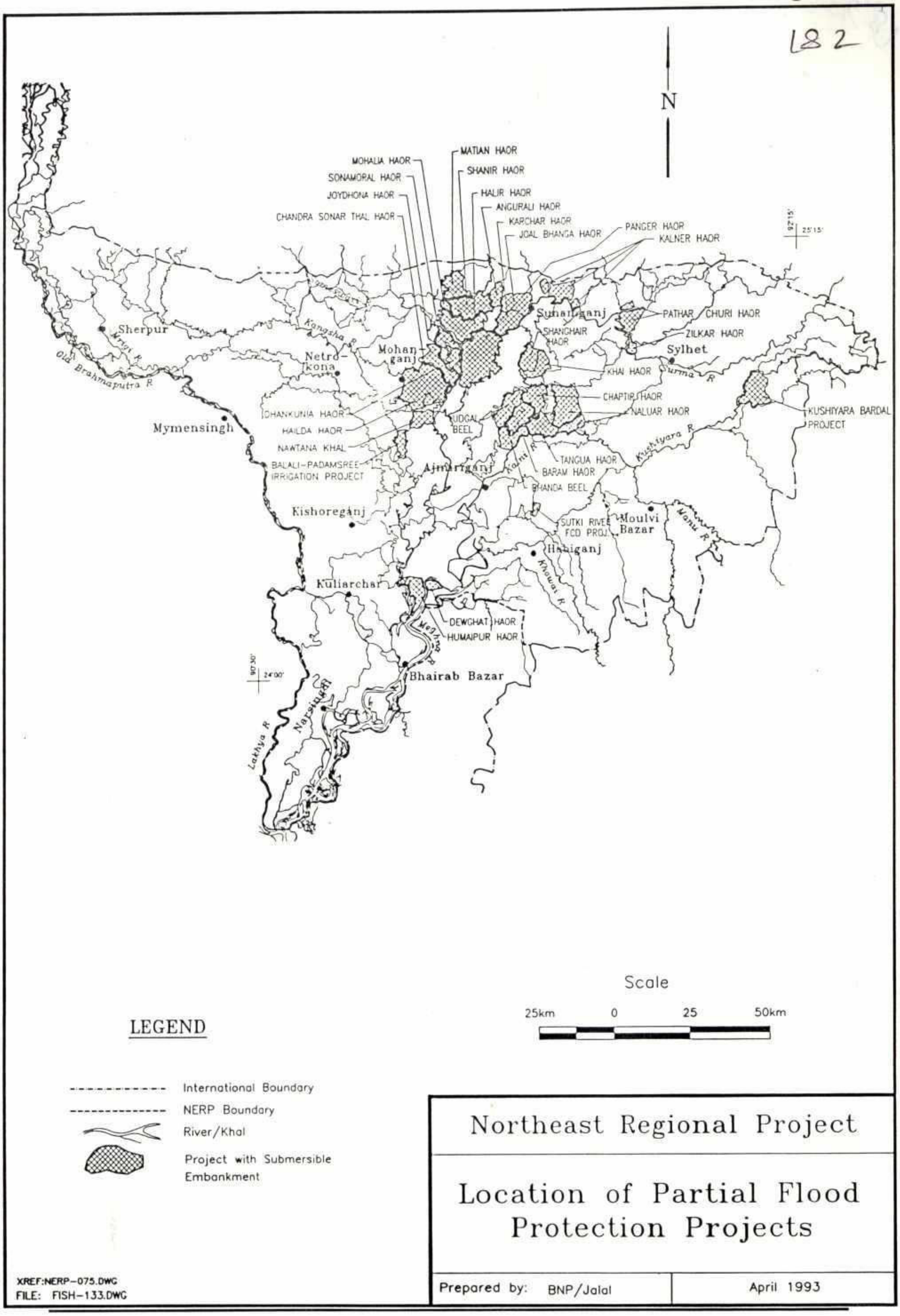
Matian Haor Project. Fishery resources are reported to have increased substantially due to the project since it helps to maintain the required depth of water for the pile fisheries. Hydrological control allows maintenance of good dry season water levels (2-2.5 m) within the haor such that fish can grow well. Large quantities of carp are produced in the *beels*.

Gurmar Haor Project. Local people report that fish resources have increased since the completion of the submersible embankment in 1989, which has increased the water retained in the permanent *beels* to the depths required for pile fisheries.

Angurali Haor Project: Local people report that *beels* in the project area produce large amounts of fish. There is no evidence that project infrastructure has affected fish production.

Sonamoral Haor Project: The fishery groups at Sonamoral and Kuraijan have stated that the project has increased fishery resources as it helps to maintain the required water level for pile fishing during the dry season.

182



Northeast Regional Project

Location of Partial Flood Protection Projects

Prepared by: BNP/Jalal | April 1993

183

Nawtana Khal Project: Due to water inflow restrictions, fish populations within the haor have been reduced tremendously. Fishermen and the lessee mentioned that FCD/I projects have negative impacts on fisheries as they have restricted the breeding migration during the early monsoon and the overwintering migration during the flood recession period. But a positive impact of submersible embankments on fisheries is that they protect against the inflow of silt into beels during the pre-monsoon flood period.

Halir Haor: The Chatidhara Fishery Group which leases Ratla Beel and the adjacent small beels have reported that the project has no negative impact on the fishery resources. However, other fishermen, lessee and the TFO maintain that the overall fish production in the area has declined by 40-50% over the last ten years due to the following causes:

- Overfishing and annual fishing
- Rapid deforestation within the haor area due to expansion of agricultural land and a domestic fuel shortage;
- Siltation which reduces the water retention capacity of the jalmohals (Bolhor beel has been silted up by this process). It is anticipated that sediment deposition in the beels will further affect fisheries.

Joydhona Haor Project: Local people consider that the project to date has had no impact on fisheries.

Karchar Haor Project: Local fishermen report that fish production has been severely reduced by sediment deposition in Harnur Beel and Karchar Beel by the Chalti River. The Laiya Gazaria and other jalmohals are rapidly silting up. Fisheries have not declined in Karchar beel or the western *beels* that are not affected by sand deposits from the embankment breaches. Illegal fishing and overfishing are going on without any control. Large numbers of current jal and bel jal are used in the open water. Annual fishing by complete de-watering is another reason for the rapid decline of fish population in the area.

Mohalia Haor Project: Due to the seasonal nature of the beels, local people do not consider the project embankments to have affected the fishery in any way.

Pagnar Haor Project: Local people have reported that fisheries have decreased. It is generally believed that this is the result of sediment deposition in the *beels* as a result of which most of the *beels* become dry during the winter. Farmers reported that silty-sand has been deposited to a depth of about one meter in the lower *beel* areas. The Surma River carries large quantities of silt and sand and these are carried into the Pagner Haor area when the river breaches its bank. Some of the smaller *beels* have been filled with sediment in recent years. It appears that only silt (as suspended material) is transported by the floodwater into the project area. Any sand or gravel (bed load material) appears to be retained within the river banks and does not normally enter the project area.

East Sylhet Depression Group

Chaptir Haor Project: Local fishermen state that the project does not have any adverse impact on the existing fish resources.

Shanghair Haor Project: Subsistence fishermen at Hasnabad compartmental bund have stated that there has been no change in fisheries due to the development of the project.

Tangor Haor Project: A representative of the Hariya Beel lease-holder association stated that the project has affected the migration of fish during the spawning period. Subsistence fishermen around Bhadalia Beel state that the project has not had any apparent impact on the existing fish resources. At the time of the field visit (25 July 92) fishermen were catching carp fingerling of Rui (7.5 cm), Catla (11.5 cm), Ghonia (9 cm) Kalibaus (13 cm) and Laso (11.5 cm). These probably entered the project area from the Kushiyara system as fishermen reported catching millions of 2.5-4 cm carp fry (Rui, Catla, Ghonia and Kalibaus [but no Mrigel]) in the Kalni River (near Tukchandpur), Bhadalia Khal and in the Kushiyara.

Baram Haor Project: Reportedly, the project has a negligible impact on the fishery resource. However, there is a perception that the resource is diminishing because of sediment deposition within the *haor* area. Sediment deposition is taking place in the Chamti-Darain River, especially around Nawagaon and Harinagar villages. Reportedly, the silt load of the Kushiyara is very high and over bank spilling leaves behind large silt deposits every year. This has resulted in reduced discharge capacity of all the minor drainage channels in the south. Local people also say that recently sediment deposition has occurred at the outfall of the Darain River.

Kalner Haor

Kalner Haor Project: Historically Kalner haor has been a good fish producing area but has declined by 70-75% over the last 10-15 years. Fishermen believe that the decline in recent years is due to fish disease and not project works. However, after the construction of the embankment rapid siltation occurred in the internal canals of the haor. Important water bodies now have insufficient water during the winter season.

Chhatak Area

Patherchuri Haor Project: The project has a positive impact on the jalmohals. After the construction of the submersible embankment, there is less sedimentation within the project area. As a result an average depth suitable for the pile fisheries is usually maintained. But fish production has declined due to other reasons: deforestation, overfishing, annual fishing and fish disease. Farmers report conflicts with *jalmohal* lease holders over the operation of the hydraulic structures. The leaseholder drains the *haor* to catch fish, making land preparation difficult and causing drought damage to crops. The farmers would prefer to retain water for *boro* cultivation. Fishermen also cut the embankment to harvest fish.

185

Hail Haor

Hail Haor Project: The total fish catch from the haor has declined 75% over the past 5 years. People of the area mentioned that carp species were more or less extinct in the haor since 15-20 years before. Other than carps, cat fish and smaller species of fish also declined by 50-60% over the last 5-7 years. The decline in production is attributed to the following factors:

- Over exploitation, uncontrolled use of current jal, chat jal (kapri jal) and annual harvesting of fish by complete de-watering of the basins.

- Heavy siltation of the water bodies and reduction of dry season water hectare months For example, the Gopla river is gradually silting up which reduces channel volume and discharge capacity. This results in regular high flooding.

- Deforestation within the haor area.

- Expansion of agricultural land and excessive use of insecticides in the paddy fields.

- Growth of excess aquatic vegetation in the beels during the rainy season. This is due to impeded discharge rates at the downstream end of the haor, which induces water logging and poor drainage.

- Fish disease.

Local people state that the project to date has had little fisheries impact. Cutting of submersible embankments sometimes creates an opportunity for catfish and barbs to carry out upstream spawning migration during the rainy season. Usually, however, spawning was prevented because the broodstock was trapped by local people. Overfishing and poaching are two major reason for rapid fish decline in the area.

Upper Kushiyara

Kushiyara-Bardal Project: It appears that the project has had little impact on fishery resources.

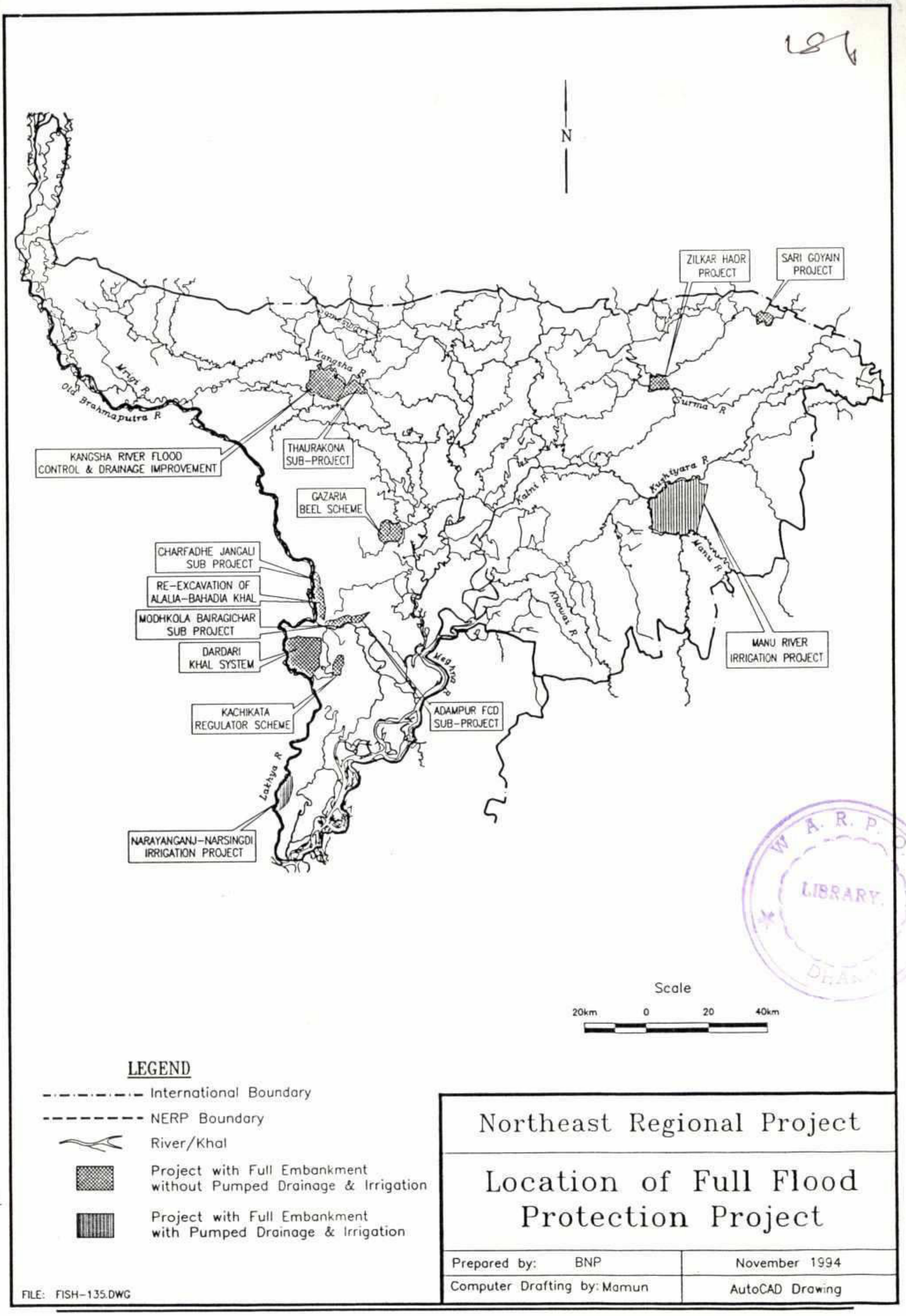
Lower Baulai

Humaipur Haor Project: People fishing in the project area report that there has been no change in fishery activities due to project implementation. No direct negative impacts on fisheries were mentioned by the fishermen. After construction of the submersible embankment, sedimentation had been reduced and water retention capacity has been slightly increased.

Full Flood Protection Projects, (without pumped drainage or irrigation)

These projects typically consist of full flood embankments (often incorporating paved roads) surrounding a haor or other flood prone area, and one or more hydrological regulators. Their purpose is to create conditions for double or triple cropping by protecting *aus* and *aman* crop from monsoon flooding, as well as *boro* from pre-monsoon floods. The projects are located in a semicircle band around the Sylhet Depression on moderately flooded land, mainly concentrated in the south region area, and with outliers in the Surma, Kushiyara and Kangsha basins. Summaries of production trends and FCD/I impacts for 13 projects are presented below:

Figure 54


N
ZILKAR HAOR PROJECT
SARI GOYAIN PROJECT
Kangsha R
Mrigi R
Old Brahmaputra R
Surma R
KANGSHA RIVER FLOOD CONTROL & DRAINAGE IMPROVEMENT
THAURAKONA SUB-PROJECT
Kushiyara R
Kalni R
GAZARIA BEEL SCHEME
CHARFADHE JANGALI SUB PROJECT
RE-EXCAVATION OF ALALIA-BAHADIA KHAL
MODHKOLA BAIRAGICHAR SUB PROJECT
DARDARI KHAL SYSTEM
Manu R
Khowai R
Meghna R
MANU RIVER IRRIGATION PROJECT
KACHIKATA REGULATOR SCHEME
ADAMPUR FCD SUB-PROJECT
Lakhya R
NARAYANGANJ-NARSINGDI IRRIGATION PROJECT
Scale
20km 0 20 40km
LEGEND
International Boundary
NERP Boundary
River/Khal
Project with Full Embankment without Pumped Drainage & Irrigation
Project with Full Embankment with Pumped Drainage & Irrigation
FILE: FISH-135.DWG
Northeast Regional Project
Location of Full Flood Protection Project
Prepared by: BNP
November 1994
Computer Drafting by: Mamun
AutoCAD Drawing

187

Surma Basin

Sari-Goyain Project: Before construction of the structures, the low lying areas were flooded during the rainy season and local people harvested small species (Tengra, Mola, Chingri, Lati, Foli etc). At present these species are still present, but the total catch has been reduced by 75%. People living near the Teli Khal Regulator consider that fishery resources have increased since water in the Teli Khal and Gobrajan Khal is retained by the regulator.

Zilkar Haor Project: The lessee fisherman group of Zilkar haor have reported that after the construction of the embankment and the sluice gate, fish production has been reduced by 60-70% within the haor area. The decline in catch was attributed by fisherman to the following factors:

- Partial restriction of fish migration by the sluice gate,
- Over fishing,
- Annual fishing,
- Fish disease,
- Siltation within the haor areas.

Subsistence fishermen from the Dhum Khal area report that the project's engineering works have had little impact on fisheries. They also stated that over-fishing of the *beels* (all the water bodies are harvested annually) has had a large negative impact on fisheries, and that many fishermen have become labourers. There are conflicts between the farmers and the lease-holders of the *jalmohal*. The lease-holders are the stronger group, and they drain out the *haor* completely in late November or early December. Farmers indicate that their preference would be to close the regulators at the end of December. The sluice gates were not designed appropriately to facilitate fish migration into the haor. As a result the natural fish stock has declined rapidly.

Kushiyara Basin

Hangarbhanga Beel Project: No negative impacts on fisheries were reported.

Shaka Borak Subproject: Local fishing in the *khals* has reportedly not changed. The embankments along parts of the Kushiyara have no impact on fisheries according to one fisherman. Another says it is very bad for fisheries. It prevents big fish from coming into the river from the beels.

Sharifpur FCD Subproject: Local people who fish in the Manu have stated that the embankment has not affected their fish catch.

Kangsha Basin

Kangsha River Improvement: One way vertical sluices have a negative impact on fish migration, particularly from the river into the beel. Due to that, fish abundance within the project area has declined by 75-80%. As a result the majority of the fishermen in the area have either shifted their traditional profession into small trading or become agricultural labourers, or migrated. Fishermen and other local people attribute the destruction of fish habitat to reduction of the disruption of the natural flooding system. Most of the bigger size fish species have already been eliminated from the area. Due to overfishing, smaller species are also gradually decreasing. Observations on the impacts of three of the sluice gates are as follows:

- Tehmohini Sluice (near Shaldigha village): After the construction of the sluice, fish production within the project area declined by 50-60%. This is due to restriction of fish migration by the sluice and the total harvesting of fish by complete de-watering of the water bodies. Moreover local people claim that due to insufficient water passing capacity of the sluice, water congestion sometimes occurs on the project side which creates strong currents in the downstream part of the river. As a result fish do not move to the beels and erosion of the embankment occurs.

- Moishakhali sluice (near Koiya beel): This structure has 10 vents. The sluice can only discharge internal water of the project into the Kangsha River (one way system). Due to complete restriction of river water entering the beels, fish production has declined significantly (about 60-70% over the last three years). It has also created an opportunity at the mouth of the sluice to catch large brood fish during the periods of spawning and overwintering migration. This will ultimately reducing the overall production of the area. Since construction of the sluice gate very few fish are present within the beels. Before the construction of the sluice gate, Koiya beel was famous for producing *Koi*. This species is now more or less extinct.

- Shingrajan sluice gate (near Thakurkona): This three vent sluice gate was designed to protect against Kangsha water discharge into the project. Since its construction, fish abundance has declined within the project area. Local fishermen and farmers claimed that after the construction of the project, the paddy cultivation has increased at the cost of decreased fish production. This is due to the restriction of fish migrations to their breeding grounds and grazing areas.

Fish availability in the Jaria, Durgapur and Purbadhala area have been reportedly reduced by 75-80% over the last 10 years due to:

- High siltation rate of the major beels and duars,
- Use of LLP for irrigation during the Boro crop season. As a result beels have dried up,
- Overfishing,
- Deforestation within the beel area,
- Conversion of more land for agriculture, which has resulted in shorter water hectare months.

In general, the quantity of fish in the local market is decreasing, prices have risen, and there has been a reduction in the number of species. Local people state that fish reduction in the market is mainly due to fish disease and increased export to urban areas like Dhaka and Netrokona.

Kachikata Regulator Scheme: Local people believe there has been no major change in fisheries since the closing of the khal with the structure in 1955.

Adampur Subproject: Local people report that project implementation has had no impact on fisheries.

Alalia Bahadia Khal Re-excavation: Local people report little fishing activity in the *khal*, either before or after project implementation.

Balushair Embankment Project: Local people have stated that there has been a reduction in floodplain fish abundance after construction of the embankment.

Dardaria Khal System: Fishermen believe that the project has reduced the numbers of fish in the area. Though the project regulator remains open for a significant period of the monsoon smaller fishes are reportedly unable to migrate from the river to the floodplain through the regulator due to high water velocity. This is one factor which is causing the decline of fish in the area.

Gazaria Beel Scheme: Fishermen of the area mentioned that before the construction of the sluice, large numbers of fish were present within the area. Major carps, *Boal, Ghonia, Air, Guzi* and many other smaller species were abundant. After the construction of the project, fish production has reportedly declined by 50-60%. The species composition has shifted to smaller species (especially livefish), and most of the *boromaach* have been lost. The main reasons for the decline in fish production are:

- Exploitation of fish by *chat jal* and *current jal.*
- Restriction of fish migration by the sluice gate.

After construction of the project, the fisheries resource and the fishing communities were seriously affected. At present they have the right to fish in the area, but there are very few fish in the beels and the average catch value ranges from Tk 10-20 per day during the rainy season. During the premonsoon and monsoon the regulator across the khal is kept closed and the river's water level builds up in front of the regulator. This prevents river water from entering to replenish beel water levels, and also prevents movements of fish in either direction across the regulator. So there is little chance of the fish stocks of the beels being replenished from river stocks. The overall result has been that while in the past *rui, catla, air, boal, koi, mrigel* and many other fish species used to be harvested, now there are very few fish caught at all.

Modhkhola-Bairaghirchar Project: Fish production from the area is low.

Full Flood Protection Projects (with pumped drainage and irrigation)

These projects are similar to the previous category, except that they cover substantially larger areas and require electrically powered pumped drainage (which is very expensive) and an irrigation system. A summary of production trends and FCD/I impacts for one project situated in the south region area is presented below (the only other such project is the Manu River Irrigation Project — see section 3.1.2):

Narayanganj-Narsingdi Irrigation Project: The impact on flood plain fisheries has been negative. Local people have stated that the project has eliminated the floodplain fisheries.

River Channelization Projects

Two types of projects are included in this category:

- Rivers which have been "confined" by the construction of full flood embankments along one (Konapara) or both (Khowai, Manu) banks. The former is generally carried out for larger rivers, and the latter for spate-type tributaries. The objective is to protect rice crops planted on the hinterland behind the embankment(s). Normally this does not involve works of the next type (an example of an exception is the Khowai near Habiganj);

- Rivers which have been straightened by eliminating meanders and loops (sic loop-cutting), such as the middle Kushiyara. Loops are cut not by excavation, but by gouging a shallow channel across the base of the loop and allowing the monsoon flood to excavate the bypass channel. This results in large masses of sediment (much of it bedload) being transported downstream. No embankments are erected.

Summaries of production trends and FCD/I impacts for four projects are presented below:

Khowai River System: There is very little fishing activity in the Khowai and, reportedly, before project implementation fishing activity was low. Local people have not noticed any impact from the project on floodplain fisheries. However, embankments along the Khowai prevent fish from reaching shallow floodlands lateral to the river channel to spawn. But fish growth inside embanked areas is good because closing of sluice gates results in higher water levels during the dry season. There is the example of the Mattajuri fishery. It was an unproductive borrow pit before the project, but after the Khowai embankment was built the fishery was much improved. It now produces 2,000 kg/ha of carp, *boal*, prawn and *magur*.

Konapara Embankment Project: During the site visit, no fishermen were available for interview. Local people report that the quantity of fish produced in the area is low and has not changed since project implementation.

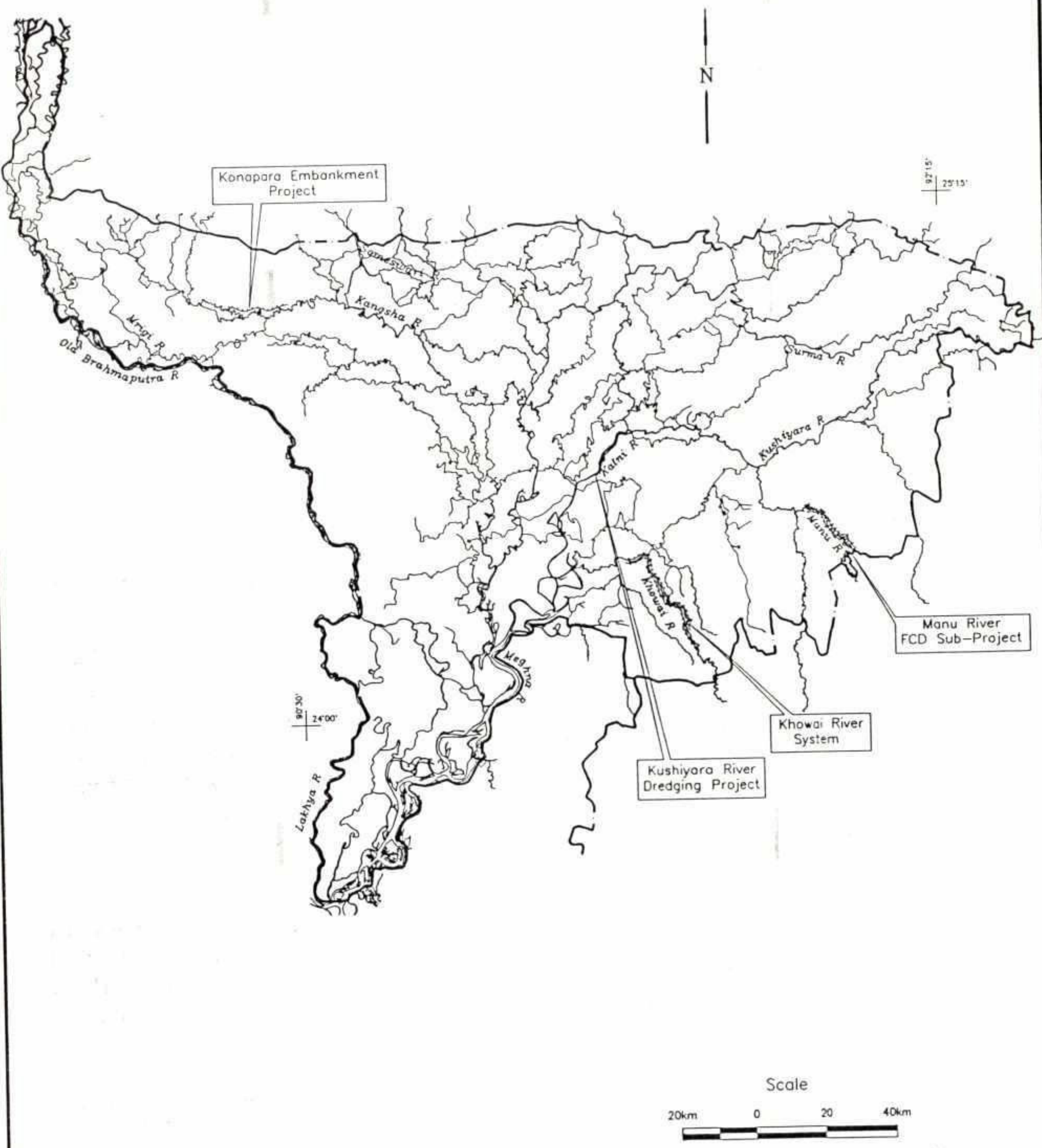
Kushiyara River Channelization: Loop cutting from 1952 to 1983 to straighten the river between Sherpur and Ajmiriganj has resulted in:

- Considerable degradation (deepening) of the channel between Sherpur and Markuli by up to 5 m;

- Substantial aggradation (siltation) of the channel around and downstream of Ajmiriganj, with the river bed rising by up to 5 m.

Deepening of the river near Sherpur has attracted boromaach broodstock. Sherpur fish market is remarkable in having large adult *boromaach* (major carp, large catfish, *Chital*) originating from the Kushiyara on sale year round. This indicates that there is a good population of broodstock resident and transient year around in this part of the river. The sedimentation further downstream has had severe negative impacts, especially on the Bheramona fishery. Once the fishery was renowned for producing larger size fish. Before 1972 it was one of the deepest fisheries in the area. The average depth of each duar was about 13-15 m in March/April.

Figure 55



LEGEND

- International Boundary
- NERP Boundary
- River/Khal
- River Channelization Projects

Northeast Regional Project	
Location of River Channelization Project	
Prepared by: BNP	November 1994
Computer Drafting by: Mamun	AutoCAD Drawing

FILE: FISH-136.DWG

The major fish species included *Pangas* (80%), *Nandin, Bacha, Koral (Berkul), Catla, Rui, Chitol, Kalibaus, Ghonia, Pabda, Boal, Air, Golda chingri, Batashi, Chapila*. At present *Pangas*, *Nandin, Bacha* and *Koral* are more or less extinct. After 1972, a massive sedimentation process began in the area and the major water bodies became silted up and moribund. Now, each year, large quantities of sediment are deposited at the Ajmiriganj river port. As a result, silt-bearing turbid water enters the low lying lands of Sulla, Itna and Khaliajuri areas and remains stagnant for several months. People of the area claim that heavy siltation in the area is the result of:

- Embankments constructed in the upper part of Kushiyara River;
- High sedimentation downstream in the Upper Meghna River near Bhairab bazar;
- Excessive use of katha and bamboo sticks in the rivers.

At present fishing activities are carried out only in the floodplain of the Bheramona area. Overfishing is not a serious problem and cannot be cited as the cause of local species extinction. The evidence points rather to sedimentation of deepwater habitats.

Manu River FCD Sub-System: Due to confinement by the embankments, the water level of the Manu River at Katarkona can now increase by up to about 5 m over a 24 hr period due to spate rainfall. Both turbidity and velocity are high. These new environmental conditions are not favourabie for fisheries. Production has reportedly declined up to 25% during the monsoon, and a very negligible amount of fish is caught during the dry season. Due to the decline in fish abundance in the Manu the fishermen of Tukli and Mathapura villages have changed their profession. It is difficult to separate the impacts of this project from those of the Manu River Irrigation Project, since they affect the upstream and downstream reaches of the same river. The fish stocks can be assumed to move freely (or at least, had been able to move freely in the past) along the entire Manu channel and on out into the Kushiyara. People do not catch any large fish in the Manu after construction of the barrage.

River and Khal Re-excavation Projects

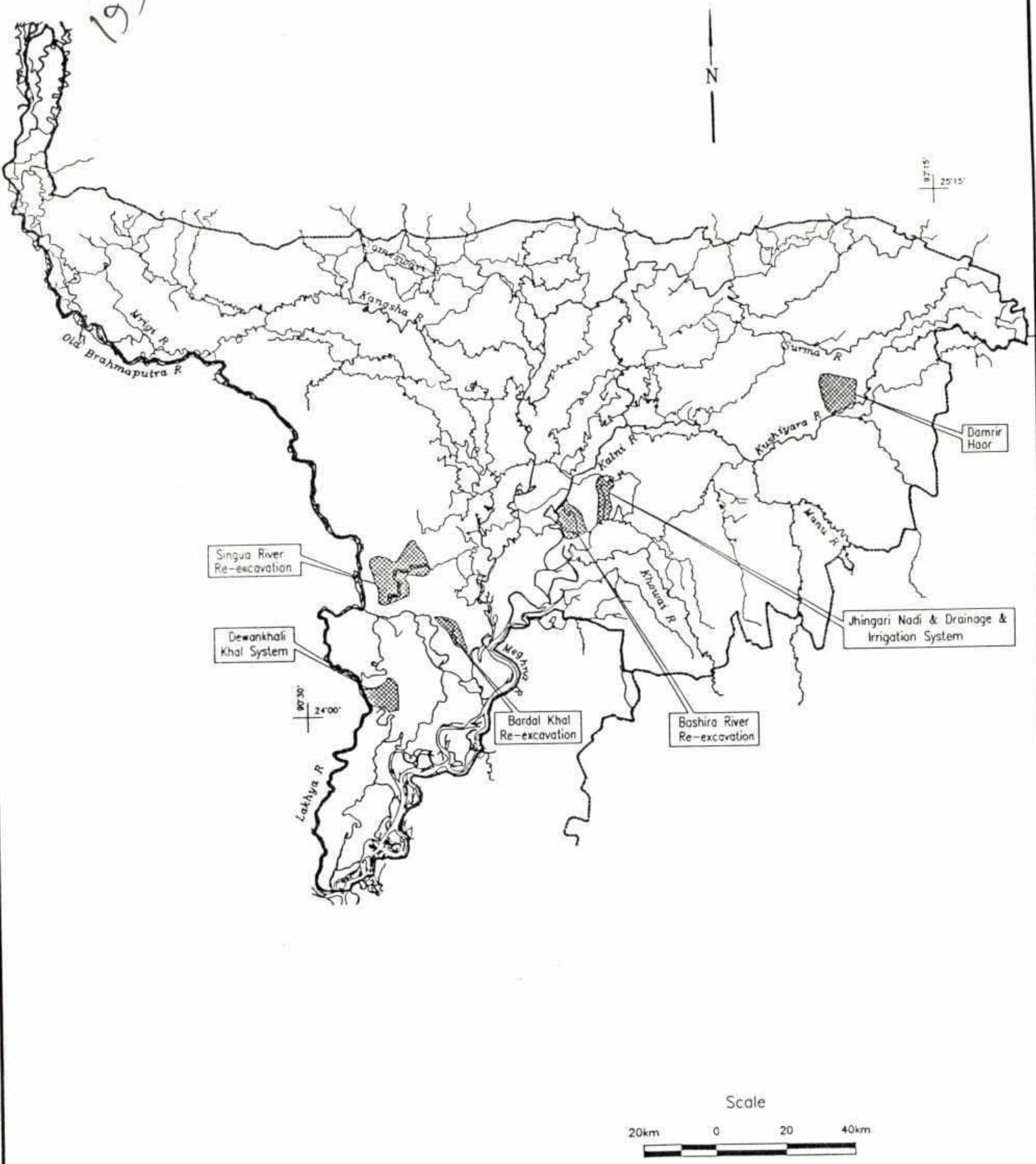
This type of project removes sediment from drainage khals and rivers which have become silted up. This improves drainage flows in the late monsoon and relieves drainage 'congestion', thus permitting early planting of boro seed beds. Most projects are in the south region area, and one is located in the Kushiyara basin (Damrir). Summaries of production trends and FCD/I impacts for six projects are presented below:

Bardal Khal Re-excavation: No fishermen were available for interviews during the field visit. Local people state that fishery activities have increased since re-excavation of the *khal*.

Singua River Re-excavation: No fishermen were available for interview, but local people state that fish production increased after project implementation.

Dewankhali Khal System: Local people state that fish were not plentiful in the *beels* before the project, and that this is still the case.

Figure 56



LEGEND

- International Boundary
- NERP Boundary
- River/Khal
- River & Khal Re-excavation Project

Northeast Regional Project

Location of River & Khal Re-excavation Projects

Prepared by: BNP	November 1994
Computer Drafting by: Mamun	AutoCAD Drawing

FILE: FISH-137.DWG

Damrir Haor Project: Fishermen in the area say there has been no change in the fishery. At present the main problem of the area is siltation. During the flood, river waters carry large quantities of silt into the project. In the open areas silt has settled and results in frequent flooding during the months of March and April. There is less water during the months of December and January. Farmers say that Karam Khal and Ashadur Khal (an internal *khal* northwest of Karam Khal) have silted up.

Bashira River Re-excavation: There are no flood embankment in the project area. It is a river re-excavation project which should in theory have a positive impact on fisheries as the river bed will hold more water year around. However fishermen have reported that there has been a decline in the fish catch from the *beels of* possibly 50% over the last three years. They stated that fish disease was the main cause for the decline. Other probable causes include sedimentation, over exploitation and violation of the fish regulations. Local people put emphasis on river re-excavation projects as 40-50 years before there was no early flooding in the area. They also mentioned that river re-excavation and river straightening process will increase the water storage capacity within the river. As a result water flow should sharply increase and ultimately mitigate the sedimentation process in the area. Sedimentation in this area has increased after the construction of flood protection structures further upstream.

Jhingari Nadi Drainage and Irrigation System: Fishermen at the *beels* have stated that there has been a decline in the fish population. They attribute the decline mainly to fish disease.

Water Retention Structures Projects

This type of project consists of a large regulator built across a stream, and lateral embankments. The purpose is to pond river water behind the regulator for irrigation during the dry season. A summary of production trends and FCD/I impacts for one project (located in the south region area) is presented below:

Bohara WRS Scheme: The structure appears not to have altered the fish habitat in the Sonai River.

Impacts of FCD/I projects in the region are summarized in Tables 3.5 through 3.7.

Figure 57

Northeast Regional Project

Water Retention Structure Projects

Prepared by: BNP	November 1994
Computer Drafting by: Mamun	AutoCAD Drawing

FILE: FISH-139.DWG

Table 3.5: Impacts of Partial Flood Protection Projects on Fisheries

Project Name	FCD/I Impacts on Fish Production
Matian haor	Positive: higher water level for katha.
Gurmar haor	Positive: higher water level for katha.
Angurali haor	No impact.
Sonamoral haor	Positive: higher water level for katha.
Nawtana khal	Mixed impacts: Negative: reduced fish production, restricted fish migration; Positive: prevents siltation.
Halir haor	Mixed impacts: No impact: according to one fishery group; Negative: Reported 40-50% decline over last 10 years.
Joydhona haor	No impact.
Karchar haor	Negative: severe reduction in fish production.
Mohalia haor	No impact.
Pagnar haor	Negative: fish production has decreased.
Chaptir haor	No impact.
Shanghair haor	No impact.
Tanguar haor	Mixed reports No impact: according to one subsistence fishermen. Negative: affected fish migration.
Baram haor	Negligible impact.
Kalner haor	Negative: Reported 70-75% decline over last 10-15 years.
Patherchuri haor	Positive: higher water level for katha, prevents siltation.
Hail haor	Negative: Reported 75% decline over last 5 years.
Humaipur Haor	No impact
Kushiyara-Bardal	Little impact.

197

Table 3.6: Impacts of Other FCD/I Projects on Fisheries

Project Name	FCD/I Impacts on Fish Production
Full Flood Protection (without pumped drainage)	
Sari-Goyain	Negative: Reported 75% decline.
Zilkar haor	Mixed impacts reported: No impact: according to one subsistence fishermen; Negative: Reported 60-70% decline.
Hangarbhanga beel	No impacts.
Shaka Borak	Mixed impacts reported: No impact: according to one some fishermen; Negative: prevents migration.
Sharifpur	No impact.
Kangsha River	Negative: Reported 75-80% decline.
Kachikata River	No impact.
Adampur	No impact.
Alalia Bahadia Khal	No impact.
Balushair embankment	Negative: reduction in fish abundance.
Dardaria khal	Negative: reduction in fish abundance.
Gazaria beel	Negative: Reported 50-60% decline.
Modhkhola-Bairaghirchar	Negative: low production.
Full Flood Protection (with pumped drainage)	
Narayanganj-Narsingdi Project	Negative: eliminated floodplain fishery
River Channelization	
Khowai River	No impact.
Konapara embankment	No impact.
Kushiyara River	Mixed impacts reported: Positive: increased *boromaach* catches in upper area; Negative: severe decline in lower area due to siltation.
Manu River	Negative: Reported 25% decline.

Table 3.7: Impacts of Other FCD/I Projects on Fisheries (cont'd)

Project Name	FCD/I Impacts on Fish Production
River and Khal Re-excavation	
Bardal Khal	Positive: increased production.
Singua River	Positive: increased production.
Dewankhali Khal	No impact.
Damrir Haor	No impact.
Bashira River	No impact.
Jhingari Nadi Drainage and Irrigation	No impact.
Water Retention Structures	
Bohara Water Retention Structure	No impact.

These case studies had difficulty separating the effects of FCD/I projects on fish production from non-FCD/I factors. However, the following appear to be the principal impacts of different FCD/I project types on fish production:

- Partial flood protection projects tend to have positive and no impacts more frequently than negative impacts. Benefits are associated with higher water levels which improve pile fisheries and with prevention of siltation. Submersible embankments increase the surface area of beels during the dry season. Reduced production is associated with obstruction of fish migrations. Submersible embankments impede fish migration in either direction for about 10-20 days during the early monsoon until the embankment is overtopped. As fish stocks may include early spawners and late spawners, submersible embankments will select for late spawners. Early spawners overwintering in rivers will probably swim further upstream to headwaters and tributaries.

- Full flood protection projects (both with and without pumped drainage) have only negative — caused by reduction in flooded area and obstruction of fish migration — or no impacts (frequently because the area was not fish producing prior to project construction).

- River channelization projects can have very mixed impacts. River loop-cuts have a severe negative impact on carp reproduction as ox-bow bends are a favoured spawning habitat. Sedimentation of duars is another negative impact.

- River and khal re-excavation projects have positive or no impacts. Benefits are probably due to greater habitat depth, better flow regime and improved connection with other channels and their fish stocks. Greater use is probably also made of the re-excavated khals by migrating fish stocks.

199

- Water retention schemes have no impacts. However, WRS projects in the region are not performing well.

The conventional wisdom on FCD/I impacts on floodplain fisheries has been determined (sometimes, but not always) from actual case studies in Bangladesh, such as the Chandpur Project, Cauline Beel Project. (MPO, 1985; Ali, 1991). The following impacts are attributed to FCD/I:

- open water fish production declines due to general reduction in the area (hectare-months) of floodlands and beels (such as reducing the area of nurseries and feeding grounds);

- regulators prevent migration and recruitment of migratory species, especially major carp;

- small sized fish and prawn species replace large sized species;

- elimination of oxbows by channelization destroys prime carp spawning grounds;

- cross dams on rivers prevent migration upstream, and consequently the upstream fishery disappears;

- embankments cut off channels (khals) which connect beels to rivers thus preventing both water and fish stock replenishment of beels.

- submersible embankments delay spawning migrations, resulting in resorption of ova and milt in frustrated brood stock. (This may be a non-issue. Tsai et al (1981), for example, witnessed 11 spawning episodes of major carp in one river bend locality between 21 April and 25 June. Submersible embankments designed to overtop $\pm$ 16 May will still allow late spawning to take place. Carp which have overwintered in rivers are not inconvenienced as they can swim to spawning localities further upstream).

To summarize, negative impacts center on interference with fish migration/reproduction and general reduction/disruption of aquatic habitat quality and area. Many of these conventional impacts have been observed or reported from the region. However, given the high number of partial flood protection projects as a percentage of total projects in the region, FCD/I impacts on fisheries would not appear to be as catastrophic as may be the case in other regions of Bangladesh. In evaluating the impacts of the FCD/I projects in the region, it is of importance to bear in mind that many FCD/I projects do not behave according to design plan. Problems frequently seen are:

- too early overtopping of submersible embankments;

- too much breaching of submersible and full embankments either by floods or by public cuts (ie farmers and/or fishermen trying to drain out fields or to flood them for various and frequently conflicting purposes);

- too many drainage and irrigation structures inoperable due to mechanical damage and siltation;

- river channel siltation contributing to the above and limiting navigation.

The relevance to fisheries of these failures is profound because it implies partial reversions to pre-FCD/I conditions (in effect, natural or local community initiated "mitigation"). Clearly, the impact of any particular FCD/I project has the potential to vary from one year to the next. Furthermore, as there is an overall decline in the maintenance of structures in the region, the general regional direction of drift is towards pre-FCD/I conditions. In conceptualizing and assessing the impacts of FCD/I projects one must clearly distinguish between what might happen over the long term if the structures performed perfectly, and what has actually transpired given the highly imperfect behaviour (from an FCD/I engineering perspective but not necessarily from a fisheries perspective) of many projects.

3.1.4 Conflicts between fisheries and agriculture

A principal source of conflict between farmers and fishermen within existing FCD/I projects is related to land reclamation for paddy. This results in a reduction of water area in the beels due to more people claiming agricultural lands within the beel area. While farmers may want to drain beels to create more agricultural land, fishermen might want to retain high water levels required for the katha production system.

A second area of conflict relates to surface water storage for mid-winter irrigation, and beel de-watering for total fish harvesting. Jalmohal leaseholders and/or fishermen often want to drain beels to facilitate total harvesting of fish, while farmers want to retain water for their boro crop irrigation needs. Regulator operation is under the control of the BWDB and normally serves agricultural interests, but the BWDB tries to arrange compromises between fisheries and agriculture (ie recognizing the desire of fishermen to drain beels during the dry season to facilitate fish harvesting). Complete de-watering is extremely destructive to the fishery resource and is not considered a biologically valid method of fishing.

Timing of draining or flooding constitutes another complex of conflicts. Fishermen may want to cut embankments or open regulators on 16 May to allow pre-monsoon flood water into the haors so that fishing can begin, but farmers may resist this if all the *boro* crop has not yet been harvested, or if they are expecting to harvest an additional *boro* crop *(demi)*.

Social tensions between farmers and fishermen often revolve around the fish resource itself. Fishermen brought in from outside by leaseholders are resented by surrounding farming populations. Fishermen catch fish which would otherwise be available to farmers when their land is seasonally flooded. Farmers claim customary rights to unimpeded fishing in water bodies. Also, wealth accumulation by leaseholders is resented, so leaseholders end up posting armed guards around jalmohals - further increasing tensions.

3.1.5 Modelling the impacts of FCD/I projects on floodplain area and fish production

Although it is clear from the various case studies that fish production in the region is negatively affected by many non-FCD/I factors, there is still a need to be able to predict quantitatively in pre-feasibility studies the potential fisheries impacts of new FCD/I projects and to estimate the benefits to fisheries that could be realized by upgrading existing projects. Within the data base presently available, a predictive model would mainly be based on area flooded indices for different types of FCD/I projects and gross estimates of percentage declines in fish production obtained from field interviews. The effects of regulators on fish migration are more difficult to incorporate into a model in a direct manner. Remote effects of a particular full flood protection project (see section 3.1.1) are also difficult to quantify and model. An impact as disastrous as the destruction of a carp spawning ground or mother fisheries by a project within its boundaries would have serious effects inside and outside the project area. These impacts would be far greater than those of a FCD/I project constructed around non-critical fish habitat. Thus the reduction in overall fish production of the floodplain due to the construction of a full flood control project such as the Manu River Irrigation Project would be much greater than what would be predicted from the area of the project alone or the percentage reduction in fish catch within the project area. The approach that will be taken here is to simplify the model so as to generate only a robust first approximation of impact. More detailed feasibility studies would have to be carried out at individual proposed or existing project sites to improve on the prediction of the model.

Development of the model requires an analysis of FCD/I effects on area flooded. The most general objective of FCD/I projects is to redistribute water volumes and flows in time and space so as to create sharply delimited artificial local environments (*sic* FCD/I projects) which are in most cases intended to be conducive to a specified type(s) of rice culture. Each FCD/I project therefore 'removes' or 'decouples' a certain area of floodplain surface from the surrounding flood regime. Submersible embankments delay flooding (thus reducing only flood duration), while full flood embankments greatly reduce or eliminate flooding altogether (thus severely reducing flood duration and flood area/volume). FCD/I projects can be conceptualized as creating "islands" of less flooded or non-flooded land within the overall boundaries of the greater floodplain.

Water management planning engineers use two different measures of FCD/I project area. Gross area refers to the entire area contained within the embankments plus the area covered by the embankments themselves. The strip of riverbank between the outer margin of the embankment and the river shoreline is also generally included, but this introduces only a small area overestimation error as embankments are usually not set back any significant distance from the riverbank. Net area is the area inside the embankments which is cultivable. It excludes beels, khals, roads, homesteads and villages. For purposes of the MAF fish production equation (see Section 2.5.3, and below) gross area will be used. Gross and net areas for the six projects by type are presented in Tables 3.8 through 3.13.

Table 3.8: Gross and Net Areas for Partial Flood Control Projects

Project	Gross Area (ha)	Net Area (ha)
Matian haor	6380	6310
Gurmar haor	5360	5000
Sonamoral haor	3725	3160
Humaipur haor	5260	4730
Nawatana khal	3120	2145
Bhanda beel	4000	3600
Chaptir haor	4453	3542
Halir haor	7325	6680
Joydhona haor	1330	1214
Karchar haor	7770	6600
Mohalia haor	1356	1200
Naluar haor	12141	10724
Shanghair haor	5000	4200
Tanguar haor	5000	4500
Kalner haor	7120	6070
Patherchuri haor	6060	5466
Pagnar haor	19075	17165
BalaliPadamsree	2390	2020
Udgal beel	5900	4700

Project	Gross Area (ha)	Net Area (ha)
Sutki R FCD	1417	810
Sutki R Embank	12146	10446*
Joal Bhanga haor	4370	3660
Hail haor	24370	20958*
Haijda Embankment	9716	8097
Dhankunia haor	1780	1619
Dewghar haor	1221	980
Chandra Sonarthal	4450	4046
Baram haor	5500	4800
Angurali haor	2592	2430
Kushiyara-Bardal	7000	4200
Shanir haor	7010	6677
TOTAL	194337	167749

* *Net Area undefined. Estimate based on a net/gross area ration of 0.86*

203

Table 3.9: Full Flood Protection Projects
(without pumped drainage)

Project	Gross Area (ha)	Net Area (ha)
Sari-Goyain	5385	4210
Kachikata Regulator	6000	3750
Adampur Subproject	1340	1200
Hangarbhanga Beel	1620	1300
Shaka Borak	4520	3800
Sharifpur FCD	1460	1170
Alalia Bahadia Khal	1820	1420
Zilkar haor	5260	4250
Balushair Embankment	900	560
Dardaria khal	6200	3700
Kakon Nadi	7700	4600
Gazaria beel	2720	1640
Kangsha River	11600	11140
Thakurakona Subproject	3158	2050
Modhkhola-Bairagh	2063	1855
Hamhami Chara	2544	1294
Gangajuri FCD	15850	13240
Ganakhali Subproject	2665	1750
Charfaradhee-Jang	3485	3015
Baraikhali khal	9385	7500
TOTAL	95675	73444

Table 3.10: Full Flood Protection Projects
(with pumped drainage)

Project	Gross Area (ha)	Net Area (ha)
Narayanganj-Narsingdi (Block A1 + Demo Unit)	4800	3230
Manu River Irrigation Project	22580	14730
TOTAL	27380	17960

Table 3.11: River Channelization Projects

Project	Gross Area (ha)	Net Area (ha)
Khowai River System	25790	21664
Konapara Embankment	3480	3120
Surma River Left Bank	7900	7000
Kushiyara River Channel	**	**
Manu River FCD Subproject	1615	840
TOTAL	38785	32624

** Not Applicable

Table 3.12: River and Khal Re-excavation Projects

Project	Gross Area (ha)	Net Area (ha)
Bardal Khal Re-excavation	3520	2460
Singua River Re-excavation	4920	3200
Dewankhali K System	2700	1600
Damrir haor	18212	7285
Bashira R Re-excavation	7150	1900
Jhingari Nadi project	4260	3600
TOTAL	40762	20045

Table 3.13: Water Retention Structures Projects

Project	Gross Area (ha)	Net Area (ha)
Bohara WRS Scheme	285	210
Malijhee River WRS	6650	2820
Chillakhali Subproject	1440	1200
TOTAL	8375	4230

FCD/I project areas are summarized in Table 3.14. The combined gross area under FCD/I projects in the region is 4,053 sq km, or 18.7% of the maximum floodplain area of 21,170 sq km.

In a simple predictive model, incorporating the impacts of FCD/I projects into the MAF fish production equation would be done by subtracting the combined gross FCD/I project area from the area of the floodplain. This needs to be qualified however, as there are associated factors which would introduce under- or over-estimation errors. Partial flood embankment projects do not change the area flooded and therefore the MAF equation would be insensitive to their impacts. However the reduction in flood duration results in reduced growth and therefore less production of fish biomass. The channelization effect on migrating broodstock of submersible embankments during the pre-monsoon (see Section 3.1.1) results in bypassing of the project and thus less spawn production within the project area (hence, fewer fry, fingerlings and juveniles) and more crowding on spawning grounds further upstream. Case studies in the region do not indicate a consistent pattern of reduction in fish production caused by partial flood embankments, and in some cases they increase production. The impact of partial flood protection projects is certainly neither a 100% decrease inside the project boundary, nor is the impact nil. A decrease of 50% in fish production inside the gross areas of projects providing partial flood protection will be used as a working estimate in order to allow for some beneficial effects and to give weight to the delayed access to the floodplain.

205

Table 3.14: Summary of FCD/I Project Areas (km^2)

Parameter	Project Type *						Total
	1	2	3	4	5	6	
Projects (Number)	31	20	2	4	6	3	66
Gross Area	1943.37	956.75	273.80	387.85	407.62	83.75	4053.14
Net Area	1677.49	734.44	179.60	326.24	220.45	42.30	3180.52
Ratio: Net/Gross Areas	0.86	0.77	0.66	0.84	0.54	0.51	0.78
Mean Gross Area	62.69	47.84	136.90	96.96	67.94	27.92	61.41
Mean Net Area	54.11	36.72	89.80	81.56	36.74	14.10	48.19

* *Notes on Project Types:*

- *1* *Partial flood protection*
- *2* *Full flood protection without pumped drainage or irrigation*
- *3* *Full flood protection with pumped drainage and irrigation*
- *4* *River channelization*
- *5* *River and khal re-excavation*
- *6* *Water retention structure*

Fish production within even the "driest" of full flood protection projects is never nil. Rainfall, controlled irrigation of paddy plots, and public embankment cuts will generally ensure that some surface water is retained in any residual depressions (beels, khals, borrow pits) within the project area. Thus the post-project level of fish production equilibrates at some new "baseline" level, which is usually a small fraction of the pre-project level. A decrease of 90% in fish production inside the gross area of full flood protection projects (with and without pumped drainage) will be used as a working estimate.

River channelization projects usually include full flood embankments. Loop cutting induces sedimentation of duars downstream (a remote effect). Reported losses in fish production range from nil to 25%. A decrease of 25% in fish production inside the gross project area of a river channelization project will be used as a working estimate.

River and khal re-excavation projects generally have no impact on fish production, or else a positive impact due to the restoration of water flows and connections with other tributaries. A nil impact on fish production will be used as a working estimate, as any increase would presumably be a restoration to pre-sedimentation yield levels (and not an enhancement above the pre-project natural production level).

The water retention structure projects in the region appear to have a nil impact on fish production, despite their theoretical potential to have a positive effect.

The net production of the floodplain is calculated to take into account losses from FCD/I projects as shown in Table 3.15.

Table 3.15: Calculation of Floodplain Fish Production

MAF Fish Production Equation: $C = 4.23 A^{1.005}$ *				
Project Type	**Gross Area (km^2)**	**Potential Yield (t)**	**Calculated Loss (t)**	**Net Production (t)**
Partial Flood Protection	1943	8540	4270	
Full Flood Protection (with and without pumped drainage)	1231	5400	4860	
River Channelization	388	1690	423	
River Re-excavation and Water Retention Structures	491	2140	0	
Entire Upper Meghna River Floodplain	21170	94120	9553	84567

* *Notes:*

C = catch in tons
A = area in km^2

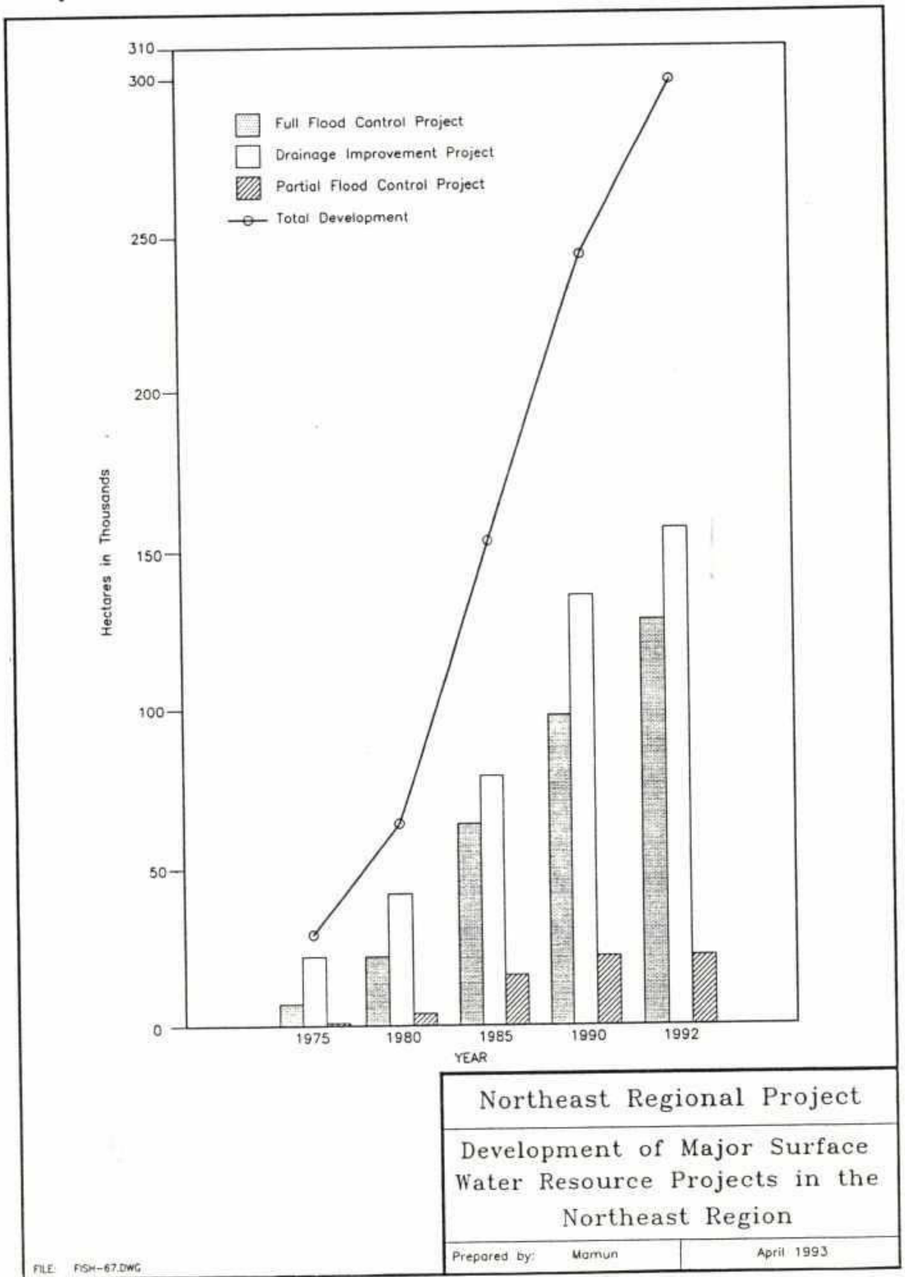
A loss of 10.1% in Upper Meghna floodplain fish production due to existing FCD/I projects is calculated. This figure is relatively low because it reflects the large share of partial flood protection projects (48%) of the combined FCD/I gross area. It also does not contain a correction for remote effects (the destruction of the carp spawning habitat and mother fishery caused by the Manu River Irrigation Project in particular) which are significant. The MAF equation of course also does not take into account non-FCD/I induced losses in floodplain fish production. The actual loss in production from all negative factors is thus much greater than the 10.1% which is attributed only to reduction in flood intensity.

The proposed modelling procedure for robust estimation of the predicted change in fish production for FCD/I project pre-feasibility studies is to calculate the potential yield of the gross project area using the MAF equation, and adjusting this by the appropriate percentage for project type:

- Partial flood protection, decrease by 50%
- Full flood protection (with and without pumped drainage), decrease by 90%
- River channelization, decrease by 25%
- River and Khal Re-excavation, nil decrease
- Water retention structures, nil decrease

The resulting estimate should be adjusted upward or downward, depending on the % of project area covered by beels. A numerical procedure for doing this is presently being developed.

Figure 58



3.2 WATER POLLUTION

3.2.1 Chhatak Pulp Mill impacts

Pulping and Bleaching Process: The mill is a relatively small one with a maximum production capacity of 100 t/d, although this is almost never reached due to mechanical breakdowns and shortage of furnish. Actual production varies between 30 and 80 t/d. The mill uses the kraft (sodium hydroxide, soda) process for pulping and chlorine/calcium hypochlorite with caustic extraction for bleaching. Mercury is used as a bactericide. Furnish consists of reeds grown locally.

Effluent Quality and Treatment: The main chemical constituents of the effluent are sodium salts and chlorinated phenolics. The effluent treatment system consists of two lagoons subdivided into 4 compartments, and having a total area of 50,000 m^2 Suspended solids settle out in the second lagoon. Effluent residence time is 7-8 days before release into the Surma. Normal effluent discharge is about 1200-1300 m^3/hour. Chemical analysis of the treated effluent is regularly carried out by the EPC (Environment Pollution Control). EPC suggested standard are given in Table 3.16.

Table 3.16: EPC Pollution Standards

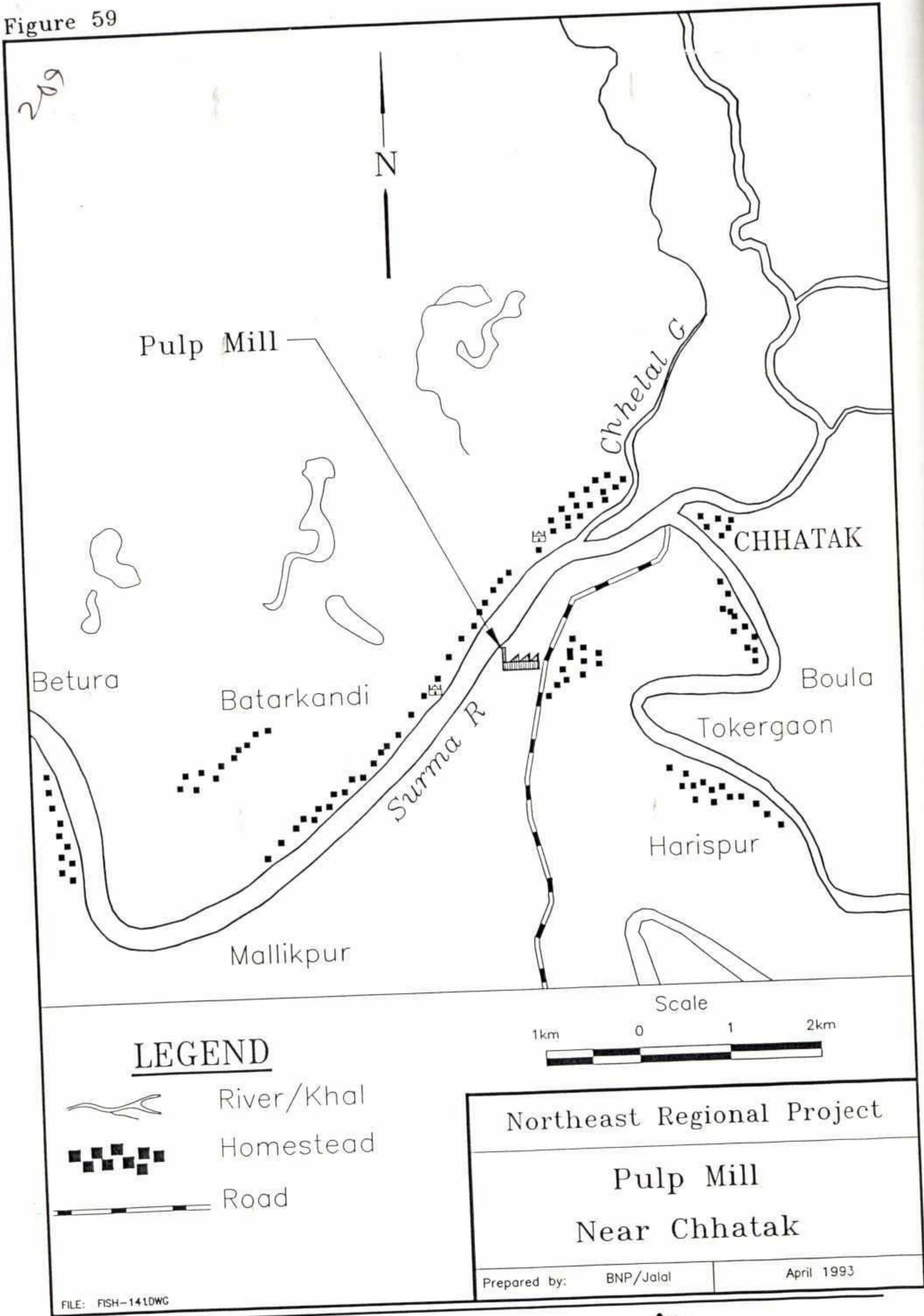
Parameter	Range
pH	6-9
SS	150 mg/l
TDS	2250 mg/l
Cl	600 mg/l
DO	4.5-8 mg/l
BOD_5	75 mg/l
COD	200 mg/l
Temp	40°C
Color	pale
Odor	Nil

Impact on Receiving Water Quality: Chemical analysis of effluent and river water in March (average for 1991 and 1992) is given in Table 3.17.

Table 3.17: Chemical Analysis of Effluent and River Water in March

Location	pH	DO	SS	COD	BOD_5
Lagoon-2 (inlet)	9.52	4.23	254	246	178
Lagoon-2 (outlet)	8.3	1.3	199	267	202
River Water (near pumphouse, 100 m upstream from effluent outlet)	7.4	6.75	169	63	1.5
River water (0.8 km downstream from effluent outlet)	7.5	6.34	190	86	22.2

Figure 59


N
Pulp Mill
Chhelal C
CHHATAK
Betura
Batarkandi
Surma R
Boula
Tokergaon
Harispur
Mallikpur
Scale
1km
0
1
2km
LEGEND
River/Khal
Homestead
Road
Northeast Regional Project
Pulp Mill
Near Chhatak
Prepared by:
BNP/Jalal
April 1993
FILE: FISH-141.DWG

The data indicates that the treatment lagoons decrease pH by 1.2 units, increase dissolved oxygen by 2.9 ppm and reduce suspended solids by 22%. COD and BOD5 however both increase, 8.5% and 13%, respectively. The treated effluent increases Surma water slightly (0.1 unit), lowers dissolved oxygen marginally (0.4 ppm), increases suspended solids by 12%, increase COD by 37% and very significantly increase BOD5 by 20.7 ppm.

The river water is silty yellow/green in colour, while the effluent is dark brown. There is no extensive effluent plume at the surface of the river. Rather, the effluent "sinks" into the river water almost immediately at the outfall point along the south bank of the river indicating that the effluent is denser than water. This means that the plume spreads along the river bed. To the extent that the river bed is itself channelised the plume will tend to be confined to the lowest part of the channel. It is not known how quickly the effluent mixes with the river water, or if the plume persists underwater for some distance.

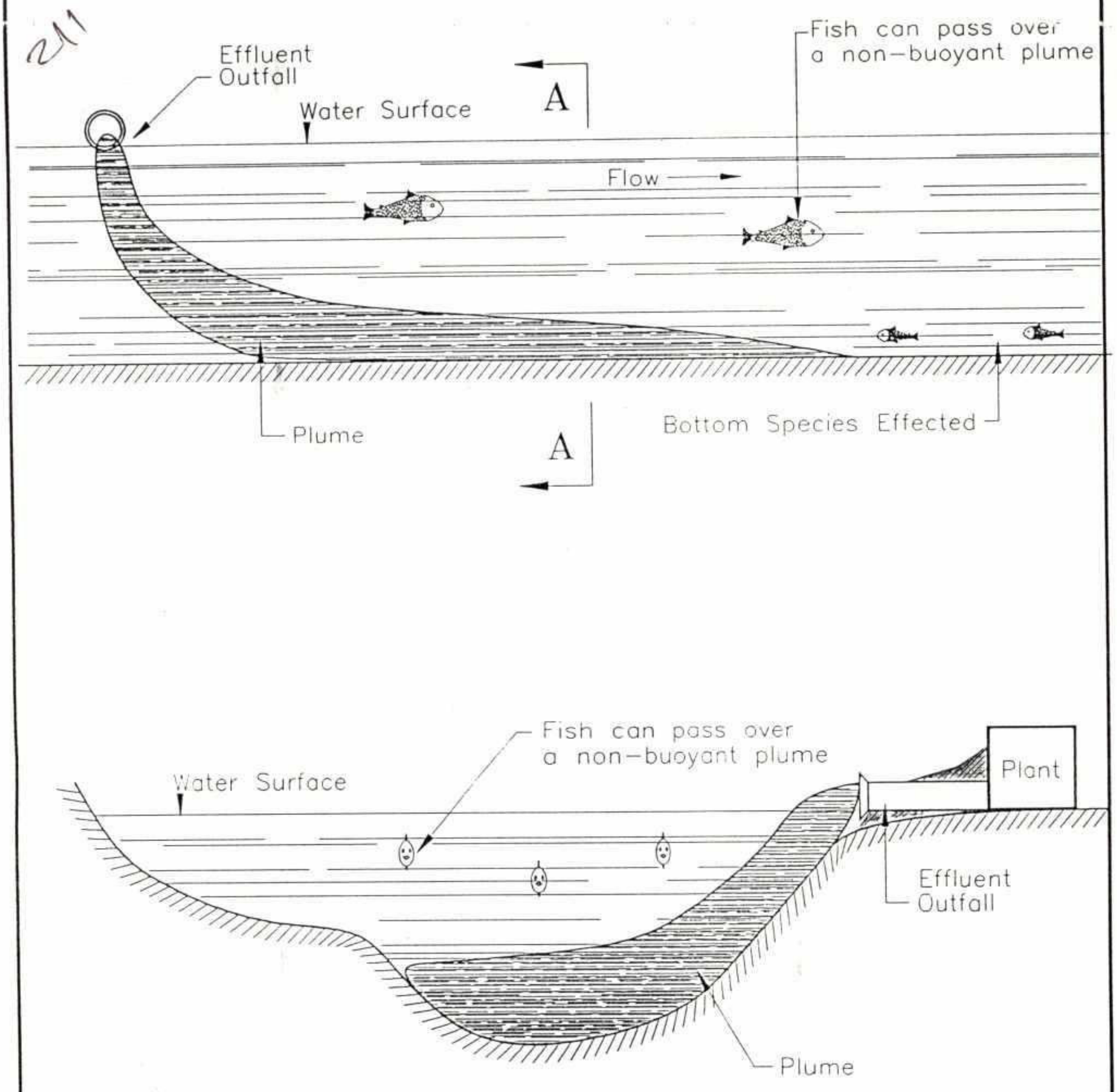
During the monsoon season, Surma discharge is high and results in maximum dilution of effluent in river water. It is estimated that at the time the effluent is much less than 1% of river water. As river flows decreases during the dry season, the submerged plume occupies a greater proportion of the river channel and contaminant effects are more pronounced (as local people report is the case). According to AFI, the Chhatak effluent effects are felt as far downstream as the Dhanu river.

Impact on Fisheries: Various fishing gears are used downstream of the effluent outlet, including *Sangla jal* (in midstream for Ilish), *Kona jal*, and long lines with mixed small and large hooks. Species caught include: *bacha, baila, baim, bata, catla, chanda, chapila, chela, chirain, gharua, gilon chaki, gutum, hilsha, jhainja, kechki, kholisha, lachu, mola, potka, puti* and *rani*. During the monsoon, fish abundance is the same upstream and downstream of the effluent outlet. However, fish production declines sharply in the downstream area during the dry season. An anomaly is that fish abundance may be higher downstream from the mill than upstream. This is probably due to the chemical attraction effect chlorine produces on the olfactory organs of fish at certain sublethal concentrations.

There are no reports of massive fish kills due to the toxicity of the effluent throughout the history of operation of the pulp mill. This suggests that the effluent's impact is entirely at the sublethal level. This may not be entirely correct as the corpses of killed bottom species may never show at the surface, or in fishermen's nets. To the extent that the river bed is itself channelised the plume will tend to be confined to the lowest part of the channel. Implications of this situation are that it is species inhabiting the river bed which will be most affected. Species which frequent the surface layers of the river water may well pass the contaminized zone unscathed. Thus it is reported that fish caught upstream of the effluent discharge outlet are relatively free of odour even if they have travelled up the Surma through the effluent contaminated stretch.

The flesh of fish inhabiting the river downstream from the pulp mill at least as far as Sunamganj has a bad chemical odour and taste which is attributed to the pulp mill effluent. This organoleptic problem is greatest during the dry season. Local people refuse to eat fish from the Surma caught downstream from the pulp mill because of their bad taste and smell. The price of tainted fish is about 50% less than fish harvested from other areas. This fish ends up being sent to Kazi Bazar in Sylhet or to Dhaka.

Figure 60



SECTION: A-A

Northeast Regional Project

Diagram of Spread of Chhatak Pulpmill Effluent in Surma River

Prepared by: BNP/Jalal | April 1993

FILE: FISH-127.DWG

Other Impacts of Plant: Local people who use river water do not feel any distress due to the industrial effluent during the monsoon when the dilution is high. However, during the dry season the river water cannot be used for domestic purposes because of low dilution. Anything (hands, feet, clothes) coming in contact with the water of this area takes on the odour. People try to avoid any use of this water during the dry season. They have had to install tube wells for their regular domestic water needs. Local people maintain that there must be a negative impact on all living organisms (either in the water or on the embankment) when the concentration of the effluent become high during the dry season. If mercury is present it will definitely create problems for human health. No studies have been made of the effects of the effluent on human health or fish breeding.

The atmosphere of the area is also contaminated with the same odour (mercaptans) from the pulp mill. No steps have been taken for the removal of bad odour. Activated charcoal treatment or a scrubber may remove the odour, but it is costly.

Recommendations: Because the Surma is a critical overwintering habitats for major carp, large catfish and other commercially important fish species, urgent action is required. Installation of a treatment system should be considered a priority. "Solutions" such as re-routing the effluent to two small southward flowing rivers (the Boka nadi and the Ghanura nadi) which flow past Banskhola and Mashinagar villages are not considered appropriate. These rivers pass through an area of beels and eventually join the Mohasingh river near Dabor. While saving the Surma, this "solution" would simply reroute the problem and cause hardship elsewhere. It would create serious problems to the fish and people in these connecting beels and minor rivers (where effluent dilution would be very low). It is a principle of pollution control that if contamination is unacceptable the contaminant must be dealt with at its source, (for example, it must be treated at the plant until it has been degraded into a harmless form). A better solution would be to clean up the effluent completely before discharging it to any receiving water (or possibly recycling as much of the water as possible within the mill itself).

Canadian aid can play a positive role here as the Canadian environmental industry possesses a clear comparative advantage. Canada has over 100 pulp mills, some of which are enormous with a daily production capacity of several thousand tons. Canada has extensive experience in effluent treatment (primary, secondary and tertiary) and is a world leader in research on environmental impacts and treatment technology. Chhatak is a small problem by comparison, and effluent treatment cleansing rates would be high (that is, more efficient) under the subtropical climate of Bangladesh, compared to Canada's temperate climate. Good grounds exist therefore, based both on Bangladesh's need for clean water and fish and Canada's expertise in the treatment of pulp mill effluents, to propose that Canadian aid be used to install a tertiary level treatment system at the Chhatak pulp mill.

3.2.2 Fenchuganj Fertilizer Plant impacts

Production Process: The factory produces urea and sulphate fertilizers, as well as byproducts such as carbon dioxide. It was opened in Dec 1961, and has exceeded it projected life span by 8-10 years. Two plants exist in the factory:

- Urea plant
- Sulphuric acid plant

213

CO_2, NH_3, SO_2, flue gas ($CO_2 + N_2$), lubricants, oil and alum are raw materials used in the manufacturing processes. Because of its age, the factory is running at a risk. At present it is producing 250 to 350 tons of urea daily, which is approximately its design capacity of 300 mt/day. Running costs are increasing and the factory loses Tk 1704 per ton of product. Every day it suffers from leakages which increase the degree of pollution.

Effluent Quality and Treatment: The main components of the plant effluent are $CaCl_2$, NaOH, NH_3, H_2SO_4 and lubricants. A very highly concentrated liquid (containing liquid ammonia, caustic soda and lubricants) is the main discharge of the urea plant. Up until three years ago, all raw untreated plant effluents were discharged continuously and directly into the Kushiyara. Three years ago a treatment system was installed, but this is not functioning well. The system consists of the following components:

- Two concrete tanks (an "upstream" tank and a "downstream" tank) located inside the plant, where the liquid effluents are stored until the tanks fill up.

- The upstream tank is equipped with a submerged electric heater which causes the liquid ammonia to evaporate. The lubricants settle out.

- The downstream tank is connected to the upstream tank by a 2.5 cm diameter pipe installed about 0.5 m below the rim. It receives overflow from the upstream tank and acts as a simple storage reservoir.

- Once the downstream tank is full, the effluent is pumped out through a pipe to a 0.6 ha lagoon. The lagoon was constructed 2 years ago. The lagoon is situated on the bank of the Kushiyara near the pump house. More evaporation of ammonia takes place in the lagoon. Fish die immediately if released into the lagoon, indicating that the effluent is still highly toxic.

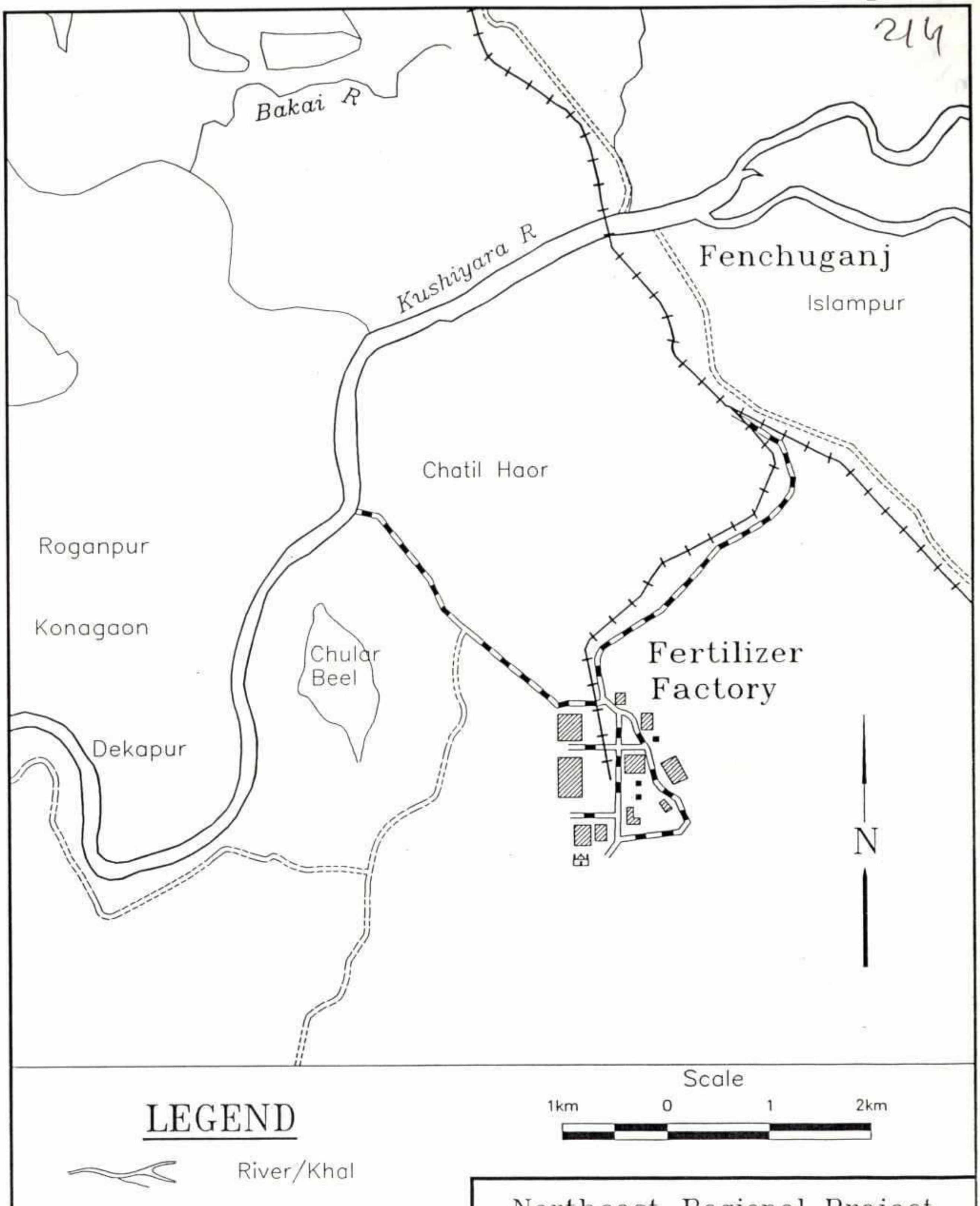
Normally, lagoon effluent is not discharged to the river, and its volume is regulated by evaporation. However heavy rainfall or flooding can cause the lagoon to fill and overflow into the river. This results in a pulse of toxic effluent passing downstream.

Not all plant effluents pass through the treatment system. A very large quantity of water washes out from the sulphuric acid plant and is discharged directly into the river. This effluent contains raw sulphuric acid and undoubtedly has a negative impact on aquatic life.

Impact on Receiving Water Quality: The impact of the plant is more severe to the aquatic environment than to the atmosphere (although the latter is also affected). Effluent impacts are greatest during the dry period.

Impact on Fisheries: Fishermen used to catch large *rui, catal, ghagot* weighing up to 50 kg each before construction of the factory. Boromaach were present throughout the year. During April - May some large fish in the Kushiyara were full of eggs but most of them were spent or reproductively inactive.

214



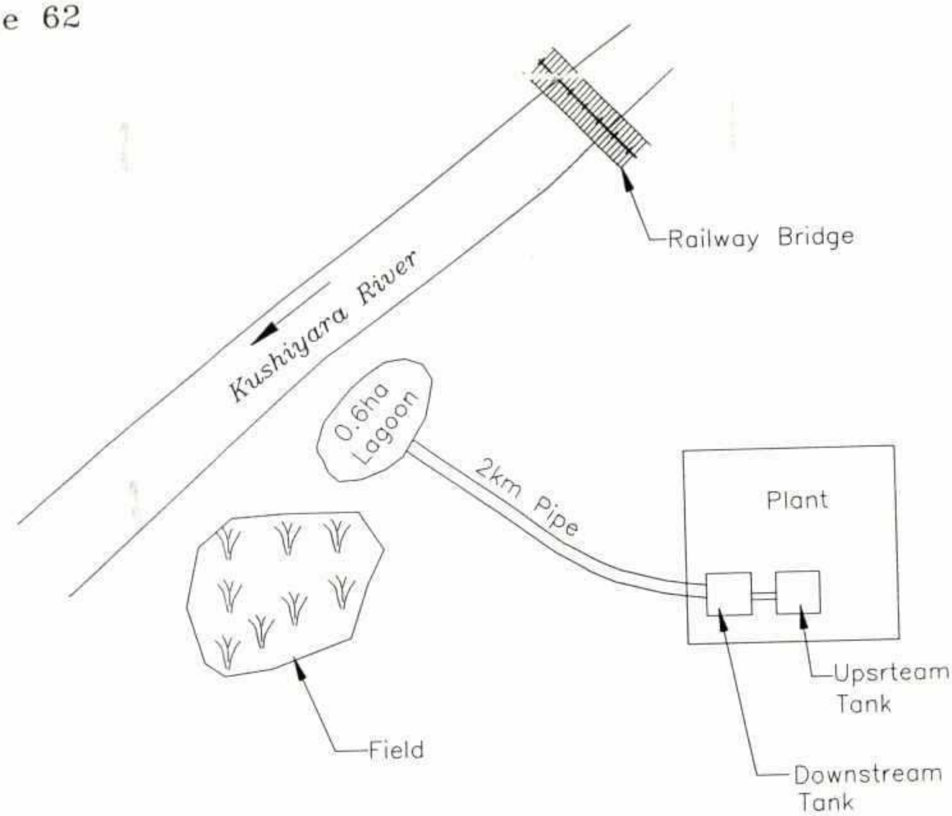
Northeast Regional Project

Fertilizer Factory Near Fenchuganj

Prepared by: BNP/Jalal | April 1993

Figure 62

215



Fenchuganj Fertilizer Factory
Effluent Discharge Location

It is claimed that fish production has declined by 70-80% following construction of the fertilizer factory. The factory has serious negative impacts on haors and rivers in the region as a whole. The occasional pulse discharge of toxic effluent from the lagoon causes the death of fish and other aquatic organisms in the Kushiyara as far downstream as Markuli and Ajmiriganj during the dry season. The fish populations of Chatal beel and Chilner haor near the pump house have been completely destroyed. Moreover, the flesh of the fish of the Kushiyara has a bad odour during dry season.

Scaleless and bottom feeding species (*air, ghagot, boal, rita, bagair*) are affected first. It is suspected that effluent is denser than water and thus affects bottom dwelling fishes selectively in the river stretch closest to the outflow. Larger size carps are also killed. For example, in March 1990 a massive fish kill occurred after a heavy discharge of effluent into the Kushiyara. Mr Md Ali, fisherman from Kaistaghat (Kandigaon), stated that he harvested Tk 26,000 worth of dead RUI (5 to 10 kg each) within a day of the discharge. Dead female fish were found to be full of eggs. Another fish kill took place in mid-October 1992.

Hakaluki haor is a suspected breeding ground of carp, and is located 1-1.5 km upstream of the factory. Carps spawning migrations have been seriously affected by the effluent.

Other Impacts of Plant: Sporadic leakage of sulphur dioxide, ammonia, urea dust and carbon dioxide gas causes atmospheric hazards within the area. People state that occasionally there are large discharges of ammonia into the lagoon area and the air becomes irritating to the eyes and causes people to flee. Sulphur dioxide liberated to the atmosphere causes respiratory trouble to the people resident nearby. The sulphur dioxide forms sulphureous acid when the rains start.

Urea dust also pollutes the environment. No plants grow on the western hillside of the factory, and the soil there has become reddish black due to gas "burns".

There is one haor (Chatal) and one beel (Chilwar) near the factory where different types of rice are grown. Rice is inundated by the water from Kushiyara. Water from the Kushiyara also enter the transplanted aman rice fields. Farmers irrigate their boro land with the water from Kushiyara. Farmers believe that their aus and broadcast rice are damaged by river water containing effluent from the factory. Plants start to rot rapidly when they are submerged. It is also observed that the percentage of undeveloped grains in aman and boro rices is high. A decrease in the land price has been reported.

Recommendations: The plant management as well as the local resident have requested that the factory be modernized. The effluent delivery system to lagoon could be improved by installing a pipe network to distribute the incoming effluent more evenly over the entire lagoon area. This would improve evaporation. The size of the lagoon should also be increased.

3.2.3 Other industries

Cement factory discharges at Chhatak are very negligible and there are no reports of negative effects. Industrial plants, mines (for example, coal — see section 2.3.2 Duars in the Sari River), and other pollution sources probably exist in the Indian catchment and release toxic wastes which flow downstream into Bangladesh. Further investigation is needed.

3.2.4 Pesticides

The increasing use of pesticides in the region parallels the introduction of hyv rice. This presents a threat to floodplain fisheries as it leads to contamination of fish flesh by pesticides which have moved up the food chain, rendering it unsafe for human consumption. Statistics for 1988-89 show that 538 t of pesticides were distributed to the region (10.7% of the national total). The total area of rice cultivated in the region is 1,996,755 ha (19.1% of the national total). The average application rate in the region is thus 0.27 kg/ha. This is 44% less than the national average of 0.48 kg/ha. Some 0.16 kg of pesticide is applied per ton of rice produced in the region, compared to 0.28 kg/t for all Bangladesh. As some pesticides are used on non-rice crops, the real quantities of pesticide applied per ton of rice produced are somewhat lower.

A first approximation of annual pesticide loading of the aquatic environment can be made for the region. Assuming an annual water supply of 173.3 km^3, the maximum possible dissolved pesticide concentration (assuming complete solubility and no losses) would be 3.104 micrograms per l. A more realistic index would be the amount applied to rice fields (that is 0.27 kg/ha). Assuming an average inundation level of one meter of water, the maximum possible dissolved pesticide concentration is 27.0 micrograms per 1. In higher elevation areas with lower water inundation levels, and where two or three crops are grown each year, pesticide concentrations could be much higher.

Residue analysis of fish tissue from representative markets needs to be undertaken to establish the magnitude of the fish flesh contamination problem at regional level. Case studies of residue levels in fish caught in selected rice fields also need to be undertaken, and this needs to be related to pesticide usage in the fields.

217

Table 3.18: Pesticides Distribution and Import — 1989
(tonnes)

Distribution

Region	1	2	3	4	5	6	7
Sylhet	55.8	13.8	5.9	11.8	4.9	0.5	68.8
Dhaka	56.7	9.6	1.3	0.8	6.3	0.1	0
Mymensingh	220.3	45.6	6.3	4.7	7.9	0.4	0
Rangpur	6.9	1.1	0.4	0.1	0.1	0	0
Total	339.7	70.1	13.9	17.4	19.2	1	68.8
Bangladesh	3956.8	693.0	120.0	62.0	110.0	5	94.0

Source: Monthly Statistical Bulletin, 1991, BBS. pg177

Imports: Bangladesh

Quantity	4808.9	1334.8	60.3	93	117	9.9	179.7
Value ('000 tk)	19232.2	20021.4	846	1860.2	1490	126.1	1621.6

Source: Monthly Statistical Bulletin, Feb 1992, BBS, pg43

Notes:

1 Granular
2 Conventional Pest Complex
3 Soil Insecticides
4 Acaricides
5 Fungicides
6 Rodenticides
7 Weedicides

218

Table 3.19: Rice Area within Region in 1990-91

District	Total Rice Area (ha)	Percentage of Total Bangladesh Rice Area	Percentage of Total Bangladesh Cropped Area
Sylhet	886,890	8.50	6.31
Dhaka	122,936	1.18	0.87
Jamalpur	173,505	1.66	1.23
Mymensingh	772,675	7.40	5.49
Rangpur	27,829	0.27	0.20
Total	1,983,835	19.01	14.11

Table 3.20: Rice Area, Production and Yield in Region

Region	Production (t)	Area (ha)	Yield (t/ha)	% of Bangladesh Production
Sylhet	1,340,102	887,000	1.51	7.51
Dhaka	231,932	123,000	1.89	1.3
Jamalpur	298,350	174,000	1.71	1.67
Mymensingh	1,338,177	773,000	1.73	7.5
Rangpur	50,568	28,000	1.81	0.28
Total	3,259,129	1,985,000	1.64	18.26
Bangladesh	17,852,000	10,435,223	1.71	

Source: Monthly Bulletin, BBS, 1992

219

3.2.5 Fertilizers

Chemical fertilizers can increase fish production, but in large doses lead to negative impacts because of excessive aquatic macrophyte growth and direct chemical effects. There has been an increasing trend of fertilizer use for crops in the region as is illustrated in Table 3.21. Urea (70.4% of total) is by far the most commonly used fertilizer in the region, followed by triple super phosphate (22.4%) and potassium oxide (4.7%):

Average loading of the environment in 1987/88 was 95 kg/ha for the region as a whole (2,418,000 ha), or 115 kg/ha for rice hectarage only (1,996,755 ha). Some 60-70% of nitrogen fertilizer may remain residual in the soil and become dissolved in flood or irrigation water. Other ions may be more efficiently taken up by crops. Assuming that about 30% of applied fertilizer remains in the environment, the concentration of fertilizer dissolved in the water column would be 0.4 mg/l for the region as a whole (173.3 cu km annual water supply).
A more realistic index would be the amount applied to rice fields (ie 115 kg/ha). Assuming an average inundation level of one meter of water, the maximum possible dissolved residual fertilizer concentration would be about 35 mg/l. In higher elevation areas with lower water inundation levels, and where two or three crops are grown each year, the annual loading would be greater. Nutrient-rich runoff would eventually make its way to beels and rivers, and cause eutrophication. Case studies have shown that this is indeed taking place, and that where FCD/I projects result in stagnation of surface waters (ie increase the water mass residence time) problems of low water quality and fish disease increase.

Table 3.21: Fertilizer Utilization

Year	Fertilizer Distributed in Region (tons)
1981/82	122,534
1982/83	114,966
1983/84	161,820
1984/85	196,731
1985/86	175,437
1986/87	198,090
1987/88	229,888
1988/89	209,559 *
1989/90	87,556 *
1990/91	30,870 *

* Incomplete Data

Table 3.22: Fertilizer by Type

Fertilizer Type	Distributed 1987/88 (tons)	% of Total
Urea	161,749	70.4
Triple Super Phosphate	51,427	22.4
Potassium Oxide	10,778	4.7
HPPS	5,626	2.5
Zinc sulphate	279	0.1
Gypsum	140	0.1
TOTAL	229,888	100

3.3 FLOODPLAIN DEFORESTATION

Clearing of land for rice culture has caused massive deforestation of wetland trees in the region. This constitutes a major and severe environmental modification of the region. About 19,968 sq km (83%) of the region is under rice. Allowing for other crops such as tea and pineapples, it is likely that less than 5-10% of the region is still forested, and a portion of this is not original floodplain/wetland forest. Little relatively undisturbed floodplain forest remains in the region.

This massive deforestation has meant a severe reduction in the environmental and economic functions that floodplain forests serve. Of particular concern are the benefits to fisheries. It is difficult to quantify lost production because of deforestation, but it seems likely that this has taken place (given the widespread opinion that fish abundance is higher around inundated tree stands). Shortages of *hijal* branches for *katha* raises the cost of fish production.

3.4 SEDIMENTATION

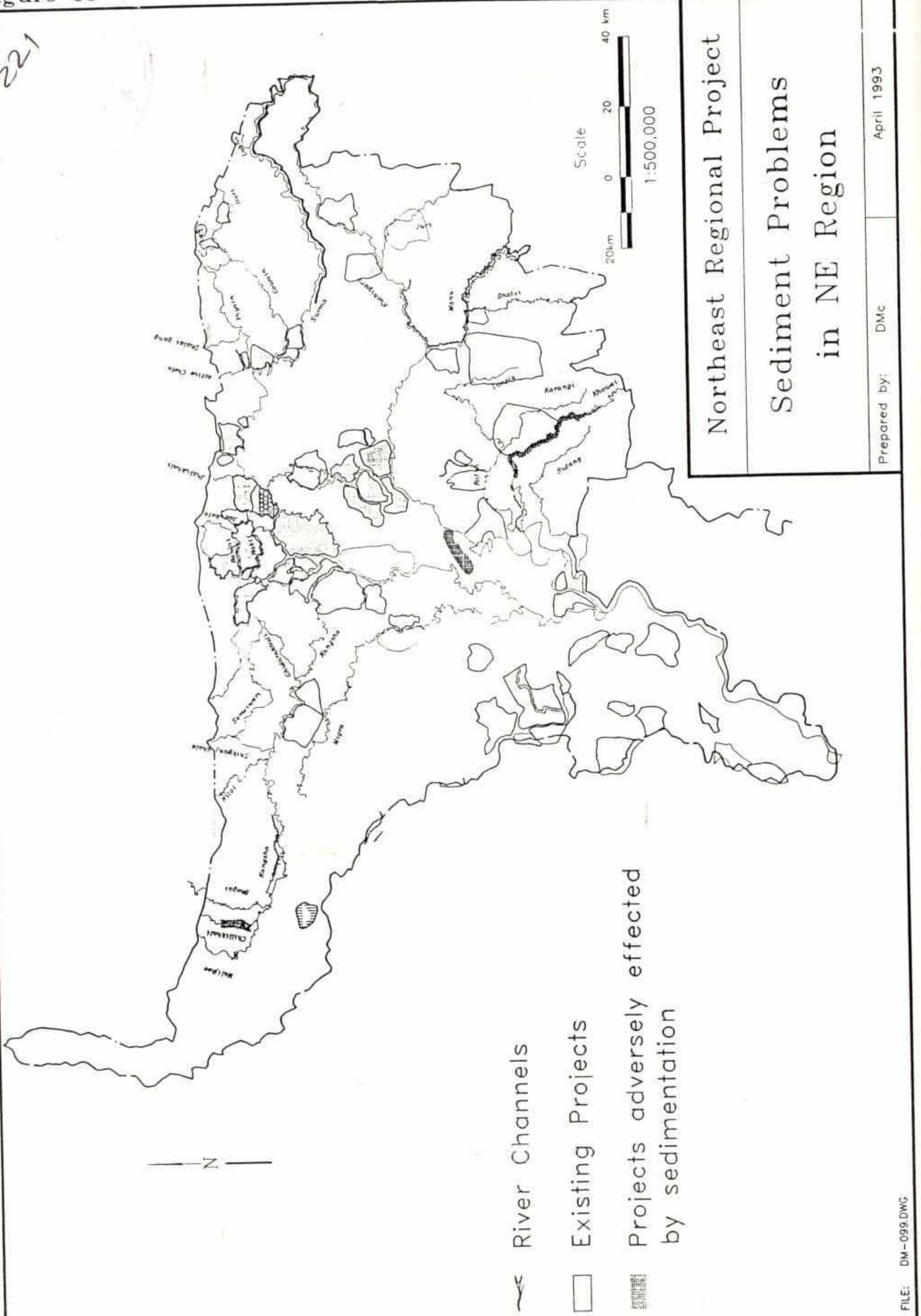
Sedimentation is occurring in various parts of the region and is a problem for both fisheries and agriculture. The northern part of the Sylhet Depression and the lower part of the Kushiyara River are the most severely affected. Infilling of beels reduces mean depth and cubic meter months of dry season aquatic habitat, and converts some beels from permanent to seasonal status. River duars are also being filled in. It is widely believed that this reduction in water volume and elimination of deeper water habitats is negatively impacting fish production. Examples of sedimentation problems are given below:

Beramona Fishery: This important fishery near Ajmiriganj is now gradually silting up. It is connected by Katakhal to the Kushiyara, Kalai, Beramona. As a rule, the water in the Dhanu river is transparent and the Kushiyara is turbid. The heavy turbidity, prevents installation of the *katha* before September — if installed sooner, the *katha* go under silt. Local people claim that three thanas (Sulla, Khaliajuri and Itna) are adversely affected (damage to crops, siltation of fisheries, erosion of embankments and paddy lands) due to siltation and blockage of the Beramona passage. The navigation network is also affected. For a long time, people have asked for the construction of one embankment with a sluice gate at the mouth of Beramona passage. However, without re-excavating or dredging the downstream reach of the Kushiyara it is not possible to build an embankment.

Dhanu and Surma Rivers: The Dhanu and Surma are major sources of fish. Beels in the area are overwintering places for many fish species. 50-60 years ago, there was no early flooding in the area. At that time haors were inundated only in June-July. In recent decades rapid siltation has caused earlier flooding in the area.

Astagram: People of Astagram and Bangaalpara claim that rapid siltation of the Upper Meghna River is the result of excess use of *katha* and *jaak*. From Bhairab Bazar to Ajmiriganj, about 0.5 million bamboo stakes are in place in the river which may restrict the current velocity and induce siltation.

Figure 63


Northeast Regional Project
Sediment Problems
in NE Region
Prepared by: DMc
April 1993
Scale
20km 0 20 40 km
1:500,000
N
River Channels
Existing Projects
Projects adversely effected
by sedimentation
FILE: DM-099.DWG

Karchar Haor: Siltation is a major problem in the area. The Chalti River carries large quantities of sand from the Indian hills. Sand from the Chalti River has been deposited over extensive areas of Karchar haor. As a result Laiya Gazaria and other *jalmohals* are rapidly silting.

Tangua Haor: The Jadukata River is the main feeder river of the Tangua haor basin and carries large quantities of sand and stones from the Indian hills. As a result, the river bed is gradually rising day by day. This decreases the storage capacity of the river. The major problem started after the 1988 flood. Due to low carrying capacity of the Jadukata River, flash flood water routes down the Maharam River. This river now carries a large quantity of sand to the Matian haor and Tangua haor areas. As a result the Alam duar of Tangua haor is gradually silting up. Pachasloal beel has already been destroyed by siltation. Re-excavation of the old Jadukata River has been requested by the local fishermen to protect Tangua haor.

Management of river sediments is a major constraint in the planning and design of water management projects in the region. As is most of Bangladesh, the region continues to be a deposition zone for sediments carried downstream from India. The rivers have alluvial channels, formed from their own sediments. When the rivers overtop their banks the sediments that are carried over the floodplain tend to deposit there, the coarser sediments drop out near the river and the finer sediments are carried into adjacent haors, beels, and khals. These are natural processes which account for the formation and the very being of the region and the rest of Bangladesh.

Expressions of these processes include:

- Formation of natural levees adjacent to the river channel and the characteristic basins and khals between rivers. The classic example of this is the upper Surma/Kushiyara system where levees have formed along side the river channels and the overflow collects within the intervening basin which is drained by Sada Khal in a direction more-or-less parallel to the main rivers.

- Braided channel pattern and periodic shifting of piedmont streams. These rivers exist in a "perched" condition in which the banks are higher than the floodplain and therefore when the river overtops its banks it may experience a wholesale shift in location. An example is the Someswari where the original course of the river has been substantially abandoned since the 1970s.

- Reduction in channel size and capacity in the downstream direction. This is illustrated by the Khowai. Prior to constructing embankments, the rivers' capacity decreased from 700 m^3/s at Ballah to 100 m3/s near Habiganj due to overbank spill.

It is incorrect to suggest that embankments cause siltation since as noted above, it is a natural process. The embankments alter the location where the sediments are deposited and if the new locations are the sites of hydraulically important features (for example control structures or drainage channels) a problem may result. It is not at all obvious that construction of embankments will generally lead to sedimentation problems. Confining the sediments to the channel will tend to cause the channel to become shallower and steeper (that is reduced profile slope). However the discharge will also be confined which tends to cause the channel to become deeper and flatter. Furthermore the confined sediments are generally of the suspended or washload size and are less important than the bed load in the formation of the channel geometry. These are, however, generalizations and the actually effect will vary form place to place.

What can be stated with some certainty is that local sedimentation effects will be accelerated because of the increased sediment load and water discharge within the channel. An offtake or lateral drainage structure which is poorly sited or poorly-designed and is subject to siltation will experience even more siltation after the modification. In addition the channel will tend to become wider as a result of its increased sediment load and increased discharge which will be expressed as an increased tendency toward bank erosion, although this change may be masked by other changes. A dredged channel will silt in again, other factors being equal.

The influx of sediment is unlikely to have increased as a result of land use changes in India as appears to be a commonly held view. Some benefit may be had from the program of damming the tributary streams on which India appears to have embarked. Such dams and reservoirs, if operated correctly, will tend to reduce the peak flows and to trap sediments which otherwise would be discharged into Bangladesh. This will make the control of river sediments less difficult but will reduce the rate of aggradation of the land in Bangladesh in the long-term. There projects unfortunately have the potential for decreasing the base flows during the winter season if water is drawn for irrigation, but they could also be operated to increase the base flows if the storage capacity is sufficient and if they are operated for this purpose. To do so will require cooperation from India and probably some contribution by Bangladesh to the cost. Other sediment control measures may include the construction of small dams built to trap sediments.

4. FISHERIES MANAGEMENT ISSUES AND PROBLEMS

4.1 STATUS OF FISH STOCKS

4.1.1 Decreasing stock abundance

It is widely believed that the stocks of many fish species, both boromaach and chotomaach, are decreasing in abundance in the region. Particularly hard hit are major carps, some large catfish, large prawn and some smaller cyprinids. Some species are close to complete regional extinction (See Section 4.1.2 below).

Among the major carp, *Kalibaus* is the most abundant, followed by *Rui*. *Catla* is becoming increasingly scarce while *Mrigel* is heading toward extinction. The large catfish *Pangas* is now rarely seen at markets. Bajitpur area (Ghorautra River) was once famous for giant fresh water prawn. It is still present, but the sizes are small (50-100 grade).

The causes for declining stock abundance are several (FCD/I impacts, overfishing, sedimentation, deforestation, industrial pollution, pesticides, fertilizers, diseases). There has been little progress in controlling and reducing the negative impacts of these factors on fish stocks to the present. Nevertheless, GOB has initiated a massive floodplain stocking programme, the Second ADB project (see Section 2.8.6 above), in an effort to increase recruitment of carp. The project had planned to rotenone up to 1600 ha of beels in the region. This programme has become a controversial issue. Not only are the economic benefits unclear (implying that the stocking programme is experimental in nature), the rotenoning of nursery beels destroys a part of the subsistence food fish resource. Hail Haor was stocked with 49 tons of (invoiced) fingerlings in 1991: *rui, catla, mrigel*, Silver Carp, and Common Carp. But according to some DOF sources, middlemen are benefitting, not the fishermen communities, as the carp end up in the *katha* of leaseholders. There is an important economic issue here. If leaseholders are indeed over-exploiting the resource (such as major carp brood stock), then the ADB stocking programme is in fact a subsidy to jalmohal leaseholders (as well as private hatcheries) and rewards bad fisheries management behaviour and practices. This is clearly the antithesis of sustainable development and will subvert any attempts to put into place a sound fisheries management regime. It is also not clear if the intent of the project is a once only rehabilitation of certain carp stocks and introduction of exotic carp species, or if it is to become an annual stocking service to jalmohal leaseholders.

Any stocking programme needs to be accompanied by better resource ownership and fishing effort management, otherwise the goals of stocking will be defeated. Until there is greater ownership and control of capture fisheries by genuine fishermen, stocking of carp will likely only benefit status quo capital interests such as leaseholders.

4.1.2 Decreasing biodiversity

The increasing pressure of FCD/I and non-FCD/I factors on the fish fauna of the region has resulted in the extinction of some species which were formerly commercially important. These are:

- *Nanid*: This major carp was once very common throughout the region. It may be at the point of regional extinct, since it is very rarely reported in recent years. Two individuals were seen at Sunamganj market in 1992. *Nanid* is said to prefer

228

deep sediment-free waters and to be intolerant of high turbidity and sedimentation.

- *Angrot*: Another carp which appears to be extinct in the region.
- *Pangas*: This once abundant large catfish is now rarely seen in the region and is probably close to extinction.
- *Mohasol*: This large carp was once more abundant in hilly areas but now is practically extinct. Rare individuals are caught in the Surma and Kangsha catchments.
- *Koral*: A brackish water species which enters freshwater. It is no longer seen in the region.
- *Sarputi*: This medium size cyprinid was once very abundant and common, but now has seriously declined.

Other species are going extinct at local level, for example: *Bedha* in Kaliajuri area; *Taki* and *Gagla* in Humaipur Haor area; *Batcha* and *Chitol* in Ajmiriganj area.

Extinctions are caused by changes in environmental conditions and harvesting patterns, either of which can selectively increase the mortality rates of vulnerable species. Less vulnerable species may find the new conditions favourable, and respond by increasing their population sizes. Attempting to rebuild populations of extinct or near-extinct species without first mitigating the environmental and/or harvesting factors which caused the population die-back would logically appear to be an exercise in futility. Although stocking of fingerlings may result in some recruitment to the fishery, a self-sustaining population will probably not materialize. Catches might only be sustained over longer periods under such conditions if an annual massive stocking programme were carried out over a long term period. The cost of such a programme would however be enormous and most probably would not be economically viable.

Competition with introduced exotic species may in future become a new cause of extinctions. At present, wild populations of exotics are still fairly small in the region, but the long term risk is unknown. Given the high level of indigenous biodiversity, further introduction of exotic species should be stopped.

4.1.3 Fish disease

Epizootic ulcerative syndrome fish disease has become a serious problem in much of Bangladesh, including the region. It is suspected that it was introduced into the country from imported exotics. Fisheries monitoring field studies at Shanir Haor Project and Manu River Irrigation Project indicate that fish disease has played an important role in reducing fish production. The situation in beels and haors (where disease outbreaks are sometimes very severe and result in mass mortality) contrasts sharply with riverine fishes (which are more or less free from disease).

Table 4.1: Catch Composition of Fish Landed in the Sylhet-Mymensingh Basin

Species	Gacherdahor Beel (1967)		Anonymous Beel (1973-74)		
	Weight (kg)	%	No.	Weight (kg)	%
Labeo rohita	118,298	28.2	68	219	14.69
Catla Catla	3,447	0.8	10	83	5.51
Cirrhina mrigala	22,589	5.5	81	175	11.72
Labeo Calbasu	57,153	13.4	181	221	14.78
Labeo gonius	73,302	17.9	34	24	1.57
Labeo nandina	4,334	1.1	50	215	14.35
Puntius sarana	16,389	4.0	52	30	1.99
Mystus aor	7,847	1.9	72	25	4.96
Wallago attu	25,946	6.3	58	262	17.51
Notoppterus chitala	15,785	3.8	37	92	6.12
Silondia Silondia	27,034	6.6	-	-	-
Chanara marulius	-	-	3	10	0.03
Mystus	-	-	67	83	5.54
Others	38,646	9.4	-	-	-

In both Shanir Haor and Manu River Projects external lesions are only visible beginning in the late monsoon when the water level of the area starts to recede, (and there is little rain or flash flooding and when the weather is mostly sunny and cool). Diseased fish are not found during the pre-monsoon and early monsoon floods. The disease starts in the higher elevation and shallower regions and progresses to the deeper areas on the floodplain. Stagnant water bodies close to intensively farmed agricultural plots are most susceptible.

222

The degree of contamination in different areas (beels) of different haors was related to the following factors:

- depth of the beel
- water exchange rate
- density of aquatic weeds
- agricultural land uses
- fish species

In Shanir Haor the following areas were studied: Dhawa beel area, Phaura bon area, Keuti beel area and Boigani group fishery area. In the Manu Project, the areas studied were: Majher band beel, Patasingra beel, Salkatua beel and Chatal beel. The following observations were made:

- Shallow water areas with densely rooted aquatic weeds are more effected than deeper open areas.

- Beel without any connecting canals with other water bodies are more effected.

- The incidence of disease is greater in beels surrounded by more intensive agricultural activity.

- Small shallow water herbivorous species and slow swimming species are infected earlier than other species.

- Flash floods and rain water reduce the incidence of infection.

- Rarely were riverine fish observed to be infected.

Several other areas were visited to collect further information. This are listed in Table 4.2.

Some additional points of information were collected:

- Beels surrounded by reeds are less effected than the others (ie Arainoli beel).

- Large land area which possess extensive elevated agricultural land (and including beels, haors, villages) surrounded by embankments with a single inlet/outlet regulator are more affected.

- Beels surrounded by intensive agricultural activity (near the canals carrying water from tea gardens, HYV paddy land) are highly infected.

Table 4.2: Areas Studied for Fish Disease

District	Thana	Haor	Beel/River
Moulvibazar	Moulvibazar Kulaura Baralekha Rajnagar	Hakaluki	Beribeel, Nagua Dhalia, Chatal Chaukka, Ghar kuri, Parati
Habiganj	Nabigonj		Chatal beel, Bali khal
Sunamganj	Taherpur, Jamalgonj	Tangua Halir	
Sylhet	Companigonj Goainghat	Bara	Arainoli beel

These observation suggest that certain environmental factors may be responsible for the annual late monsoon outbreaks of infections, and furthermore may control the severity of infection. The following sequential scenario is proposed as a hypothesis:

- Macrophyte grow rapidly during late monsoon due to less turbid water, less water movement and regular sun light;
- Receding water level causes death as well as spoilage of aquatic weeds.
- The water body becomes polluted and loses its primary food producing capacity.
- Runoff water from adjacent agricultural land containing residual insecticides and fertilizers increases the degree of pollution. Urea may directly cause more infection.
- In the course of time both the degree of pollution and the fish density increase.
- The metabolic activity of fish decreases due to low temperature.
- Herbivorous fishes (having low resistance power) are attacked by disease immediately due to environmental pollution, less metabolic activity, sudden dropping of food resource and reduced water exchange.
- Carnivorous fishes are attacked later on and carry the disease over the long term.
- Reduced water velocity on the floodplain during the monsoon due to siltation and different types of infrastructure causes water stagnation, and more spoilage due to anaerobic oxidation of benthos organisms in the bottom of the water body.
- In sandy areas phosphate fertilizer may acidify the beel environment.

The degree of fish loss from disease in different beels was determined through discussion with the fishermen and is presented in Table 4.3.

229

Table 4.3: Degree of Fish Loss from Disease

Beel Name	Thana	Location	Loss due to Disease
Majherband	Rajnagar	Middle of Kawadighi Haor, shallow beel located SW of Akali river	65-75%
Patasigra	Rajnagar	Mid-west of Kawadighi Haor, deeper than Majerband, connected with a canal	40-50%
Chaukka	Kulaura	West side of Hakaluki Haor, not connected with any canal, closer to tea garden	>80%
Nagua Dhalia	Kulaura	Middle of Hakaluki Haor, good water exchange	30-40%
Parati, Maichla Polo Bhanga beel	Baralekha	connected with Juri river	20-30%
Koier and Gorchighona	Baralekha	Blocked water body, intensive agricultural activity	60-70%
Beri, Kaltra, Gupain, Kakdor Rupaia beel	Nabigonj	NW of Nabigonj town, blocked water, surrounded by agricultural land	No fish other than Chingri and Singhi
Chatal beel	Nabiganj	NW of Nabiganj town, less blocked and less agricultural activity	Less fish loss than other beels
Boro haor	Goain ghat	Connected with river, intensive agriculture activity	50%
Arainoli beel	Companiganj	Surrounded by reeds, connected with rivers, less agriculture activity	10-20%
Boigani group fishery	Taherpur	Connected with rivers, deep water body, intensive agriculture activity	20-25%

Everywhere it was observed that heavy rain and flash floods greatly reduce the incidence of disease (by up to 90%).

Differences in hydrological conditions in the region from year to year likely have an impact on incidence of disease. Fishermen and local people clearly identified the hydrological conditions as is one of the main parameter for fish disease. The greater flood intensity of the 1993 monsoon appears to be linked to less disease outbreak in beels area compared to the 1992 monsoon (75% less). However pond fish were equally infected in both years. Field observations on disease outbreak following the 1993 monsoon are given in the following Table 4.4:

Table 4.4: Fish Disease Status in 1993

LOCATION and DATE	CATCH (kg) and SPECIES	NO of DISEASED FISH	COMMENTS
Sadipur Bridge near Sherpur Ghat(23/2/94)	50; kazali, bacha, mola kechki etc	12	Catch of 6 fishermen group. Disease declined by 90% of last year. More disease in beel area than river.
PaglaBazar (23/2/94)	15; singhi	Nil	Market survey. No diseased fish was observed. Some diseased fish were observed two months before but it was less than 10% of last year.
Joy Kalash (23/2/94)	125; puti, kaikkya, bheda, foli, tengra etc	Nil	Fish baskets observed at roadside. Diseased fish may have been removed. Disease declined by 80%. Higher water level caused improvement
Joisti (23/2/94) 200m west of Joykalash	80; foli, singhi, magur, shoal, gazar, tengra, mola	Nil	Catch by dewatering a Doba surrounded by paddy land. Last year the area was not flashed over and most of the fishes were infected, but this year the area was under water for several weeks. Last year production was about 25% of present year.
Fish from Betua Beel (23/2/94)	600; singhi, magur	Nil	Total beel catch transported to Sylhet. Few fish were observed to be diseased during December.
Gachilara near Sunamganj (23/2/94)	15; chapila, kaikkya, chanda etc	Nil	About 6/7 diseased fish were sorted out. About 85% decline compared with last year
Kharish River, BaraHaor	3; icha, gutum	Nil	Some diseased fish was observed 1/2 months before but these are negligible compared with last year.
Mohipur, Pachpak, Goainghat (23/2/94)	25 ; mola, puti, foli	4 foli	Pond fish are more effected than the beel fish. Diseased declined by about 75% of last year. Highly embanked pond fish are more affected than open one.
Tikar para, Rakhail, Kashir gram;Bianibazar (23/2/94)			Fish disease reduced by 70% in beel area but increased by 100% in pond than last year. Tengra, lati and baim are main affected species. Some diseased rita were caught from the river.
Kalanger Bridge (Sylhet-Companiganj road)(25/2/94)	60; boal, shoal, baim, chanda, puti, chela, foli	Nil	Fishing through dewatering. Pond fish are more diseased than beel fish. Puti and tengra are mainly affected.
Arainoli Haor (25/2/94)			Two months earlier batha, tengra, shoal, gazar, baim, lati, puti were observed to be affected. Disease declined by 25% of last year.
Nabiganj fish market(28/2/94)		a few	Disease declined by 40% of last year. Baim and tengra are mainly affected
Habiganj Fish market(28/2/94)		Nil	About 30% less than the last year. Diseased fish observed about 2 months before.

231

The PMP studies at Manu River FCDI Project and Shanir Haor FCD Project also showed that the occurrence of diseased fish was less in 1993 than in 1992. Even the duration of occurrence was shorter in 1993. Disease declined remarkably in the open beel area in 1993, while more diseased fish were observed in the partially enclosed shallow areas. The largest number of diseased fish were observed in ponds which were not inundated by high flood. The main depression area was less affected than the adjacent higher area. A very few riverine fish were observed to be effected by disease. Temperature may also play an important role (the duration of the low temperature season was not as long in 1993 as in 1992). Areas subjected to flooding and inundation, were observed to be disease free. Comparison between the two projects indicates that disease intensity was greater in the Manu Project than in Shanir Haor in both years.

It may be concluded that more intense flooding helps to reduce fish disease, and that longer inundation improves fish condition and makes them more resistant. Habitat improvement would appear to be the most important (or only) way of controlling fish disease outbreaks. FCD/I projects need special measures since disease seems to thrive under the conditions of water stagnation that projects create. Structural solutions are justified because mass fish mortality due to disease results in large economic losses and deteriorating nutrition amongst the human population.

4.2 CONTROL OF FISHING EFFORT AND GOB REVENUE COLLECTION

4.2.1 Jalmohal leasing system

Because the largest area of deeply flooded land occurring anywhere in Bangladesh is located in the region (the Sylhet Depression), and because Bangladeshis in general prefer the taste of freshwater fish, the region has received much attention within the nation as "the fish mine" of Bangladesh. During the present century, the region's fisheries have undergone a major change in ethnic and tenure structure. At about mid-century, de-colonization and partition almost eradicated the previous monopolistic hold of the Hindu community on the fisheries sector. Muslim capital interests supported by the new national government took over the sector and introduced the system of leaseholding of beels (*jalmohal* leasing). Muslim fishermen became the largest ethnic labour group in the fishing sector. Certain Hindu castes of professional fishermen continue to exist today, partly in response to a limited demand for highly skilled fishing labour. The change from Hindu to Muslim ethnic predominance within the fisheries sector has also apparently had an impact on stock levels. Currently there is little user group management and conservation of fish stocks, and a general prevalence of resource mining. It has been said that under the previous Hindu predominance there was greater effort to conserve stocks and respect for customary/traditional fishery management practices.

In the region, the term open water capture fisheries refers to fisheries practiced in rivers, khals, beels, and on the floodplain. Borrow pits dug for home construction and used for fish culture are classified as closed water culture fisheries. A few open water fisheries are in the hands of private owners in the form of WAQF estate or *debottar* property, and income from these is used to maintain Muslim and Hindu religious institutions, respectively.

Information on water body ownership is taken mainly from BCAS (1989), Ali (1990) and original sources. All rivers, khals and beels (with the exceptions noted above) are the property of GOB under the MOL. A comprehensive system of water body registration is in existence which is used for the collection of revenue from the fishery resources contained by these waters. Thus, each river is segmented into compartments. Each compartment is defined as a single fishery (*jalmohal*, or water estate), and is coded with a name and number. All beels are similarly named and numbered as individual fisheries. In some cases several small beels are lumped together as a group fishery and this can include parts of adjacent rivers. In theory, all river and beel fisheries units, of which there are about 10,000 in the region, are recorded in the revenue registers of district government. There are about 5,000 beel fisheries units.

GOB is interested to collect revenue from fisheries. In the past it did so primarily by leasing out under MOL individual fisheries, usually through open auction. Deputy Commissioners are the custodians of all *jalmohals* within their district. Lease planning and auctioning is carried out with the assistance of the Additional Deputy Commissioner (Revenue). The lease fee goes into the account of the DOR. River fisheries and seasonal (annual) beels normally are leased out for one year periods, while permanent beels are leased for 3 year terms. Some beel leases may run for 6 or, exceptionally, 9 years.

Beels over 8 ha (20 acres) are owned by MOL, and were leased out to the public by open auction in the A.D.C(Rev.) office. At the time of auction, the highest bidder for a particular jalmohal unit must immediately deposit 50% of the lease fee with the revenue accounts. Generally there is competition among the lessees. Money lenders take advantage of this situation. Usually, fishermen become the representatives of the rich money lenders and on behalf of them they go to the auction. Sometimes leases contain conditions for development investment in the fishery (i.e system of operation, tree plantation around the beel etc), but there is no monitoring to see whether such activities are being performed or not. In case of default, GOB does not usually exercise the right to cancel the lease agreement. Some beels between 1.2 ha and 9 ha have been transferred to the revenue collection systems of thana parishads for a token rent to MOL (in order for MOL to retain ownership). This is so that thanas can lease them out and earn revenue for their own use. Beels under 1.2 ha are not leased out, but the MOL allows local community residents to fish freely for subsistence purposes. Roadside borrow pits are leased out by the DRH, and FCD/I borrow pits are leased out by BWDB.

Because lease fees for large beels may run into several hundred thousand taka, lease holders are usually rich status quo individuals who are not fishermen themselves. They act as middlemen (*jalmohans*). They may either hire fishermen as daily labour to carry out fishing operations on their behalf, or may sublease to fishermen (ie sell individual fishing rights for a fee). Daily fishing labourers are paid in cash and/or receive a small share of the catch. Most of the sale value accrues to the leaseholder. Examples of lease fees and sublease fishing rights fees are as follows:

- Tk 500,000 lease fee for a small beel next to the Manu River barrage;
- Tk 800,000 for Futahawaboni Beel in Hakaluki Haor for a three year lease. The value of the fish produced may be Tk 100,000 over 3 years.
- Tk 800,000 lease fee for a beel adjacent to the Gorautra River, near Patli (Kishorganj District).
- Tk 800,000 for Bangla beel near Bajitpur. To maintain official formalities, fishermen have taken lease of the beel on behalf of one wealthy man, Mr.Kanchan Mia of Kuliarchar, who paid the lease fee. As a result fishermen do not have any right to harvest or take part in the management of the beel.

233

- Tk 100-200 fishing rights fee for fishermen to set up a *katha* in the Mogra River (at Solisa, near Netrokona), payable to a middleman who holds the lease to that stretch of the river.
- Tk 100 for the right to use a *flan jal* and Tk 10,000 - 20,000 for a *ber jal* at Hail Haor, payable to a middleman who holds the beel lease.
- Tk 50,000 lease fee for a 13 ha stretch of the Kushiyara near Sherpur. The leaseholder sells fishing rights to genuine fishermen for a fee of Tk 1,000 per boat per year.
- Tk 1,000 per net fee for fishing rights on a 8 km stretch of the Kushiyara near Sherpur, payable to the leaseholder.
- Tk 3,000 for the right to set up a fish fence (*duri*) across the Surma River near Kanaighat during the dry season, payable to the leaseholder. The auction lease fee paid by the leaseholder for a 1.2 km stretch was Tk 68,000 (the fee was bid much higher than the normal auction fee of about Tk 30,000 due to rivalry between the incumbent and a challenger).
- In certain public waters, such as a drainage canal near Netrokona, local people need not pay any fee to install *katha*.
- Examples of lease fees for roadside borrow pits paid to the DRH are: Tk 1,500 per year, plus Tk 15 tax, for a one mile stretch, both sides of road, near Kulaura (Moulvibazar District); Tk 3,000 per year for a one km stretch, near Kanaighat (Sylhet District).

Table 4.5 gives lease fees collected for various fisheries smaller than 8 ha in Rajnagar Thana of Moulvibazar from 1981/82 through 1986/87.

Nationally, government collects about Tk 460 million from jalmohal leasing, and this constitutes an important source of revenue for national and local governments.

In practice, jalmohal leasing applies only to the period of the year when the individual river and beel fisheries are demarcated (separated) from other fisheries by land. During the monsoon flood season, when much of the region is covered by a single continuous sheet of water, the *jalmohal* system is de facto cancelled out because of the difficulty of enforcing private access rights to geographical boundaries that no longer exist. Customarily, therefore, there is open access to all fishermen on the inundated floodplain during the monsoon with no fishing fees payable (although *jalmohal* and fishing fees are paid on an annual basis). The biannual conversion of the region's fishery resources from private access to public access through the agency of flood is of tremendous social and economic importance, as the flood phase allows many poor local residents to share in the benefits of a resource which is concentrated in the hands of status quo during the dry phase (Sadeque, 1990). Inundation removes "the rigid borders of private property. The whole floodplain becomes a large pool of common property resource. Erstwhile privately held agricultural plots become capture fisheries ground, source of other aquatic resources and provide numerous boatmen opportunity to earn a living. In general, the floodplains become the only common property people, particularly the poor, can depend on to make a living."

Table 4.5: Lease Fees for Various Fisheries (Tk)

Fishery	Area (ha)	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
Agadubi beel	0.4	450	450	-	-	500	750
Akali river UP		-	2500	-	-	350	-
Upar Goali beel	2.92	2000	2000	2000	2000	2000	2000
Karadhair R.P2	4.21	2700	2700	2700	-	3500	-
Koiabeel	2.12	1100	1100	1100	3000	750	950
KariaNadi	5.1	-	1000	1000	-	2000	2500
Kaliara doba		1500	1500	-	1850	600	-
Kalibari khal	4.08	-	400	400	-	-	500
Kanakigang	5.26	320	320	320	630	1000	1280
Katitaka beel	1.62	400	400	400	500	500	360
Ghagatia beel	0.41	790	790	300	860	1700	2280
Charu Pama beel	2.74	6000	-	6600	6600	7320	8250
C.M Karsha beel	5.99	-	-	-	-	-	-
Chowdighi	0.45	-	-	200	200	200	120
Chota haor beel	0.51	-	-	-	-	300	-
Chota Jira beel	2.28	-	-	-	-	300	-
Jibonia beel	5.06	16000	4310	2020	2510	2510	2510
Jira beel	4.37	-	-	-	-	500	-
Daldalia	6.11	-	-	-	-	550	-
Dewan Dighi	4.29	-	-	-	-	500	1000
Dh Baraiuri beel	7.89	7100	7100	-	-	-	-
Nolua beel	11.28	1250	1250	1250	-	-	-
Nolua Gang	7.81	-	1950	1950	-	-	-
Chapra beel	3.65	700	-	-	-	-	-

Table 4.5: Lease Fees for Various Fisheries (Tk)
(continued from previous page)

Fishery	Area (ha)	1981/82	1982/82	1983/84	1984/85	1985/86	1986/87
Nagorigang	6.6	-	-	-	-	-	-
Pur Matikura beel	2.15	4800	4800	4800	5000	6000	6000
Baladmara beel	3.16	2750	1800	1800	2500	4000	5040
Balita beel	3.83	5500	5500	5500	6880	-	10400
Boicha beel	2.65	-	-	-	-	2500	-
Bagan beel	0.5	-	-	-	-	230	300
Monu River 6th P	3.1m	-	900	900	900	1000	1300
Monu River 7th P	1.4m	-	330	-	-	330	500
Monu River 8th P	5m	850	-	-	-	110	150
Rukhua beel	5.79	7600	61500	61500	61500	-	25100
Satbhuter dubi	1.61	-	-	120	120	-	160
Hariun beel	4.13	3000	3000	3000	3750	3750	3750
Harina beel	0.81	1000	1000	1000	1600	1250	1550
Ulauli beel	2.57	59600	66200	30000	30100	30100	40000
Dhansara khal	3.15	-	-	-	-	-	-
Sagar Dighi	1.65	-	-	-	-	-	-
Machua River	7.77	-	-	-	-	-	-
Bachadubi beel	1.57	100	100	100	120	500	500

Khals can sometimes come under private ownership. Such a situation arises when a breach in a river embankment occurs. This results in the formation of a new khal which crosses private agricultural land. Apparently the owners of the land cum khal are free to exploit the new khal for fish production without having to obtain a lease or license.

There are various type of share systems (and this list is not exhaustive):

- 50% to leaseholder, 50% to fishermen (ie subleased fishing areas in the Kushiyara near Sherpur; division of catch between leaseholder and fishermen on a 3 km stretch of the Surma River near Kanaighat; arrangement for a DHR roadside borrow pit).

23 6

- a moneylender who pays the lease fee on behalf of a fishermen's coop, may, in addition to requiring repayment of the principal in cash, receive a share of the profits from the catch (which constitutes his interest).

- fishermen may be paid a flat daily wage rate.

- fishermen may get a small share of the catch.

- fishermen may get small cash shares of the proceeds of the sale of the catch.

The leasing system promotes over-exploitation. Not only does the leaseholder believe it is his right to harvest all fish in the *jalmohal*, the fisherman is also driven to maximizing catch. He faces exploitation from middlemen, money lenders and government revenue collectors, and so has to catch enough to satisfy these exposures and also be left with enough for his family to live on. Fishermen themselves suggest solutions to this issue: either government provides loans to pay for lease fees, or government should abolish the lease fee system altogether. Many want to do away with the auction/leasing system. They want to fish freely. Also, if fish stocks are depleted, there is no justification for government to charge a royalty for a resource that doesn't exist. It is also difficult to justify increasing the royalty by 10% annually (thus fuelling inflation) when fishery resources are known to fluctuate non-directionally from year to year. Very senior DOF officers in Sylhet have seen catches decline over the long term, mainly due to over-exploitation. Leaseholders now harvest piles annually, and in the third year drain the beel completely. This breaks the fishing law regulating pile fisheries. The 3 year lease period is too short. If leases ran for more than 5 years (or better 10 - 12 years) people would have an incentive to develop seasonal beels. Short leases promote over-exploitation. The 3 year pile leases are being reduced to 1 year, thus tripling fishing effort. One can identify a "plunder mentality" among leaseholders. Also, if fishery resources become depleted fishermen do not renew their licenses. The over-exploitation of fish stocks has resulted in investors showing a declining interest in bidding for *jalmohal* leases. Indeed many leaseholders have lost money in recent years. GOB has recently attempted to salvage the leasing system by terminating public auction of leases and instituting a sealed tender bidding system. The DC office publishes tender notices to lease out *jalmohals*. Tender schedules costs Tk 200-500 to purchase. NFA is firmly opposed to tendering because it further decreases public accountability of *jalmohal* leasing and increases opportunities for corruption.

MFL suffers from two major dilemmas:

- its mandate in the fisheries sector is very incomplete and several other ministries possess overlapping jurisdictions, and

- it is itself a weak technical ministry in comparison to other more powerful ministries.

MFL could benefit by forging alliances (through the agency of joint projects and other collaborative activities) with more powerful ministries. However, MFL is in conflict with some key ministries. There is a continuing tug of war between MOL and MFL for jurisdiction over jalmohals. This would not seem to be resolvable through normal means even though several attempts have been made. Conflicts also exist between MFL and MIWDFC because of the negative impacts of some FCD/I projects on fisheries and the lack of specific fisheries components within FCD/I projects. However, an alliance between these two ministries should be considered a necessity and indeed a "natural" state of inter-agency cooperation: MIWDFC is responsible for water resources management and development in the broadest sense, while MFL is responsible for management and development of a major renewable living aquatic resource contained within and completely dependent on the quality and quantity of the larger water resource. MFL/MIWDFC cooperation is beginning to take shape in the agreement between DOF and BWDB to give DOF management responsibility in selected waters owned by BWDB. This needs to be extended much further. A key strategic goal must be to forge a powerful inter-ministerial lobby backed by the fisheries sector to bring all water bodies under general MIWDFC water management and DOF fish resource supervision. Clearly MOL is completely unequipped to carry out either of these mandates and its continuing hold over jalmohals is self serving, exploitive and defeats any attempts to further develop the inland fisheries sector of Bangladesh.

4.2.2 New Fisheries Management Policy

The *jalmohal* lease system is oriented toward generating revenue for government and substantial income for leaseholders. However it exacerbates exploitation of fishermen (who do not own their own produce and therefore realize only a small part of its full economic benefits) and leads to resource mining (as the leaseholder considers all fish in the *jalmohal* to be his personal property to be totally harvested if possible so as to maximize his profit). The ownership of *jalmohals* by MOL severely weakens the capacity of the MFL to carry out its mandate to scientifically manage, protect and conserve the inland fisheries resources of Bangladesh.

Beginning in 1986, MFL has begun a major new initiative to overcome problems of exploitation of fishermen and resource mining. This is known as *Nitimala* or the New Fisheries Management Policy (NFMP). It seeks to divert the maximum benefits from fishing to the actual fishermen (termed genuine fishermen) and put into place management systems which attempt to ensure long term sustainability of fisheries resources. Under NFMP, access to fishing rights is only given to genuine fishermen. This is done through a process of local peer/official selection and certification and issuing of renewable annual fishing licenses to approved and listed genuine fishermen. The NFA draws up a list of genuine fishermen at thana level. This is first approved by the thana NFMP committee and then is sent to the district NFMP committee for approval. Because most jalmohals are much larger than what one fisherman can harvest, the DOF has elected to license out jalmohals to fishermen collectives (ie cooperatives, associations, etc). The license fee is based on the lease fee that would have been collected had that jalmohal remained under the old leasing system, as the Government insists that the aggregate total of all license fees for individual fishing gears issued for a particular jalmohal must be equal to the old lease fee. Because fishermen have little accumulated capital, NFMP also contains a credit component. The Krishi Bank has a credit window in support of NFMP and genuine fishermen to enable them to purchase gear. Resource conservation is to be achieved through installation of permanent kathas and similar FADs in designated 'sanctuary areas' within NFMP jalmohals. Closed seasons for certain species were also to be enforced.

The national NFMP committee has identified some 300 *jalmohals* out of the 10,000 in Bangladesh for inclusion in NFMP under the direct supervision of the DOF, but only 250 of these have actually been handed over from MOL. NFMP is managed by three hierarchies of committees at national, district and thana levels. All committees have (in theory) two NFA representatives. Corporate members of the national NITIMALA committee are NFA, MFL, DOF, MOL and Krishi Bank. New jalmohals are in theory brought under NFMP based on recommendations of the local *Nitimala* committee. At present the transfer of *jalmohals* from leasing to NFMP is very slow. The DOF does not consider itself well equipped to "manage" all *jalmohals* and therefore is not presently actively seeking their transfer. The MOL and DOR criticize the inability of the DOF to provide enough backstopping to genuine fishermen, and use this as an argument against transferring more *jalmohal* to DOF jurisdiction. The basic premise is that it is the DOF (and not the fishermen) who are supposed to be the managers of the fisheries. "Management" is used in the sense of revenue collection rather than the conventional fisheries usage of regulating or limiting fishing effort on the fish stock. More fundamentally, MOL is opposed to relegating jalmohals to MFL because it would lessen its jurisdictional assets and opportunities for official corruption. MOL exerts pressure on GOB to return *Nitimala jalmohals* to MOL jurisdiction when license tenure periods come up for renewal.

MANUMUKH - a NFMP village on the Kushiyara

Kushiyara River parts 17 and 18 were placed under NFMP in 1990. The fishermen of Manumukh and Chandpur are registered fishing villages entitled to fish over the Kushiyara part 18. There are 142 license holder fishermen who are entitle to fish. Manumukh is situated at the confluence of the Manu River with the Kushiyara. This stretch of the Kushiyara has the largest fish resources in the area (upstream and down stream of Sherpur Ghat) from where large fishes of various species are harvested throughout the year. The license fee is Tk 45,587 for 1992.

During the monsoon fishermen are not able to fish in the river except in 2-3 calm shallow areas. Only in the early monsoon during the first flash floods do fishermen use floating Beshal (Khora) nets and sangla jal to harvest large carp broodstock during their spawning migration. Machuakhali is the only place where fishing takes place throughout the year without any gaps. Jatka, chapila, ilish, jainja and mola are the main species caught

Mr Akil Mia (license holder fisherman) reported that a 10 kg rui caught on 17 May '92 expelled ova when landed. On that day about 20 large brood fishes were caught by the fishermen and that was their largest catch during the whole season.

Mr Hanifullah who is the Chairman of the NFMP association agreed that it is destructive to harvest broodfish though the license holder fishermen frequently do this type of illegal fishing. He identified some causes of illegal fishing:

- Downstream stretches of the river are under the leasing system where more than 90% of the migrating fish are caught. Only a few fish manage to evade capture and reach this area. If they are not caught here, they will be caught elsewhere.
- The area of available fishing grounds has been severely reduced by the Manu River FCDI project which destroyed the Kawadighi Haor mother fishery.
- The fishery resource is now much smaller and it is difficult to earn enough to support a family.
- The license fee is too large compared to the size of the fish resource; thus the Government indirectly encourages overexploitation of the resource.

239

The introduction of the NFMP has been too timid and the process has lacked political will. There are few MPs who have a fisheries background, and most are opposed to NFMP and NFA. By transferring only a minute percentage of *jalmohals* to NFMP, GOB does not challenge and change the leaseholder system, but gives the leaseholders and moneylenders an opportunity to adjust their practices without necessarily suffering any particular loss of benefits. The power of the state still largely backs, supports and actively maintains in place the *jalmohal* leasing system (it supports leaseholder status quo). Were it a simple conflict between leaseholders and fishermen, the latter would undoubtedly win out. But state partiality and intervention tip the balance in favour of leaseholders, giving them the upper hand. Fishermen have little faith that the government will help them. Some thana fisheries officers openly cater to leaseholders, and support leaseholder interests over the interests of fishermen. Fishermen fear that government and rich leaseholders will misappropriate the money intended to assist them.

In Habiganj, under NFMP, typically a fishermen society (with about 300 members) gets a beel fishing license at an annual starting fee of Tk 1-300,000 for a 6 year period. The fee increases by 10% each year, thus building government induced inflationary pressure into the cost structure of fish production. A bank loan to pay the fee costs 13% interest. In Halir Haor near Sunamganj, the Satidora Beel Group Fishery pays Tk 257,000 for 3 years for fishing rights to Satidora Beel and Rotla Khal/Beel. The lease is held directly by the fishermen's coop and not by leaseholders. The group has fished here for 6 years. The value of the catch is between Tk 10 - 12,000. The fee for the large Tangor Haor near Sunamganj is Tk 70,000.

There are five possible sources of finance for fishing operations:

- Personal savings/capital. Status quo usually have sufficient personal resources to pay lease fees and fishing labour costs. Genuine fishermen generally are constrained by lack of personal capital.

- Informal creditors or moneylenders (*mohajan*) finance most artisanal fishing activity. Fishermen coops sometimes raise loans from *mohajans* from their own village. Sometimes they lend money outright to a fishermen cooperative or association, and sometimes they take on a lease in their own name and disburse credit in the form of subleases to fishermen. The sublease fee represents their principle, while a share of the catch represents their interest. Loan periods are often short and consequently interest rates are usually relatively high, between 7 and 20% per month, compounded to 300-340% per annum. Loans are used to buy nets. Lease fees may be paid in part out of a mohajan loan and in part out of a fishermen's own capital savings.

- Community-based group savings institutions, most notably the Grameen Bank, are not especially well focused on the fisheries sector. They need to develop better programmes tailored for different fisheries needs such as: ie nets, boats, and fish processing.

- Formal institutional credit is geared more towards capital investment projects such as hatcheries (which have recently been designated as <u>industries</u> and hence qualify for concessional interest rate loans) or large-scale intensive pond operations. However some support exists for genuine fishermen. The Krishi Bank for example has a window for genuine fishermen under NFMP to enable them to purchase gear.

- Infrequently, a rich local benefactor may pay the lease fee on behalf of a group of fishermen.

Many fishermen say their biggest problem is capital. They must pay too much to government and middlemen. They want loans for boats and nets. Lack of credit is a major impediment for two reasons: fishermen cannot pay the high license fee which is the entry "ticket" to the fishery, and they cannot buy gear and boats and meet other costs associated with processing and marketing. Thus, NFMP remains a good idea (wishful thinking), but without serious government political will to implement it. Uncertainty of availability of Krishi Bank credit is a major problem for NFMP. Fishermen have to mortgage their boats, nets, immovable property and even catches for loans of more than Tk 6,000 against one licence. Loan recovery is unsatisfactory. Application procedures are complicated and receptivity is poor. Non-availability of finance means NFMP fishermen have to turn to moneylenders who charge 7-15% interest per month, or aratdars who take delivery of fish for 3% commission and a share of the catch. As long as government does not provide credit to genuine fishermen, it cannot be considered serious in its support for NFMP. Credit is the key and backbone to NFMP. A major problem with implementation of NFMP has been failure of banks (ie Krishi Bank) to come up with credit to genuine fishermen, although bound by government policy to do so. Banks request mortgages and other securities for loans, conditions which fishermen can not meet. In a few cases loans were granted and used successfully, but by and large the loans given were insufficient. The Krishi Bank fisheries investment window is more oriented towards capital investment projects, such as large intensive pond culture projects. But earmarked capital is very underutilized, despite a very competitive annual interest rate of 16%. Fishermen do not come and ask for loans to pay license fees. Many fishermen are not aware that the bank has a fisheries window. Boats and nets are acceptable security. Loan recovery is a major problem.

NFMP in the form presently implemented by GOB does not appear to present any great impediment to the rent-seeking aspirations of ex-*jalmohal* leaseholders and money lenders. NFMP is subverted and defeated in a number of ways. If the license fee is too high only middlemen and moneylenders can afford to pay. Poor genuine fishermen cannot and must turn to them for credit. Middlemen are strong opponents of NFMP and try to take control of fishermen coops. They also try to extract fees for getting fishermen's names on to the district approved list of genuine fishermen. If the aggregate license fee for a particular jalmohal demanded of a fishermen's coop is too large, an ex-leaseholder may bribe coop leaders to sell him exclusive fishing rights to the beel in exchange for paying the fee. In one such case, the leaseholder went so far as to attempt to extract a tax on all shrimp caught in an adjacent river, as well as monopsony rights to purchase the shrimp at a fixed price. In some cases, NFMP thus simply reflects existing power relationships in fisheries rather than instituting a new trend. Some of the NFMP have been over-priced and fishermen have been unable to pay the required licence fee. However even under the new tender leasing system they are still over-priced and cannot be leased out. As a result GOB revenue is declining.

In contrast, studies by BCAS (1989) on selected NFMP fisheries indicate that NFMP is a breakthrough in ensuring equity and benefits to genuine fishermen. The objective of increasing earnings of fishermen is by and large achieved under NFMP. Economic returns to capital and labour, catch value, net and pure profit and implicit daily wage rates were all significantly higher for DOF/NFMP fisheries compared to MOL-leased fisheries. NFMP has been well accepted and

241

appreciated by fishermen. Exploitation by middlemen is largely eliminated. Fishermen own their own produce and can market it themselves, thus increasing gross income. But resource conservation is more difficult to implement. There is presently no biological fisheries management at all. And not encouragingly, the Government's first concern continues to be revenue collection. Because of the DOR's insistence on high license fees, many fishermen who lack the opportunity to raise credit to pay the fee are not able to keep their fishing license and end up having to sell the fishing rights back to ex-*jalmohal* leaseholders.

Many of the so-called fishermen societies are parts of political parties, while fishermen cooperatives are under the MLGRDC. The top people in both are not fishermen. Fishermen coops have share systems for member benefits depending on the amount of work done and the size of the net brought into the fishery. However mushrooming growth of coops around highly productive jalmohals has presented problems, and many coops are still controlled by powerful middlemen who reap most of the benefits from the fisheries. Coops find their own positions and financial resources too weak to defend fisheries user rights. Members often do not play an effective role in obtaining leases of *jalmohals* or in fisheries management. A major problem with coops is that the integrity of officials or leaders. For example, the secretary of the Uttorlongla Fishermen's Committee, at Shadipur village, Hakaluki Haor, absconded with Tk 500,000 that had been collected from members to pay the lease fee for their *jalmohal*. As a result the *jalmohal* reverted back to a middleman leaseholder. Lacking politically strong cooperatives, fishermen could not take on a continuing lease of the *jalmohals*. Moreover, politically committed persons or organization are needed to help build up real fishermen organizations. If these organizations have no socio-political commitments, then they will become the "playing ball" of the strong elites. There are several constraints on strengthening of fishermen coops (BCAS, 1989):

- lack of motivation;
- lack of prior organization or group homogeneity;
- poor communication among members;
- pressure from local power groups;
- lack of monitoring and evaluation;
- illiteracy
- lack of finance
- poor leadership.

The coops remain loose and atomistic, and thus less effective than they could be. Also they do not incorporate other fisheries sector groups such as women who make nets and process fish, and fish vendors.

The National Fishermen Association was formed in 1946 but only received a certificate of registration in 1992 (because of GOB pressure). Its primary objectives are enhancing socioeconomic development of fishing communities and increasing fish production. It has remained politically neutral as an organization and is not linked to any political party. NFA is not an NGO as such, but is registered as a non-profit association. The national officers are not working fishermen, but have fishing community and caste family backgrounds. They work for the NFA on a volunteer basis. NFA is the agency which represents fishermen at national, district and thana level NFMP committees. It is also empowered to carry out registration of genuine fishermen. The NFA considers itself to be the only organization looking after the interests of the 10 million fishermen of Bangladesh. It therefore attempts to carry out a policy dialogue with the DOF/GOB. NFA activities and office overheads are financed on a subscription basis, and this severely restricts its programme. The NFA is opposed to the tender leasing system. It is in favour of nominal license fees and greatly extending the tenure period (ideally into perpetuity).

A state of conflict exists between MOL and the DOF as regards implementation of NFMP, resulting from a reluctance on the part of MOL to give up ownership (and thus administration and revenue collection jurisdiction) of jalmohals in favour of DOF. Even for jalmohals already under NFMP, MOL retains ownership, and thus these jalmohals are under an arrangement of "joint management" between MOL and DOF. There are two main reasons why MOL has adopted a position hostile to NFMP:

- *Jalmohal* leasing is lucrative and the main source of income for the MOL. Net income from revenue collection from MOL land leasing is small because expenditure for the wages of collectors is almost equal to the revenue collected. *Jalmohal* leasing is in contrast very profitable because public auctioning and tendering of leases entails almost no labour costs.

- *Jalmohal* leasing offers substantial opportunities for corruption. This occurs in several ways: i) officially recorded *jalmohals* are leased out in the normal manner but the lease fee is under-recorded (for example, a lease fee of Tk 900,000 is collected, but only Tk 800,000 is recorded as paid); ii) there exist officially recorded *jalmohals* which are not leased out and are nominally derelict but are used for fishing; and iii) undeclared and unrecorded *jalmohals* which are "property" of MOL effectively become "private property" of officials, who lease them out at their discretion and retain the lease fee and any other income from shares and such.

DOF officials maintain that genuine fishermen under NFMP are now better off than before NFMP. Annual earnings of a fisherman may reach Tk 4,000 (US$100). If a fisherman's family has 5.3 members this amounts to a per person income of US$19, still well below the Bangladesh national average per person income of US$180. True, the family will have other sources of income. But as NFMP sets out to develop career professionalism in the fisheries sector it is important to recognize that the benefits accruing to fishermen are low. It is difficult to consider the system as anything other than still quite exploitive, and possibly little better than the status quo leasing system it replaces. The key driving force from the government's perspective continues to be revenue-seeking. License fee rates (cum loan interest) which can almost equal a fisherman's annual salary seem to be completely unjust and economically irrational — especially as it is not clear that the fisherman is getting very much in return for the fees (other than simple entry into the fishery). NFMP still has a very long way to go before it can make genuine fishermen and their families wealthy. The main problem now is to get the government departments to stop siphoning off economic rent — real or imagined — out of the fishermen's pocket, and let the fishermen receive the full market value of their catch — minus real capital/operating costs — as income. This is the only way they can be able to generate enough net revenue to provide for sustainable growth in personal disposable income and accumulation of capital for investment. Government should consider reducing its rent seeking control of the fisheries sector and allow the full entrepreneurial talents and energies of genuine fishermen free opportunity to realize themselves. If a genuine fisherman can earn the sum of Tk 20,000 or 30,000 a year, his increased purchasing power will lead to greater regional economic growth. There would appear to be plenty of scope for fishermen and fishermen coops to collectively negotiate better fee structures with DOF and DOR.

243

Perhaps the greatest obstruction to successful implementation of NFMP is GOB's own attitude towards natural resources. GOB has awarded itself ownership of all natural resources and accordingly considers it has the right to extract government revenue from usage of these resources. Thus the MOL leases *jalmohals*, DRH leases their borrow pits, BWDB lease its borrow pits. Typically, leases are won by wealthy individuals (investors) and rarely the landless or destitute. In practice therefore the leasing (or analogous arrangements such as group licensing) of land, water and other natural resources by the GOB prevents the poor from having access to these resources. This hypothesis is supported by the fact that the poor, do not have the cash savings to pay the high lease fees demanded by GOB. Thus, if offered first choice of leases, the poor must go to money lenders for the cash, who in turn end up effectively owning the lease and using the poor as cheaply paid labour. The major benefit goes to the money lenders. As long as GOB insists on collection of substantial amounts of revenue from natural resources sectors, it will may well be impossible for the poor to escape from the circularity of their poverty trap and substantially benefit from the exploitation of these natural resources.

Four different fishery tenure scenarios illustrates this point:

<u>Scenario 1: Single Leaseholder *Jalmohal* Leasing</u>: The standard justification for leasing/licensing is that if the value of fish in a particular *jalmohal* is Tk 1,000,000, the government is justified in asking Tk 100,000 as lease/license fee. Thus nine parts go to the lessee and only one part to the GOB (acting on behalf of the good of the entire nation). Even if the total cost of hiring fishermen to catch the fish, hiring guards, etc, plus the lease fee comes to Tk 400,000, the net profit of Tk 600,000 still represents a 150% return. This is a lucrative business, and leaves room for substantial payments to local officials. The fisherman who actually does the work gets Tk 25 per day, and is fortunate if he obtains two months of fishing labour work per year. His annual income from fishing would be around Tk 1,500. Thus the leaseholder becomes wealthy while many fishermen stay poor. From the fishermen's and local markets' perspective, the economics are as follows:

- Thirty fishermen make Tk 45,000, and this is available as disposable income for creating effective consumer demand,
- Thus, in exchange for Tk 100,000 revenue to government, Tk 45,000 of effective consumer demand is generated by the fishermen,
- An <u>Economic Stimulation Index [ESI]</u> (ratio of consumer demand created divided by GOB revenue collected) can be calculated. In this case the ESI is 0.45. [Since GOB revenue is a large percentage of total cost, it justifiable to regard it as either a stimulus or a retardant of economic growth, depending on its magnitude. If GOB revenue tends towards zero, ESI will increase and local markets will benefit. If GOB revenue tends toward infinity, ESI will decrease and local markets will contract.]
- Benefit to fishermen (Tk 45,000) minus cost to GOB (zero, as GOB loses no anticipated revenue) is Tk 45,000.

Effective consumer demand generated by the single leaseholder for Bangladeshi produced goods and services cannot be accurately estimated because a large portion would go for imported luxury goods and/or leave the country as capital flight. Local purchases by the leaseholder might increase the ESI to 1.5 or 2.0 points.

Scenario 2: NFMP Genuine Fishermen Group Licensing: Under *nitimala* licensing of the same *jalmohal* to a group of 30 fishermen, the aggregate license fee is still Tk 100,000. Each fisherman's share is Tk 3,333. However most fishermen will not have ready cash and must turn to local moneylenders who charges interest rates of 300% per annum. Thus, the actual cost of the lease fee is Tk 400,000. Normal fishing operating costs (boats, nets, lines, hooks, building the khola) might come to about Tk 50,000. This would also have to be financed, and therefore the actual cost would increase to Tk 200,000. Total costs are Tk 600,000. The catch is sold for Tk 1,000,000, and the net profit is Tk 400,000. Each fisherman gets a Tk 13,333 share (equivalent to US $333 (dividing by 5.3 for the average family size yields a per person income of US$63, about one-third of the Bangladesh average per person GNP of US$180. Compared to scenario 1 the moneylender becomes wealthy and the fishermen are somewhat better off, but still very poor. The economic effects are:

- Thirty fishermen make Tk 400,000, and this is available as disposable income for creating effective consumer demand locally,
- Thus, in exchange for Tk 100,000 revenue to government, Tk 400,000 of effective consumer demand is generated by the fishermen,
- The ESI is 4.0, which is much better than under scenario 1,
- Benefit to fishermen (Tk 400,000) minus cost to GOB (zero, as GOB loses no revenue) is Tk 400,000.

Scenario 3: Reduced License Fee (but no credit) NFMP: If the lease fee is reduced to a nominal level (for example, Tk 10,000), GOB would "lose" Tk 90,000 in anticipated revenue. Since the lease fee is now Tk 10,000, each fisherman's share is only Tk 333. Most fishermen would be able to pay this out of personal savings, but assuming a worst case situation external financing would increase the lease cost to Tk 40,000. Assuming also that fishing costs are financed (Tk 200,000), the total costs are Tk 240,000. Total sales remain at Tk 1,000,000, and net profit is Tk 760,000. The individual fisherman's income share is Tk 25,333. The economic impacts are:

- Thirty fishermen make Tk 760,000, and this is available as disposable income for creating effective consumer demand,
- Thus, in exchange for Tk 10,000 revenue to government, Tk 760,000 of effective consumer demand is generated by the fishermen,
- The ESI is 76.0, which is an order of magnitude better than under scenario 2,
- Benefit to fishermen (Tk 760,000) minus cost to GOB (Tk 90,000 in foregone anticipated revenue) is Tk 670,000, which is also much higher than under scenarios 1 and 2.

Scenario 4: Reduced License Fee Credit-Assisted NFMP: Under a highly liberalized system, the reduced lease fee could remain at Tk 10,000 (one might anticipate that GOB would decrease the size of its fisheries bureaucracy and more efficiently use the revenue that the poorest segment of the population is prepared to yield, and for which it expects in return real supportive infrastructure and government social services). Nominal fishing costs are Tk 50,000. It is also assumed that the Krishi Bank opens its fisheries credit window because they have confidence that the fishermen can easily service a Tk 50,000 loan at the current interest rate of 16% p.a. Thus the credit-assisted cost of fishing is Tk 58,000. Total cost including license fee is Tk 68,000, total sales are Tk 1,000,000, net profit is Tk 932,000, and average individual fisherman income share is Tk 31,067. The economic impacts are:

- Thirty fishermen make Tk 932,000, and this is available as disposable income for creating effective consumer demand (although some will probably go into savings),
- Thus, in exchange for Tk 10,000 revenue to government, Tk 932,000 of effective consumer demand is generated by the fishermen,
- The ESI is 93.2, which is a 22.6% increase over scenario 3.
- Benefit to fishermen (Tk 932,000) minus cost to GOB (Tk 90,000 in foregone anticipated revenue) is Tk 842,000, which is also much higher than under scenarios 1 and 2, and 25.7% higher than scenario 3.

Clearly, aside from maintaining a high level of inequality of rural income distribution, the leasing system and other GOB revenue-focused fisheries tenure systems undermine local economic growth. The marginal increase in aggregate demand which would accrue to the region's economy by changing the fisheries tenure, revenue collection and credit systems from leasing (Scenario 1) to full liberalized NFMP (Scenario 4) are very substantial, given that the number of fishermen in the region may be as high as 500,000. Under Scenarios 2, 3 and 4 the losers are leaseholder, moneylenders and GOB revenue. However, there can be little doubt that scenario 4 will lead to the fastest regional economic growth with the greatest equity possible in the fisheries sector. GOB and DOF may be willing to hand tenure of *jalmohals* over to fishermen and introduce community-based management, but, as yet, they are unwilling to give up revenue collection from the fisheries production sector. However revenue collection remains the biggest roadblock to sound management, income equity and economic growth in capture fisheries, and it is in the nation's best economic and social interests for GOB to withdraw from economic rent-seeking in the fisheries production sector. More progressive GOB taxation points from which foregone revenue can be recovered are:

- From within the fisheries sector, but further downstream from the point of production (ie from marketing) after value has been added,
- From diffuse sources within the general regional economy. All consumer items that fishing household need will be in greater demand and producers will respond by increasing supply. This will expand the regional economy and general taxation base on sales.

The approach should be to collect revenue post-production, and not pre-production, in the fisheries sector. Taxation should target in particular the *aratdars*. To impose a heavy tax right at the starting point of the production process against the poorest segment of the sectoral hierarchy preempts any possibility for equity and economic efficiency. Sustainable development objectives of economic production, growth and equity have to come first. Any bureaucratic regulations or practices which stifle or subvert these objectives should be removed definitively.

4.2.3 Community-based management

It is becoming increasingly recognized that while central government would like to believe themselves responsible and capable of managing fishery resources, the real and de facto managers of fishery resource are the fishermen themselves. Over centuries, fishing communities throughout the world have developed resource management regimes and measures (usually prominent components of village political structures and philosophical beliefs) which were successful in meeting their objectives because they were based on comprehensive functional knowledge of the resource and community protocols for equatable access and sustainable exploitation of the fishery resource on which the community depended for its livelihood. Available evidence suggests that such community-based fisheries management was economically efficient and resource conservationistic. Fishing effort would adjust itself to approximately the MSY level, or even lower (thus "overprotecting" the resource and coming close to capturing the maximum economic yield). The expansion of central governments, with objectives of revenue collection, resource rent capture and management aspirations, usually led to:

- Destruction of community-based management systems,
- Serious deterioration in resource management efficiency,
- Overcapitalization and economic waste,
- Increasing conflict over access to fishery resources,
- Exploitation by money lenders and middlemen traders,
- Decreasing incomes and poverty among fishermen.

In Bangladesh, no information is available about community-based fisheries management prior to British colonization. The British administration introduced the *Zamindari* system for land taxation to collect revenue. This leasing system was also applied to water bodies. In the Jointiapur Kingdom of Sylhet (which fell under British rule later than the rest of Bangladesh), some water bodies were given to the village people (which are adjacent to the village) for common use and resource exploitation. Usually these were minor beels, and the intention was too placate village people so they would stay away from larger *jalmohals*. These community *jalmohals* were used for bathing, fishing and dry season irrigation. No taxes (or in some cases only token taxes) were charged to the villagers. *Jalmohals* were managed by the community which enforced some rules for sustainable use of water and fishing (such as restriction on complete de-watering, complete harvesting of fish, detrimental gears and community harvesting once or twice in a year). These types of *jalmohals* were called *Mohalshamil jalkar,* and some still exist toady under village people (or in some cases exclusively under fishermen communities). In some cases management structures have come under pressure. A few examples of existing *mohalshamil jalkars* are:

Bijna River, Devpara, Nabiganj: A section of the Bijna River near Baasdor and Devpara villages was given for a token annual lease of Tk 1 to the local fishermen group. The fishermen have been managing the river section successfully since 1973/74. There is a fishermen management committee which meets once a month. Problems are discussed and savings are collected (Tk 10 per person). Group savings are spent on *jalmohal* management (cost of *katha*). No conflicts are reported among the fishermen.

247

Nandina River, Khola Chandpur village, Jamalganj thana: The portion of the Nandina (Abua) River adjacent to Khola Chandpur village was permanently allocated for their community's use by order No 734 dated 6/9/61 of the Deputy Commissioner office, Sylhet. This order was issued after the fishermen leader appeared before the court and claimed customary as well as community rights over the fishery. This took place during the hearing of a case filed by the lessee to evict the fishermen from the fishery. The fishermen have tenure over the river stretch, and there have been no conflicts either within the fishing village or with outside fishermen. The area is however too small for the number of fishermen who are entitled to share the fishery. This fishery is part of a larger fishery which is leased out to a lessee. Fishermen who fish in the remaining part of the fishery need to pay about 1000 times more than the fishermen of Khola Chandpur who fish within their allocated stretch. The government fixed the rent at Tk 4.75 and Tk 2.25 per annum for large and small nets respectively. The poor fisherman who is not able to pay the lessee's fee normally fishes in the allocated area. There are no internal rules or regulations for management because of the continuous flowing nature of the river and the through migration of the fish stock. Mr Srikanta Barman, leader of the village, mentioned that free excess to this small portion of Nandina river provides survival and livelihood to the fishermen of this village, but they are afraid of the future status of the river as it is undergoing siltation. Thirty years before, it was the deepest river (excluding the Surma) in the area and had a good stock of *Nandina* carp. Though he could not say anything about the historical background of the name of Nandina River, he believes that the name might have originated from the important and productive fishery for *Nandina* carp. He stated that only that area is named Nandina River where *kaph* (large deep holes or pockets in the bank of the river where *Nandina* carp took shelter) were abundant. The older people of the village mentioned that they observed a mass mortality of large *Nandina* broodstock during the hot days of Chaitra (March-April) around 1970. At the time, the river bed became shallower and most of the *kaph* disappeared. They mentioned that *Nandina* is not a cleaver fish like some other fish. Most of the time it prefers to hide within a certain area which appears to offer safety, such as *kaph*. They also mentioned that the fish is a hillside species which was carried by the strong flash floods into the region, though they were also observed to spawn in the river. The fishermen of the village also said that the Mohashoal had mostly disappeared, though one large Mohashoal (weight 21 kg, price Tk 2,500) was caught from the Nandina River during the second week of June 1993.

Khoiltajuri beel, Bonni village, Companiganj: This beel has a dry season area of 5-6 ha. It produces mainly smaller species of fish, and few carp. Due to some conflicts among the villagers (rich and poor), the majority of people have not been getting the benefits of the *jalmohal* since 1988.

Beels in the Rouchunni haor, Goyainghat: Mohalshamil beels are now given up for leasing to the lessee of the adjacent Rouchunni beel as these all are under the common floodplain of the Rouchunni haor. Village people meet together and decided how much money they will charge for the lease and then bargain with the lessee. Lease money is equitably distributed among the villagers. Some money is set aside for repairing of village roads and other development works. This system has been in place for more than five decades.

Kalibarir duar, Parashkhila, Atpara: This *duar* has been kept as a fish sanctuary under fishermen community management for a long time. The fishermen have traditional believed that they must protect part of the brood stocks to ensuring sustainable production in the floodplain and the rivers. The fishermen themselves protect the duar.

GOB does not recognize or promote community-based fisheries management since such a management system does not serve its interest in collecting revenue.

4.2.4 Fish sanctuaries

GOB has established a number of fish sanctuaries and protected areas. The Protection and Conservation of Fish Rules, 1985 (see Appendix O) lists 13 protected areas in the region where capture of carp (*Rui, Catla, Mrigel, Kalibaus* and *Ghonia*) is controlled. The DOF Integrated Fisheries Development Project (see Section 2.8.6) established four fish sanctuaries in the region.

The Luba River is one of these fish sanctuaries, and serves as a good example of the problems of managing such a fish sanctuary by central government. The sanctuary is 7.2 km long and about 100 m wide. The area is 150 ha. Five *duars* exist within the river of which Barar *duar* and Mainrir *duar* are very important. These *duars* are 30-35 m deep during the rainy season and act as refuges for *boromaach* broodstock: *rui* (25 kg), *kalibaus* (15-20 kg, the most abundant), *catla* (25 kg), *boal* (80-100 kg), *baghair* (100-150 kg), *mrigel, mohashol* (30 kg), rare and threatened throughout Bangladesh), and *chital* (rare in the Luba). Some *chotomaach* also use the *duars*: *bacha, tengra, puti, baim, chapila, pabda* (most abundant), *shoal* (rare), *guzar* (rare). Of very great importance is the fact that at least three other species of *boromaach* use the Mainrir *duar* as a refuge which are now extinct elsewhere in the region: the rare carp *ghora* Labeo pangusia (5-7 kg) and two other fish species known locally as *Nowraj* (60 kg) and *pakhiranga* (30-40 kg) (these species have not yet been identified by their scientific names).

In the winter season, in some parts of the sanctuary there are no water (60% area are dry up). All important fresh water fish species including Mohashol, Pangas and small Ilish) occur in the river and its tributaries. A fisherman of Laksmiprasad village caught a 150 kg *baghair* below the confluence of the Luba and the Surma River in March 1992, and the Luba/Surma confluence is well known for large fish. During April and May when rain water discharge inundates the shallow areas of the river, a large quantity of *boromaach* (*rui, catla, mrigal, kalibaus, baghair, ghagot* or *air*) are caught which are full of eggs. *Mohashoal* and *chital* are present at this time but no *pangas* or *nandina*. A sand bar in the middle of the Surma River just below the confluence is a good breeding site. There are 3-4 shallow bends which are also suitable for breeding. The water of the Luba was green and clear while the water of the Surma was yellow and turbid. During April and May new flood water inundates the shallow areas and fishermen harvest a large number of adult fish which are full of eggs. Both male and female were observed at the same time as fishermen note the occurrence of yellow (i.e. eggs) or white (i.e.milt) discharges from the fish. In some cases just after capture the fish liberated eggs or milt. Some local people have tried to stock the eggs in ponds but they failed (probably the eggs were not fertilized — see section 5.3.4). Fish catches have declined by 60-70% over recent years.

After declaring fish sanctuaries and protected areas, no additional protection or management practices have been taken up by DOF. The fish sanctuary guard of the DOF Integrated Project (Mr. Lal Mia) stated that one man with a boat is not capable of controlling the whole fishery. Although the Luba is declared a fish sanctuary illegal fishing is on-going. Last year the local DOF official seized one large net used for illegal fishing. During one field visit, a group of fishermen were observed fishing in the Luba River in the presence of a DOF official (Mr.Illias, MLSS of UFO office, Kanaighat). At the same time four groups of fishermen were fishing with *utar jal* at the Surma/Luba confluence. They use this net during the low water period. Usually they do not go to the Luba due to the restriction, though fish catch are higher then in the Surma.

249

No fishing was observed in the Surma upstream of the Luba confluence.

4.2.5 Subsistence fishing

Subsistence fishing is of great importance for maintaining the nutritional health of the rural population. About 76% (838,000) of all rural households in greater Sylhet carry out subsistence fishing, and 57% (1,072,000) in greater Mymensingh. During the flood season, there is open access over the entire flooded area, except for the areas around leased beels (which are patrolled by *Paharadars*). No fishing licenses are needed. People can catch fish including species such as *rui, catla,* and *boal*, at this time of the year where during the dry season these fish are under private control and a costly license is required. However, because the stocks are dispersed over a large area, catchability is low. During the dry season when stocks are concentrated and catchability is high, open access is restricted to local beels under 1.2 ha. In addition, land owners will attempt to harvest any fish present on their rice fields. Low bunds (*ail*) are constructed around fields to regulate water levels. Fish fences and basket traps are installed to harvest fish at drainage cuts in the *ail* in order to harvest fish. As the plot drains, the fish on the plot try to escape back towards the khal or river and are caught in the trap. Finally the field is fished out with *flan jals* or cast nets. The fish represents free bonus high value produce from the farmer's field.

Leaseholders of large beels will sometimes allow subsistence fishing with *Tela jal* (pushnets) in marginal areas well away from their *katha*, but apparently this "privilege" is being withdrawn in many beels because even small miscellaneous species are becoming increasingly valuable and marketable.

4.2.6 Illegal fishing practices

Poisonous plants are used in the Indian part of the catchment and this has caused massive fish mortality in the Sharighat and Juri rivers.

A new threat is dynamite fishing in *duars*. Because of ongoing road construction in India, dynamite is easily procured (or stolen) by miscreants, who cross into Bangladesh and throw dynamite into the Luba River sanctuary *duars* in order to kill the broodstock fish taking refuge there. This happens on a regular weekly basis. The Indian Security Force and the Bangladesh Security Force, who are empowered to ensure border security, allegedly turn a blind eye to this practice. According to the laws of Bangladesh the use of dynamite to catch fish is a criminal act. Furthermore the slaughter of brood stock, some of which are rare or endangered species, while in overwintering grounds in Bangladesh by foreign miscreants is a matter which requires immediate and forceful intervention by the Bangladeshi law enforcement agencies.

4.2.7 Conflict within the fisheries sector

While the status of fishermen is low and their economic power weak, the unit value of their product is relatively high. Because of this paradox fishermen are subjected to much abuse and victimization. Around Dabor (Sunamganj District) for example, there are many *dacoits* in the area. Some are Bangladeshi and others are Indians. They work together at night and are quite dangerous. Three years ago, five policemen were killed by *dacoits* at the Dabor bridge. There is a big security problem in the area which the Bangladeshi security forces appear unable to control. If genuine fishermen were to get *jalmohal* leases they would be unable to protect their fish from *dacoits* who would overpower them and steal the fish. Middlemen hire guards who can fight off the *dacoits* and protect the fish. However, BCAS (1989) says that middlemen leaseholders do not and cannot provide protection to fishermen against extortion, net theft and damages by miscreants, *dacoits* and local influential people. Also, fishermen settle disputes among themselves with help and guidance from elders. In more remote areas fishermen do not complain about problems with *dacoits*.

Conflict over access to rich fishery resources would appear to be not uncommon in the region, and can lead to violence and loss of life. A recent example from Tangua Haor follows:

Tangua haor is the most important hoar in Sunamganj District as well as in the region and performs an important role as a mother fishery. People of Sunamganj believe that fishing activity in Tangua haor has an impact on total fish production of Sunamganj District. Due to bumper levels of fish production (Tk 30 million in 1991 according to the general manager of the company holding the *jalmohal* lease) each year many influential status quo individuals try to get a share of this windfall by raising various tenure claims. This leads to frequent clashes between rival groups. In the winter of 1992/93, fishing in Tangua haor became impossible because of such conflict between two rival groups. Starting from late October 1992, each tried to claim fishing rights by establishing temporary shelters in two parts of the haor. Many fishermen (who are working on a daily wage basis) have been killed, injured, or lost property due to this conflict. The reasons for the conflict are as follows:

- The haor was leased out to a company called Inland Fisheries Development Corporation . Mr Abdul Wadud Pathan of Sunamganj is the Managing Director and Mssrs Moazzem Hossain Chowdhury, Ataur Rahaman, (Dr) Rakib, Abul Hasnat and two other individuals are Directors of this company.

- Mr Joinal Abedin was granted the power of attorney from the Managing Director, Mr Pathan (who was planning to staying abroad for few years) to manage the haor on a share basis as he is known to be skilled in haor management.

- When Mr Pathan returned from abroad, the other Directors accused Mr Abedin of depriving them of their share of business profits.

- Mr Pathan filed a case against Mr Abedin in the District Court at Sunamganj in Oct 1992, in an effort to evict Mr Abedin from the company and from the haor.

- The Court passed an injunction ordering a moratorium on fishing in the haor.

- At present Mr Abedin is still in the possession of the haor. During December 1992, Mr Pathan organized some local people and tried to repossess the haor by force. In ensuing gun battles, several people were shot and killed. As a result local people are at risk within the haor.

- Hired fishermen are the main victims suffering from this conflict.

5. PROPOSED STRATEGY FOR REHABILITATION AND SUSTAINABLE DEVELOPMENT OF FISHERIES OF THE REGION

5.1 IDENTIFICATION OF DRIVING FORCES IN THE FISHERIES SECTOR

An important element of development planning is the identification of those elements of the overall social, economic, environmental milieu which are in a state of change (as distinct from elements which are static and inertia-bound) and the underlying driving forces which are responsible for generating the identified change and transformation. Change manifests itself as trends, cycles, shocks and random events. Significant changes taking place in the fisheries of the region, as well as their probable causes, have been identified in previous chapters. The results of this analysis will be used to formulate strategic technical measures whose design objectives aim to either counteract or alleviate negative driving forces or support positive driving forces. Summaries of driving force/change couplets at international, national and regional levels are presented in Tables 5.1 through 5.3.

Table 5.1: International Driving Forces

Driving Forces	Observed Change
Global warming	A trend of increasing rainfall and river discharge within the region and its catchment area, resulting in increasing flood intensity which in turn increases fish production.
Decreasing world market prices for indigenous Bangladeshi freshwater finfish (due to low pricing by India and Thailand).	Decline in export of freshwater finfish from the region.
Increasing world market prices for prawns due to general increase in demand.	General increase in exports of prawns from the region.
Increasing deforestation and natural resource exploitation in the Indian catchment area.	Increasing sedimentation and deteriorating water quality of effluent discharges into Bangladesh.
Increasing foreign assistance to fiscal development budget of Bangladesh.	Increasing number of capital intensive FCD/I projects in region, and increasing conversion of natural floodplains and wetlands to agricultural land. Increasing negative FCD/I impacts on fisheries and declining production. Increasing expenditure on artificial stocking of floodplains.

253

Table 5.2: National Driving Forces

Driving Forces	Observed Change
Strong consumer demand for fish in large urban retail markets, due to population growth and declining supply.	Strong upward pressure on domestic retail fish prices.
GOB strongly focused on collecting revenue from the all economic sectors, including fisheries. Overpricing of lease fees for jalmohals. Non-implementation of economically and socially more efficient NFMP.	Recent change from public auction leasing to sealed tender leasing. Increasing over-exploitation of fish stocks and declining catches. Lack of development investment by leaseholders. Increasing relative poverty of fishermen. Declining interest in bidding for *jalmohal* leases and decreasing revenues collected.
MOL ownership of *jalmohals* and general administration of *jalmohal* leasing, characterized by high level of corruption.	Increasingly strong resistance by MOL to implementation of NFMP and transfer of *jalmohals* to DOF. Increasing pressure to return NFMP *jalmohals* to MOL jurisdiction.

Table 5.3: Regional Driving Forces

Driving Forces	Observed Change
Increasing failure of smallholder farmers resulting in landlessness.	Increasing number of non-traditional fishermen entering fisheries sector and increasing fishing effort. Increasing extension of fishing activities to restricted fishing areas (such as privately leased *jalmohals*). Increasing use of illegal small mesh fishing gears. Decreasing fish abundance and production.
Leasing of *jalmohals* by district GOB administration, characterized by high level of corruption.	Increasingly strong resistance by district administration to implementation of NFMP and transfer of *jalmohals* to DOF.
Resistance of *jalmohal* leaseholders to incursions into their leased fisheries.	Increasing militancy of fishermen, poaching and gang fishing. Increasing use of *paharadar* to police *jalmohals* and increasing abuses against fishermen. Increasing conflict between leaseholders. Increasing violence and deaths.
Increased planting of hyv rice.	Increased utilization of fertilizers and pesticides, resulting in deteriorating surface water quality and decreasing fish production.
Increasing population.	Increased disposal of sewage into surface waters, resulting in eutrophication and probably some increase in fish production.

5.2 FISHERIES ENGINEERING MEASURES

5.2.1 Multipurpose FCD/I project design

In most cases, the objectives of FCD/I projects are designed to benefit agriculture or to protect infrastructure or urban environments. Rarely are FCD/I projects constructed to benefit fisheries. The few beel embankment projects in the region (see Section 5.2.3 below) are the only instances of structural civil engineering projects loosely classifiable as FCD/I in nature that have their primary objectives as serving fishery needs. FCD/I projects are thus not generally regarded as instruments for fisheries development.

Rather, the focus of FCD/I projects on the needs of agriculture and infrastructure results in civil engineering works which are not fisheries-neutral, and many are detrimental by design to fishery production. If any benefits for fisheries are realized (ie deeper water levels in submersible embankment projects benefitting pile fisheries) they are not planned for as project objectives. Fisheries is thus placed in the position of needing 'mitigation' from the negative externalities of FCD/I projects. Failures of FCD/I to operate according to design (ie embankment breaches) also result in unplanned for benefits to fisheries, but these are again more in the nature of mitigative 'benefits' (or more exactly, a lessening of the severity of negative externality) which decrease the magnitude of the net loss, rather than real benefits derived from planned development which generates net gains.

When conceptualizing and designing FCD/I projects, there is a clear dichotomy between FCD/I projects which are fisheries development targeted and FCD/I projects which are agriculture or infrastructure targeted (and may or may not contain fisheries mitigation measures). Thus, it is a general view in Bangladesh that FCD/I projects have had little or no consideration for fisheries, that their impact on fisheries has been mostly negative and that there is no long term future for floodplain fisheries because eventually almost all flooding will be controlled. Because of the general pessimism about observed and expected negative impacts of FCD/I on fisheries, DOF development policy has shifted away from capture fisheries and now is heavily focused on aquaculture. However, from the information collected in the present study (and in other studies carried out by NERP water engineers) about the poor performance of many of the region's FCD/I projects, "catastrophic" pessimism is clearly not justified and considerable scope exists for mitigating FCD/I impacts on fisheries. There is reason to be optimistic that the threat to fisheries is not as severe in the region as elsewhere in Bangladesh and that the fisheries of the region can be "saved". The special hydrology and haor physiography of the region imparts a measure of uniqueness to the region's fisheries and the impacts of FCD/I on them, which may not be directly comparable to other regions of Bangladesh. The floodplain fisheries of the region will, however, not be "saved" if the attitude of defeatism continues in the DOF and other fisheries institutions. Moreover, the fact that most fisheries 'mitigation' is by accident rather than design, and that fisheries development FCD/I project planning is still in its infancy in the BWDB and DOF, do not give room for complacency.

It is a fact that virtually all FCD/I projects lack a fisheries component. In practice this means that no area(s) within the project is set aside and designated for fish production, and no finance is budgeted for construction of fisheries-related structures. The proposed solution to this deficiency is for all water management and development projects to be multipurpose in concept, objectives, design and operation. Thus the concept of Multipurpose Water Resource Management is proposed as an enhancement of the tradition FCD/I approach which is narrowly focused on agriculture or infrastructure. Every multipurpose project must have a fisheries purpose and component, finance for its construction and execution, and be a joint agency effort (BWDB/DOF) with full collaboration during planning, design, construction and operation. Multipurpose projects would also include clearly defined components for navigation, cattle grazing, wildlife as well as agriculture, perhaps through a zoning or compartmentalization approach. Many of the 'FCD/I versus fisheries' issues in the region might be resolvable without recourse to blanket replacement aquaculture scenarios (which may in any case be impractical).

Once criteria and design parameters are optimized for multipurpose projects, they can be applied in two ways:

- all new projects in the planning stage should be brought into conformity with a multipurpose approach to make them fisheries efficient;

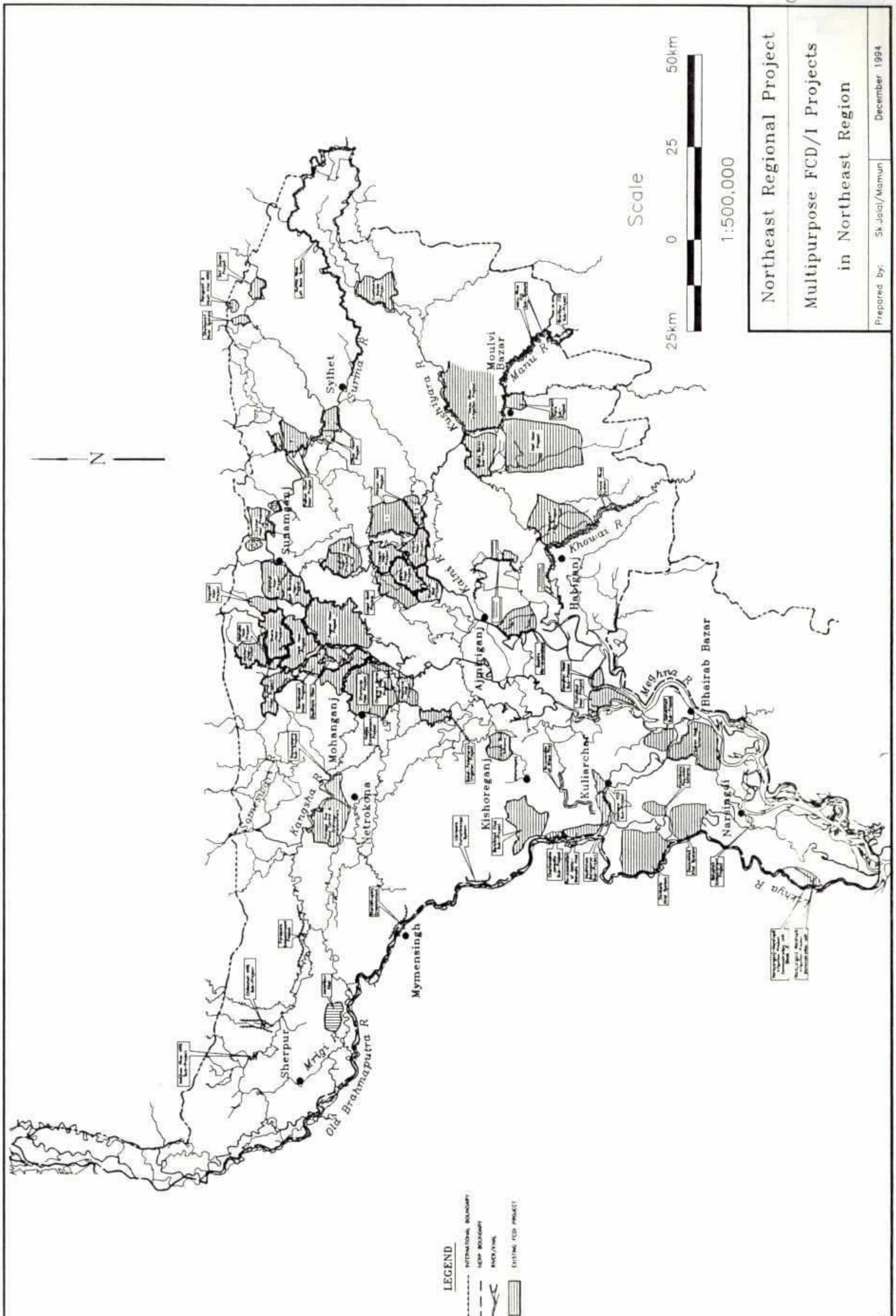
- all 65+ existing FCD/I projects in the region should be brought up to multipurpose status by new constructions. The objective would be to "fix" and "modify" existing projects so they become fisheries efficient.

The importance of the second item is greater than the first because the existing projects are more numerous than the new projects that can be expected to be built over the medium term future, and thus the former will exert a greater negative effect on the region's fisheries. Also, existing projects already occupy the most favourable locations for agriculture.

This raises the issue of the best and wisest use of the remaining areas of the region's floodplain that are not under conventional FCD/I projects. The region is overly water-rich. Under pre-FCD/I conditions it was too water rich to be efficient as a rice producing area. The objective of the existing FCD/I projects has been to redistribute water resources in time and space to create better conditions for rice production. The most favourable locations have already been altered. In the best FCD/I areas (higher lands) two rice crops can be produced per year, while in the lesser locations, only one crop (*boro*). In the locations least favourable for agriculture there are good indications that better uses of the areas can be made for fisheries and natural products (such as flood plain forests, reeds, aquatic macrophytes, wildlife, ecotourism). The relative merits and economic (as well as social and environmental) gains to be had by using the most deeply flooded areas (or flooded areas which have other special functions such as "mother fisheries") for non-rice uses rather than uneconomical rice production have to be assessed and rational decisions taken. At present FCD/I projects cover 18.7% of the floodplain of the region. The remaining 81.3% can be subdivided in terms of decreasing profitability as rice producing areas and increasing profitability for alternative uses such as fisheries and wetland forestry, and this should condition decision-making on any further expansion of FCD/I-protected rice hectarage. From the perspective of multipurpose project planning, the non-agricultural components would be given much greater weighting.

256

Figure 64



A number of existing FCD/I projects are not performing according to design. The reasons for poor performance include improperly located and/or designed regulators, insufficient number of regulators, poor quality embankment construction, suboptimal embankment routing, poor maintenance, lack of navigation passes, and so on. The NERP project monitoring studies have helped to increase understanding at two selected projects (Shanir Haor and Manu River) of what is wrong and requires attention. The result of all these structural inefficiencies is a certain amount of loss (actual and/or potential) in rice production each year from crop damage due to flooding, late planting, etc. If each and every existing FCD/I project were "fixed" so that it performed optimally, there would be an automatic increase in rice production in the region (and without any other inputs). Once farmers perceive that the BWDB is committed to solving all the structural problems of their particular FCD/I project area, they will probably feel that risk has been reduced, and would be more likely to apply more inputs (fertilizer, pest control, high yielding varieties, and irrigation) thus raising production further. Indeed improving the operation of existing FCD/I projects has the same end result as lateral expansion through new projects: more rice is produced.

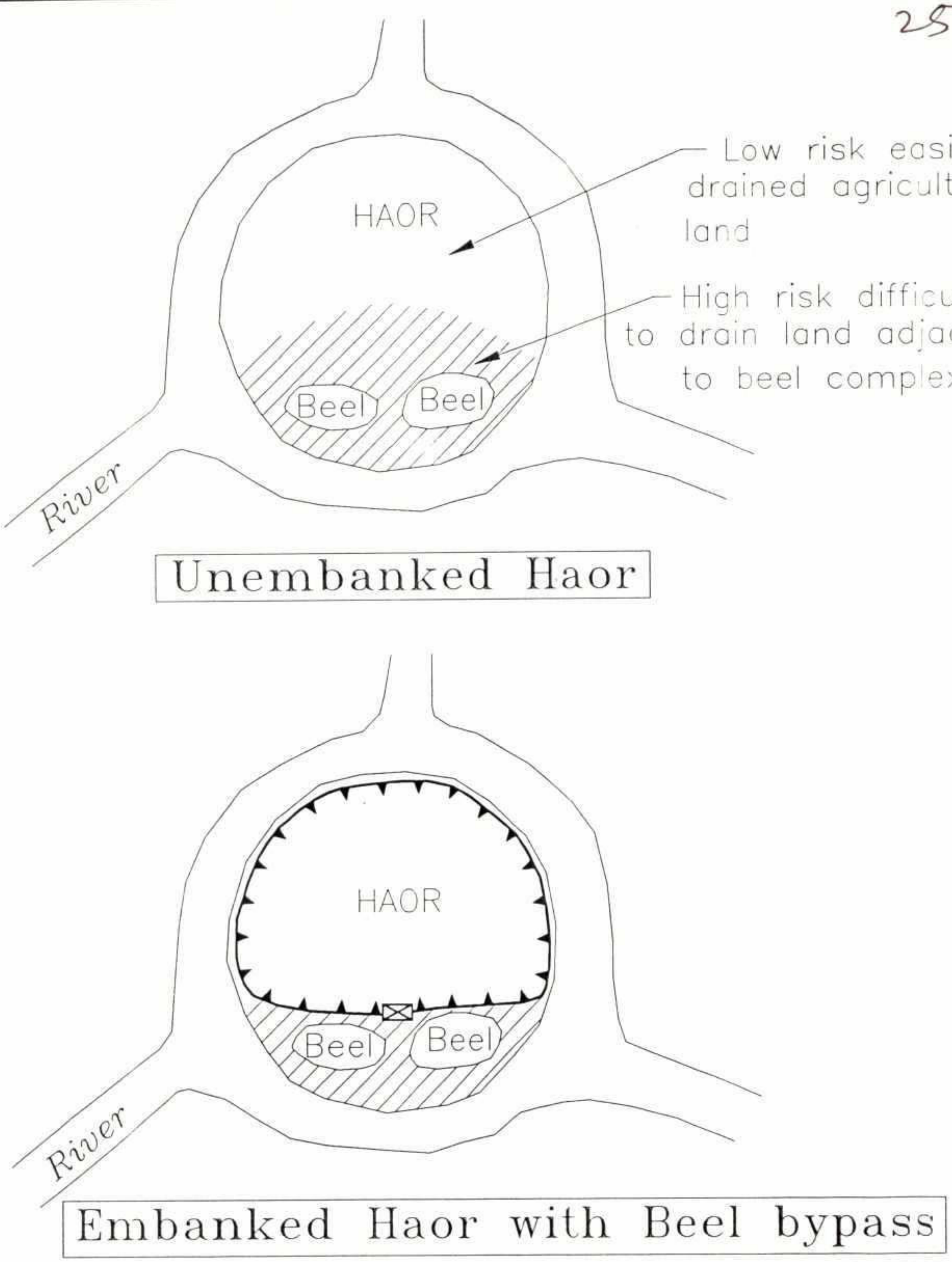
Various structural measures, both mitigative and developmental, were assessed for their utility to fisheries. The more promising are discussed below.

5.2.2 Beel bypass

A basic design criteria for FCD/I projects is the routing of the embankment. Normally the route follows river banks, and takes advantage of existing natural elevated river levees in order to reduce costs of earthworks (by minimizing earth volumes moved) and minimize encroachment and expropriation of agricultural plots. An alternative routing pattern which should be evaluated for possible application is beel bypass. Under this routing pattern, the embankment bypasses any major beels within the project area. In many haors, beels tend to be clustered in the lowest (ie "downstream") end of the haor. The land adjacent to the beel cluster is usually difficult to drain and therefore is high risk. Higher elevation kandha land is more easily drained, and thus of lower risk. Instead of locating the embankment along the periphery of the haor as is the usual practice, in a beel bypass scheme the embankment is built only around the higher elevation low risk agricultural land, and completely bypasses the beel cluster and adjacent high risk land. Thus the beels remain freely connected to the river system, resulting in unimpeded fish migrations for spawning. If the embankments are submersible, fish would get on to the low risk land in the normal manner of partial flood protection projects once the embankment is overtopped by the flood. Drainage regulators for the low risk embanked part of the haor should be located so they discharge directly into the haor cluster (rather than directly into the river). Because of land slope this would be their "natural" location in any case, and furthermore this prevents the scheme from creating new pockets of poor drainage on the low risk land.

As the high risk land adjacent to the beel cluster will now be <u>extremely</u> high risk, it can no longer be used for rice. It should revert back to natural resources utilization (apart from fish production, this would mainly include floodplain forestry, water fowl, and wild plant resources). As there would be a large increase in raw natural materials, presumably handicraft cottage industries which manufacture marketable products from natural materials could expand. This should provide the landless poor with more secure employment and higher incomes than high risk agriculture. Wild food products abundance would also increase greatly (even more if brought under managed semi-cultivation) and surplus could be marketed for cash.

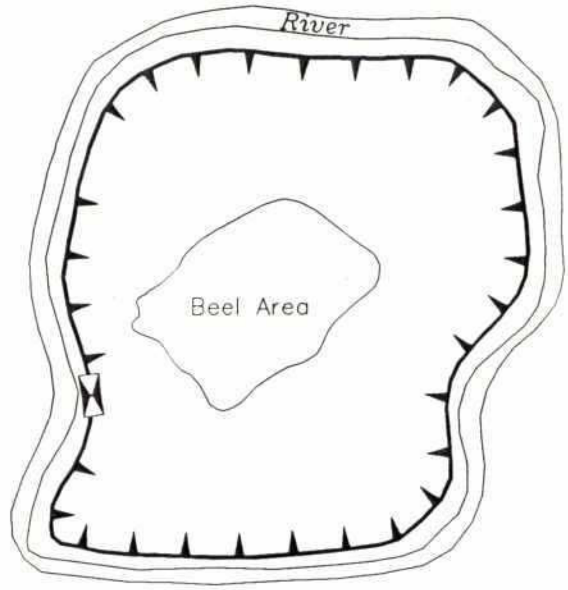
258



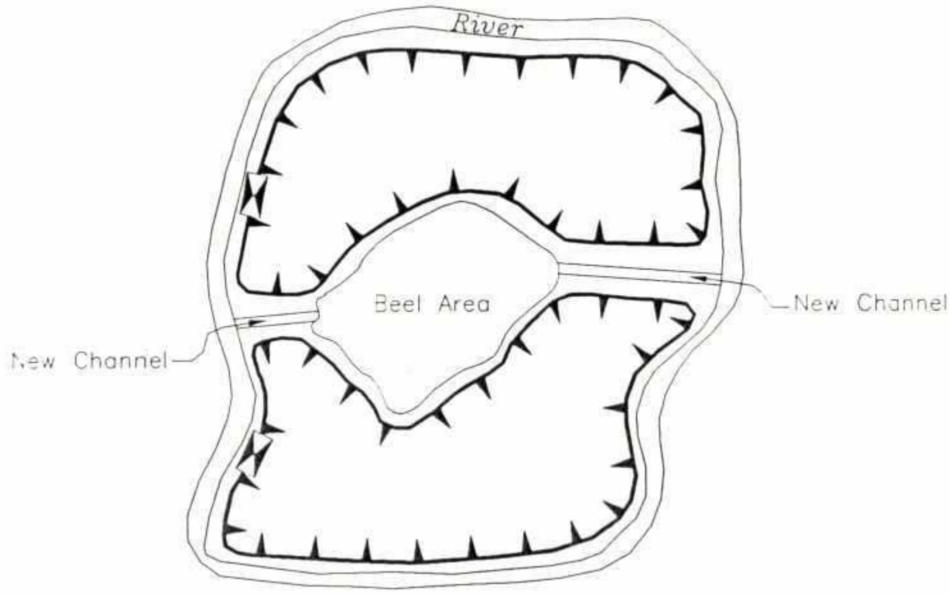
Northeast Regional Project	
Beel Bypass Scheme	
Prepared by: BNP/Mamun	April 1993

FILE: FISH-61DWG

Figure 66



NORMAL ARRANGEMENT
Embankment of entire area including beel



SUB-DIVISION OF PROJECT
Beel area connected to river system

Northeast Regional Project

Bypass of Beel Remote from the River

Prepared by:	BNP	April 1993
Drawn By:	Mamun	AutoCAD Drawing

FILE: FISH-58.DWG

Potential problems which may arise from beel bypass are as follows:

- Pre-monsoon haor drainage: In general after March there is no drainage from the haor to the outfall river as the water level of the outfall river becomes higher than that in the haor area. The haor 'drains' rainfall within itself to its beel areas which has been partially/fully emptied due to withdrawal for irrigation. To agriculture, the beel thus serves two purposes: supplies irrigation water when there is no rain, and absorbs excess rainfall-runoff when there is rain. Exclusion of the beel areas could lead to submergence of the protected crop lands.

- Sedimentation: Riverside beels outside of embankments will be more prone to sedimentation. Beels situated inside embanked areas are to some extent "protected" from excessive sedimentation.

- Remote beels: Not all beels are situated near the river bank, so beel bypass may not be a viable prospect for many haors. Attempting to include beels remote from the river (see text figure) will significantly increase embankment length and consequently increase the capital cost and maintenance cost of the project. Moreover, much crop land will be excluded from protection. Remote beels which have been bypassed may however be less subject to sedimentation than riverside beels.

The economic, social, and environmental implications of beel bypass need to be carefully evaluated. The outlook for fisheries and wild resources appears favourable. For rice production it would mean greater rationalization to eliminate potentially wasted effort on high risk land and instead focusing maximal effort and resources on low risk land to increase production vertically rather than horizontally. If fisheries could be brought under NFMP and the landless poor be given exclusive cropping and plantation rights to wetland natural resources, then the benefits to the poor would be substantial, and they would have a long term economic interest in these wetlands. They would no longer be "landless" but earn sustainable livelihood from wet lands that they have tenure to. Greater *boro* yields on low risk land might also mean increased yields of gleaned paddy to the poor.

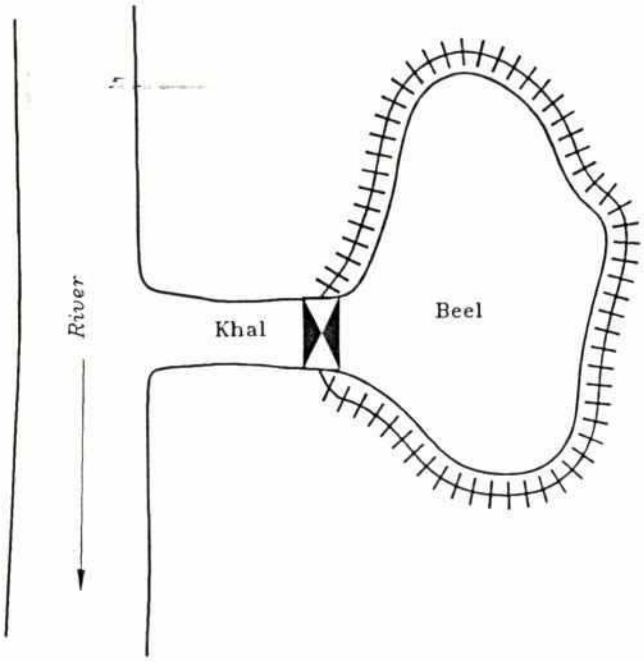
5.2.3 Beel embankment

Construction of an embankment or bund around a beel is an option that has been carried out at a number of beels in the region:

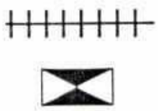
- Chatla Beel in Hakaluki Haor
- Boro Beel in Boro Haor
- Ruila Beel in Medhol Haor
- Rangamati Beel in Dekker Haor

The embankments have been successful in reducing the inflow of bed load river sediments during the monsoon and increasing dry season water retention. This option is apparently cost effective as embankment maintenance is carried out under local private sector initiatives. Ideally, a regulator needs to be provided which would be closed during the monsoon before flood recession begins (so as to maximize the volume of water stored in the beel during the dry season) and opened during the premonsoon to allow fish migrations to take place.

Figure 67



Structural scheme for transforming a seasonal bee into a permanent beel. Embankment material is excavated from tre beel and khal



Submersible Embankment

Regulator

Northeast Regional Project

Beel Embankment Scheme

Prepared by:	BNP/Jalal	April 1993

FILE: FISH-143.DWG

Constructing a low bund around beels might apply mainly to shallow seasonal beels which dry out completely during the winter months. A number of factors need to be taken into account. As a haor drains during the post-monsoon period, the residual water level (in beels) will eventually reach a contour which farmers will regard as a kind of dry-season benchmark. This water level is known as the lowest level of plantation (LLOP). When the monsoon flood water drains from haors, farmers start planting the *boro* crop in late December or early January. As the shoreline recedes towards the beel area, rice planting follows closely behind. Near the end of January farmers stop planting *boro* because if rice is planted any later it will not have enough time to mature before the next monsoon flood. Wherever the beel shoreline is located at the end of January is regarded as the LLOP. Once LLOP is reached, the regulator gate is shut because farmers want to conserve the water stored in the beel for irrigation of *boro* in February or March, as without this mid-season irrigation yields will be lower. The shutting of the gate, therefore, physically sets the LLOP beel water level, as well as the volume of water stored in the beel for subsequent use for mid-season irrigation.

The LLOP level can be regarded as the maximum beel water level acceptable to farmers cultivating *boro*. Beel water level will of course continue dropping due to evaporation, but the rate of drop will be very slow in comparison to the rate of drop before the regulator gate was shut (when the fast rate of drop was due to gravity drainage through the khal and regulator). From the farmers' point of view keeping the beel water level as close to LLOP is of the greatest importance up until the time when the stored water is actually used for irrigation.

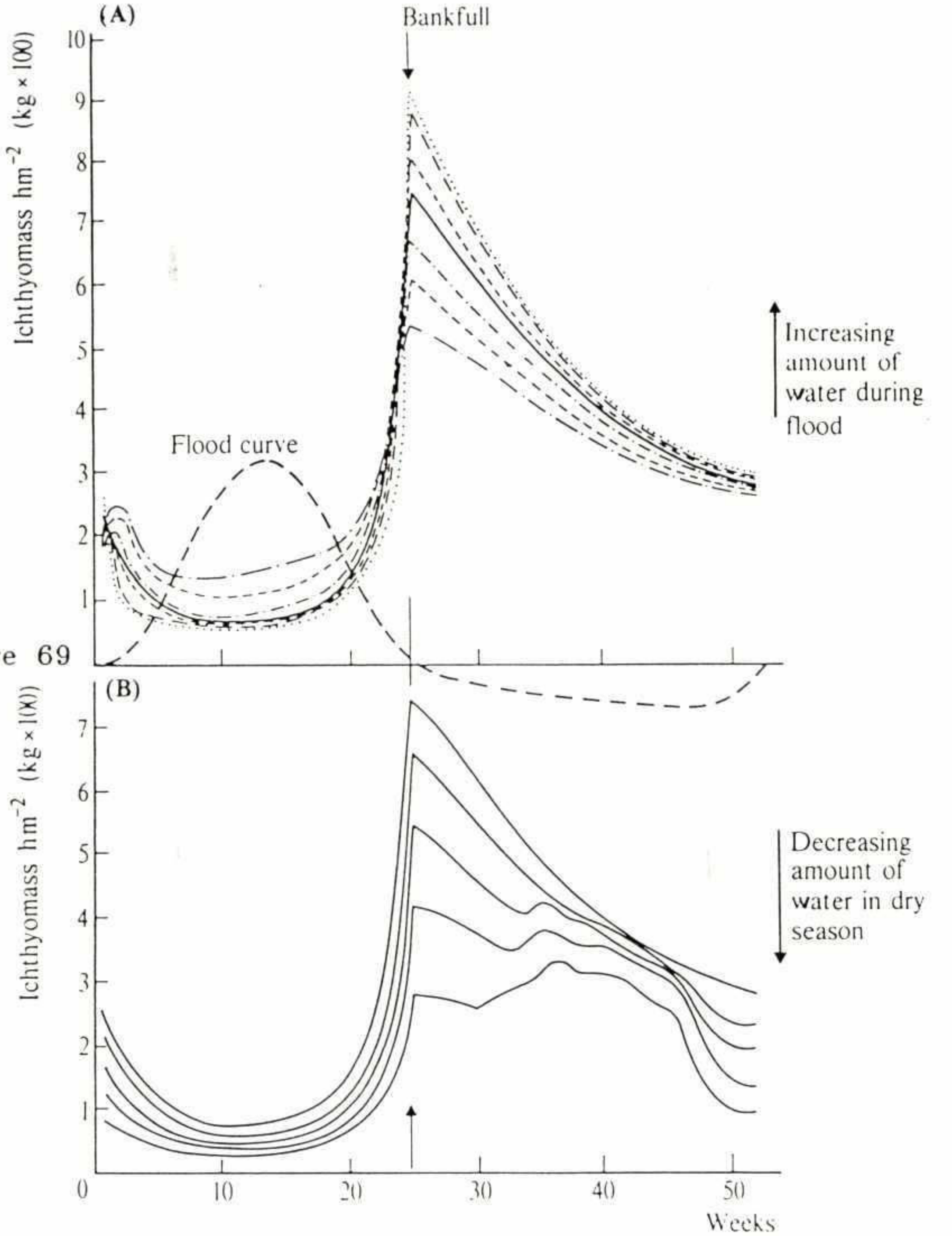
There are three general groups of *boro* farmers inside a haor, distinguished mainly by the distance of their plot from a beel. The "inner" circle of farmers (such as those up to about a 0.5 km radius form the beel) do not require mid-season irrigation at all because of the high residual moisture in the soil (and possibly high ground water levels near the beel). So they have no water demand, and accept the LLOP water level benchmark only in so far as they are at the very temporal limit of the *boro* growing season. The "middle" circle of farmers (ie those between 0.5 and about 1.0 km from the beel) need to irrigate if they want high yields and they do so in February or March using swing baskets and *dhoons* to tap beel water. Both the "inner" and "middle" circle of plots obtain yields between 1 and 1.5 t/ha. The "outer" circle of farmers cannot irrigate with beel water and their plots may yield only 0.8- 1 t/ha.

From a fish biomass production viewpoint, maintaining beel water level at the highest possible level throughout the dry season would be the optimal state of affairs. From the "middle" circle farmers point of view, this conflicts with the need for mid-season irrigation. If the irrigation water demand is high and LLOP storage volume small, it is likely that the beel would be pumped dry. Fishermen then would have the opportunity to do a total fish harvest. If storage volume exceeds demand, the residual water left in the beel would continue to function as a fish overwintering habitat. Leaseholders might still want to drain the beel completely (although this is destructive of the fishery resource), but this might only be possible by opening the regulator gate, and farmers would probably vigorously oppose this because of the risk of crop damage.

263

Figure 68

Figure 69



Computer generated curves showing changes in population density (kg/ha) with time for different flood regimes where: (A) the low water regime is constant and the high water regime varies; and (B) the high water regime is constant and the low water regime varies. Also shown is a typical water regime (-----). (After Welcomme and Hagborg, 1977)

Figure 70

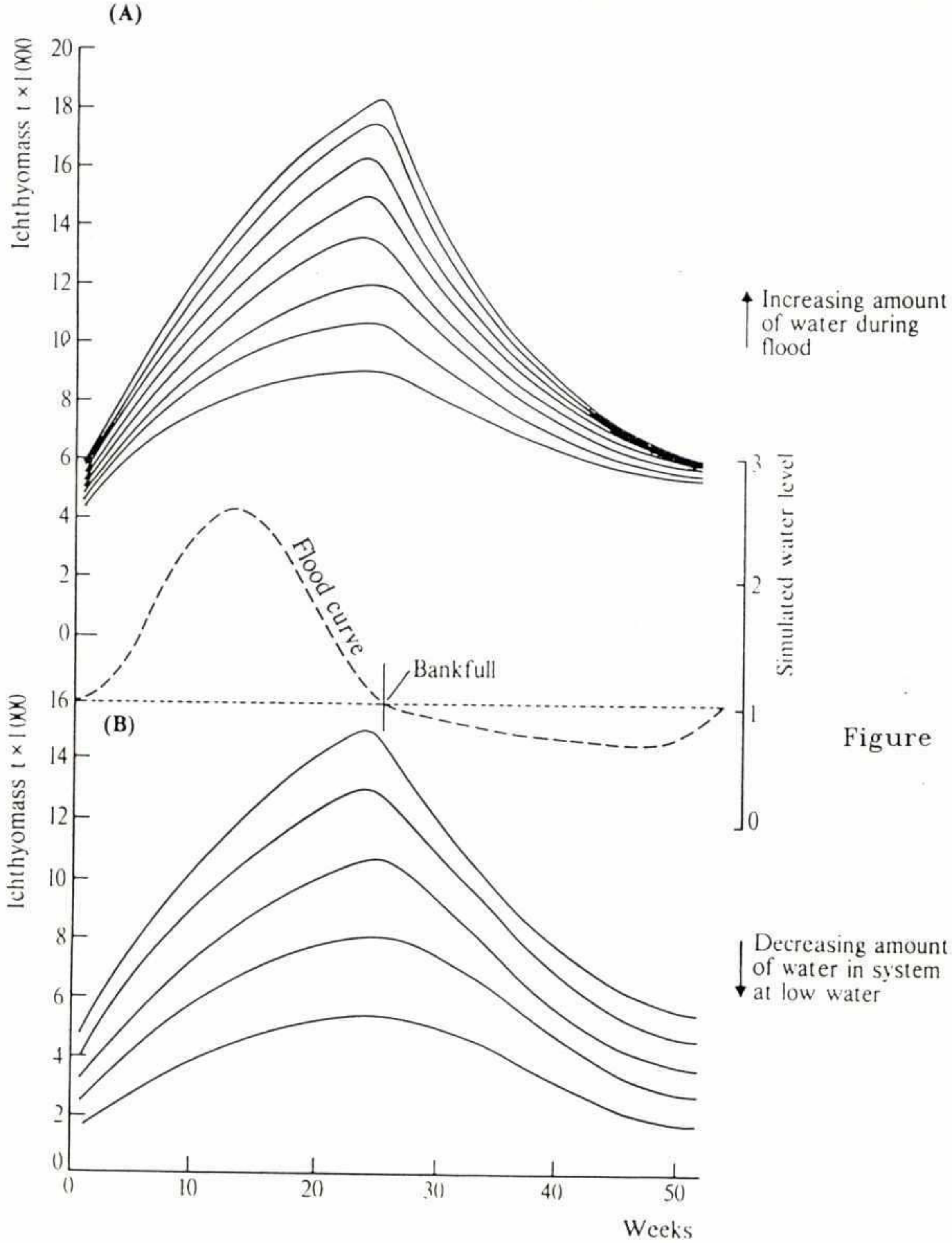


Figure 71

Computer generated curves showing changes in total ichthyomass with time for different flood regimes where (A) the low water regime is constant and the high water regime varies; and (B) the high water regime is constant and the low water regime varies. Also shown is a typical water regime (-----). (After Welcomme and Hagborg, 1977)

Farmers would like to have available to them as much beel water as possible to ensure adequate mid-season irrigation, but the area where the water is stored (ie the beel) is defined by the LLOP (so as to maximize potential rice land hectarage). If the volume of water defined by the LLOP is less than the irrigation demand, then there would appear to be only three options for solving the irrigation water deficit problem:

- pumping in river water;
- tube wells;
- increasing the storage volume within the LLOP area by a vertical expansion — either downward by excavation or upward by bunding, or both.

The first two options are straightforward and already in general use, but the third is not. Excavation would seem to be not impossible if the beel is drained completely or even partially, and the excavated earth could be used to build the bund. The bund would act as a definite physical boundary around the beel, which has its own intrinsic value because it indisputably separates rice production from fish production spaces. Planting trees (*hijal, koroch*) on the bund would also seem appropriate, and would create a vested economic interest for the owner of the plantation to maintain it and the bund. The increased storage volume of the beel could convert it from seasonal to permanent status, or at least, if it remains seasonal, supply a greater volume of water for irrigation.

One feature of beel bunding which directly benefits fisheries is what happens after irrigation water has been extracted in February and March. The partially or totally drained beel will now have vacant unutilized water storage capacity. In April rivers will start rising and spilling into haors. Fish will begin migrating, some species into the haor, and other species out of the haor. Given the existence of vacant water storage volume in a bunded beel contained within the designated LLOP area at this period in time, it should be possible to let river water flow into the bunded beel (via the regulator or a fishpass) up until the full storage volume of the bunded beel is reached, and then shut the regulator gate. This would create a "window" for pre-monsoon fish migration and at the same time not endanger the *boro* crop.

A beel bund could be constructed using excavated material from below the LLOP. A slower approach is to induce the natural formation of a bund by planting several rows of *hijzal, koroch* and other inundation resistant trees around the beel at the LLOP. This approach is based on the following factors:

- The finest soils (clay with raw alluvium) are to be found in the deepest part of the haor around beels. The coarsest soils (loamy soils mixed with sandy and silty alluvium soils) are found alongside the river bank. In between, on the higher land of a haor are found soils of intermediate coarseness (silty clay loams and clays). This suggests that there is a general process of migration of sediment from the riverbank area down the haor land gradient toward its deepest points (ie beels), and only the finest particles reach the beel area.

- In a haor where almost all the land has been cleared for paddy cultivation, this process of fines creep migration would be much accelerated.

- Local people note that wherever a grove of *hijal* is planted, the trees induce the build up of higher land immediately around the grove.

This suggests that rows of *hijal* planted around a beel would naturally induce the formation of *bunds*, thus achieving the objective of *bunding* beels with no construction costs, and make excavation unnecessary (although excavation might still be desirable if maximizing the beel's storage volume is an objective).

The problems of such an approach might be:

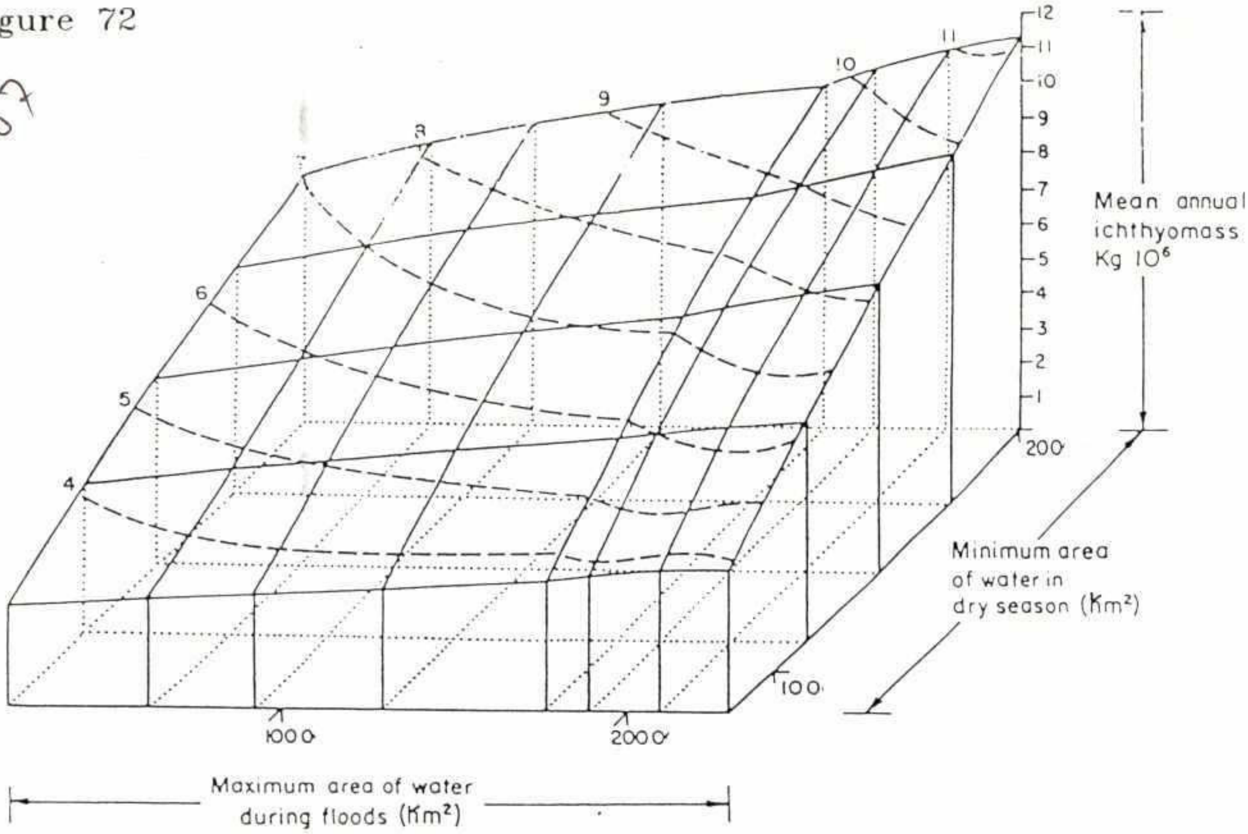
- The length of time for the *hijal* to grow and the *bund* to form might be in the order of a decade;

- Local farmers might not agree on the location of the LLOP, because once the *hijal* are planted and the bund begins forming, the LLOP will become permanently fixed. Currently, the LLOP shifts up and down from year to year depending on the pattern and timing of flood recession, risk assessment and other factors. However, planting near LLOP is high risk and is often on khas land. If the benefits to be had from increased water availability for *boro* irrigation (and there is often not enough) are seen to outweigh the bit of extra land that can be cultivated in some years (because the relevant factors points to setting LLOP at a lower elevation that year), then the farming community may be expected to support *bunding* and *hijal* fencing.

An additional possible benefit that could be considered under this idea is planting reeds (*nolkhagra*) on the beel side of the *hijal* fence/*bund*. This plant has economic value for domestic homestead structures (such as fencing and wave protection) and as furnish for the Chhatak pulp mill. It also enhances the environment for fish production. Furthermore, the *hijal*/bund could also extend along both sides of the khal which connects the beel to the river. This might increase its storage capacity and make it more useful for navigation during the dry season.

Figure 72

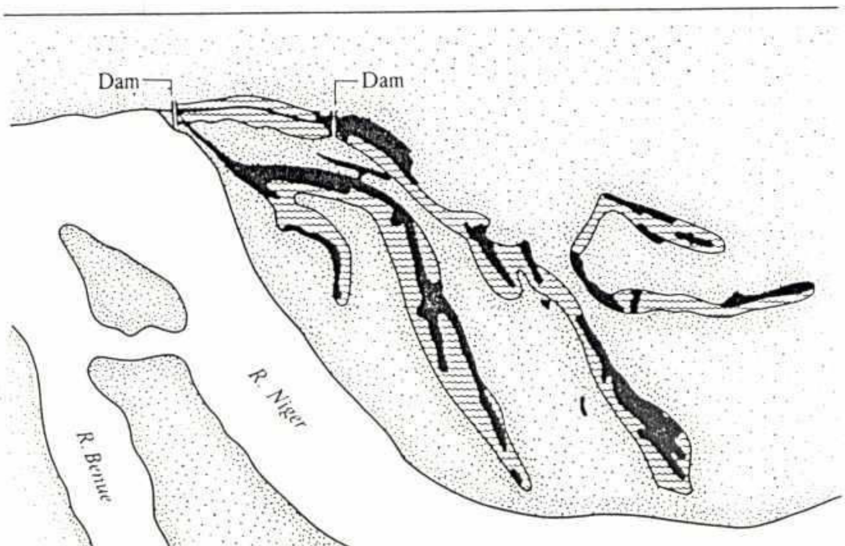
267



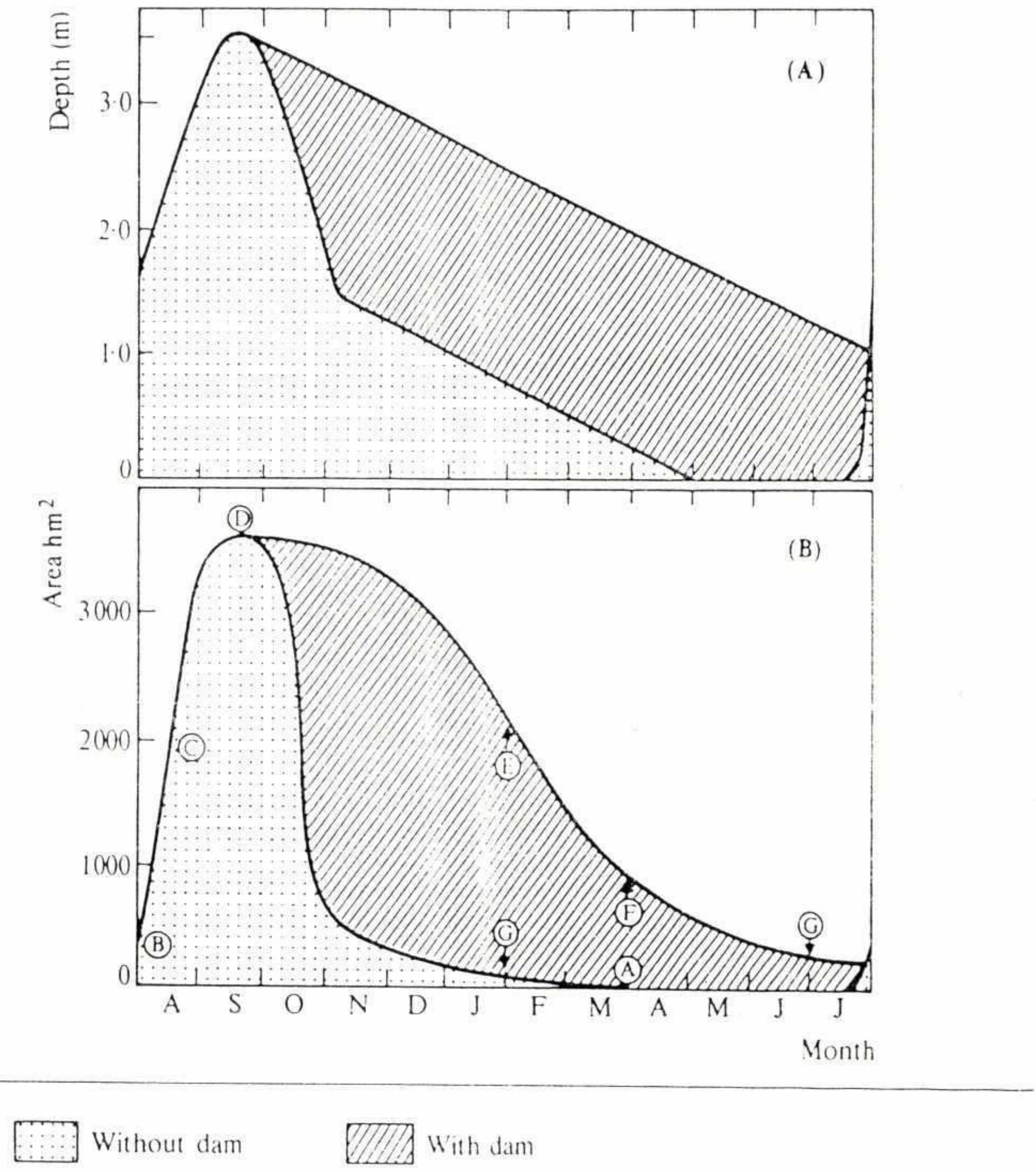
Three dimensional plot of mean annual ichthyomass as related to water regime. Dashed lines join points of equal ichthyomass on the derived surface.

From: Welcomme and Hagborg (1977)

Figure 73



Tracing from aerial photograph of the Niger floodwater retention dams, showing the original water area and the area flooded after the placing of the dams. (After FAO/UN, 1969a)



Difference in changes in (A) depth and (B) area of a floodplain pool before and after damming of the main access channel. Encircled letters refer to individual illustrations in Figure 1.8

269

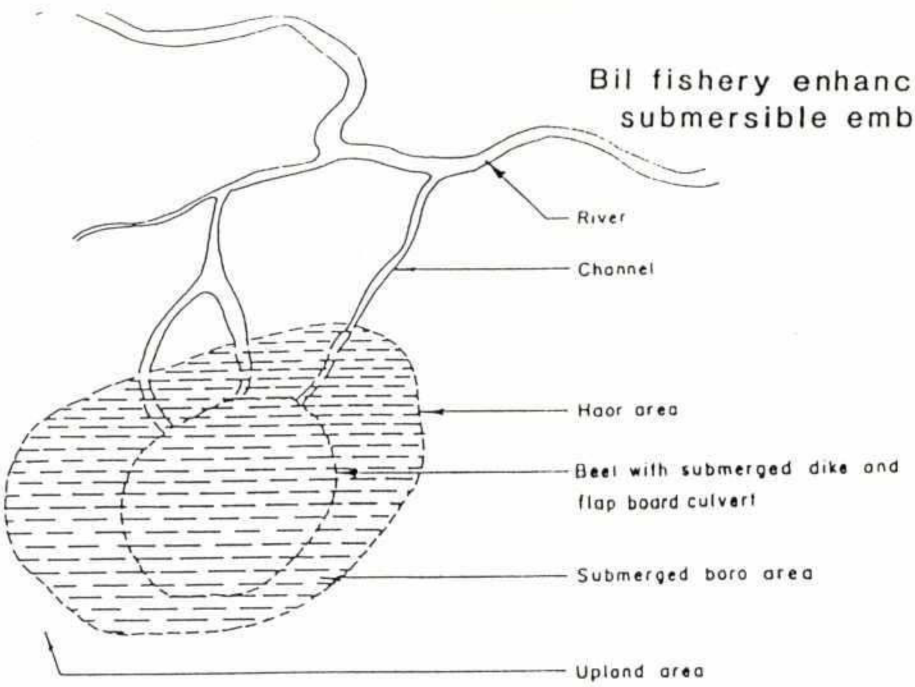
Theoretical studies and computer modelling suggest that losses in floodplain fish production due to a decrease in mean area flooded (the result either of lower rainfall/river discharge or FCD/I projects) can be recovered by increasing the water area/volume stored on the floodplain during the dry season in beels. This is because the magnitude of fish production during the annual flood period is sensitive to the amount of water remaining at the end of the dry season in refuge habitats (beels, khals, rivers). More specifically, the size of the broodstock population that survives the dry season to spawn during the premonsoon is determined by the quantity of water residual on the floodplain during the dry season. It is reasonable to assume that carrying capacity during the dry season of larger beels is probably higher per hectare for both biomass and number of species than smaller beels.

The effect of increasing dry season water hectarage may be illustrated by the following example. A floodplain having a mean flooded area of 2,000 sq km and a dry season water area of 100 sq km would be expected to have a mean annual ichthyomass of about 5,400 tons. If the mean area flooded is reduced by 50% to 1,000 sq km (but the dry season water area remains constant), the mean annual ichthyomass would decrease to 4,500 tons. In theory, the lost ichthyomass of 900 tons could be recovered by increasing the dry season water area to 120 sq km. Thus, a mean ichthyomass loss of 17% caused by a 50% reduction in mean area flooded could in theory be mitigated by a 20% increase in dry season water area. This assumes of course that the lost flooded area does not include any mother fisheries or crucial spawning grounds of long distant migrants such as major carp (or at least that their loss is in proportion to their contribution to overall fish production).

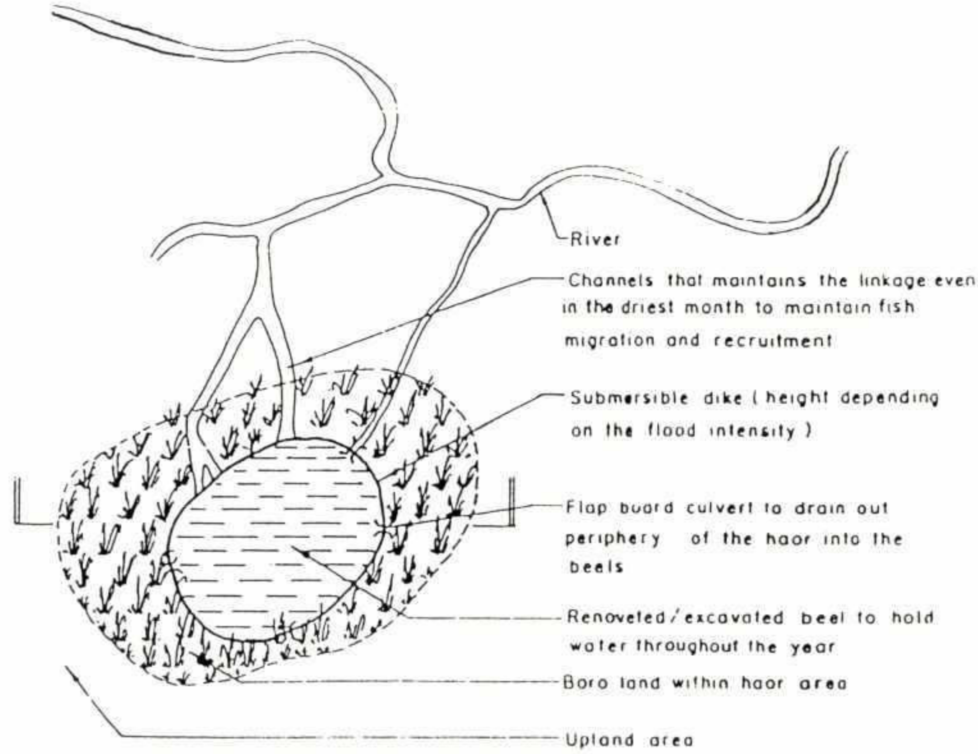
Actual fishery yield of a floodplain with a mean flooded area of 2000 sq km would be predicted by Welcomme's floodplain fish production equation to be about 8,800 tons (Section 2.5.3). Reducing mean flooded area to 1000 km^2 would reduce fish catch by 50% to 4,400 tons. Because of the rapid turnover of the *Chotomaach* stocks and the high fecundity of *boromaach* broodstock, the annual fish catch of a floodplain is greater than mean annual ichthyomass by a factor of 1.63. Thus, small increases in dry season water area (ie 20%) will result in only approximately equal increases in mean annual ichthyomass (17.%), but this will boost fish catch by much larger amounts (50%), so that production losses due to large decreases in mean area flooded (50%) can be fully recovered. Thus, relationship between catch and mean area flooded is approximately linear, but the relationship between catch and dry season water area (as a percentage of mean area flooded) is not linear. Increasing dry season water area is, therefore, a highly efficient approach to recovering losses of fish production caused by FCD/I-induced reduction in floodplain area because, in theory, a moderate increase in dry season area can compensate for a large decrease in maximum area flooded during the inundation period.

One approach to increasing dry season water area is to build retention dams across the main outflow khals. This results in a significant increase in water depth and area (and therefore volume) during the dry season. In Bangladesh, however, such an approach is not feasible, since it would increase the amount of land that remains flooded (regarded by farmers as a "drainage" problem). Practically the only approach that might gain acceptance under the constraint imposed by agriculture in the region (maximum area of dry land during the crop growing season) would be to increase dry season water storage volume without simultaneously increasing dry season water area. This could be accomplished by excavating beels and/or building bunds or embankments around beels. This would increase the storage volume of permanent beels and transform seasonal beels into permanent beels.

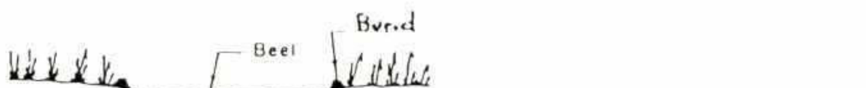
Bil fishery enhancement by submersible embankments



Conceptual picture during mid May through November: Water in the entire haor



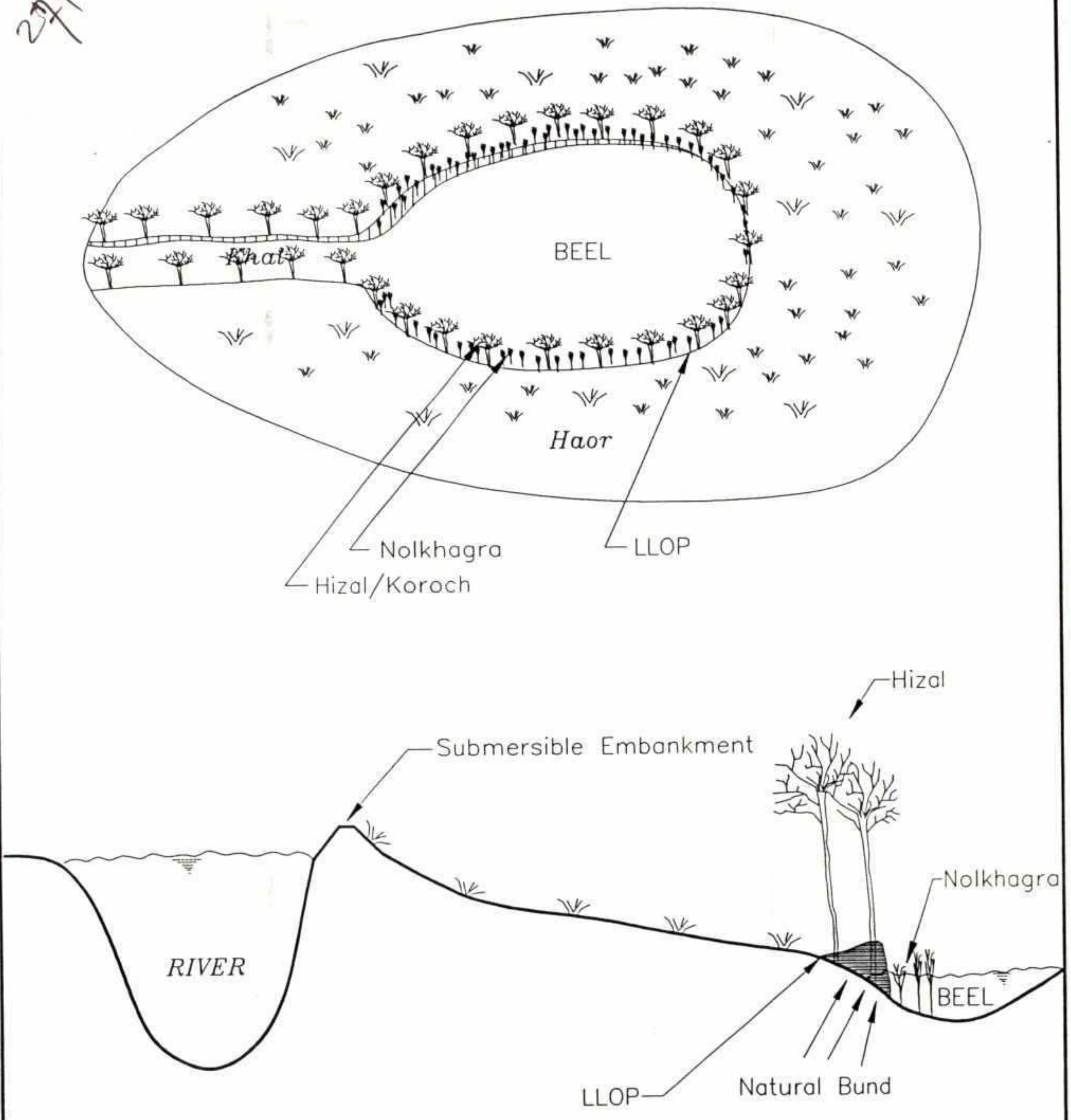
Conceptual picture during late November through before flood: Water only within the beel



C.S OF THE BEEL

From: NWHC/SAL (1986)

Figure 76



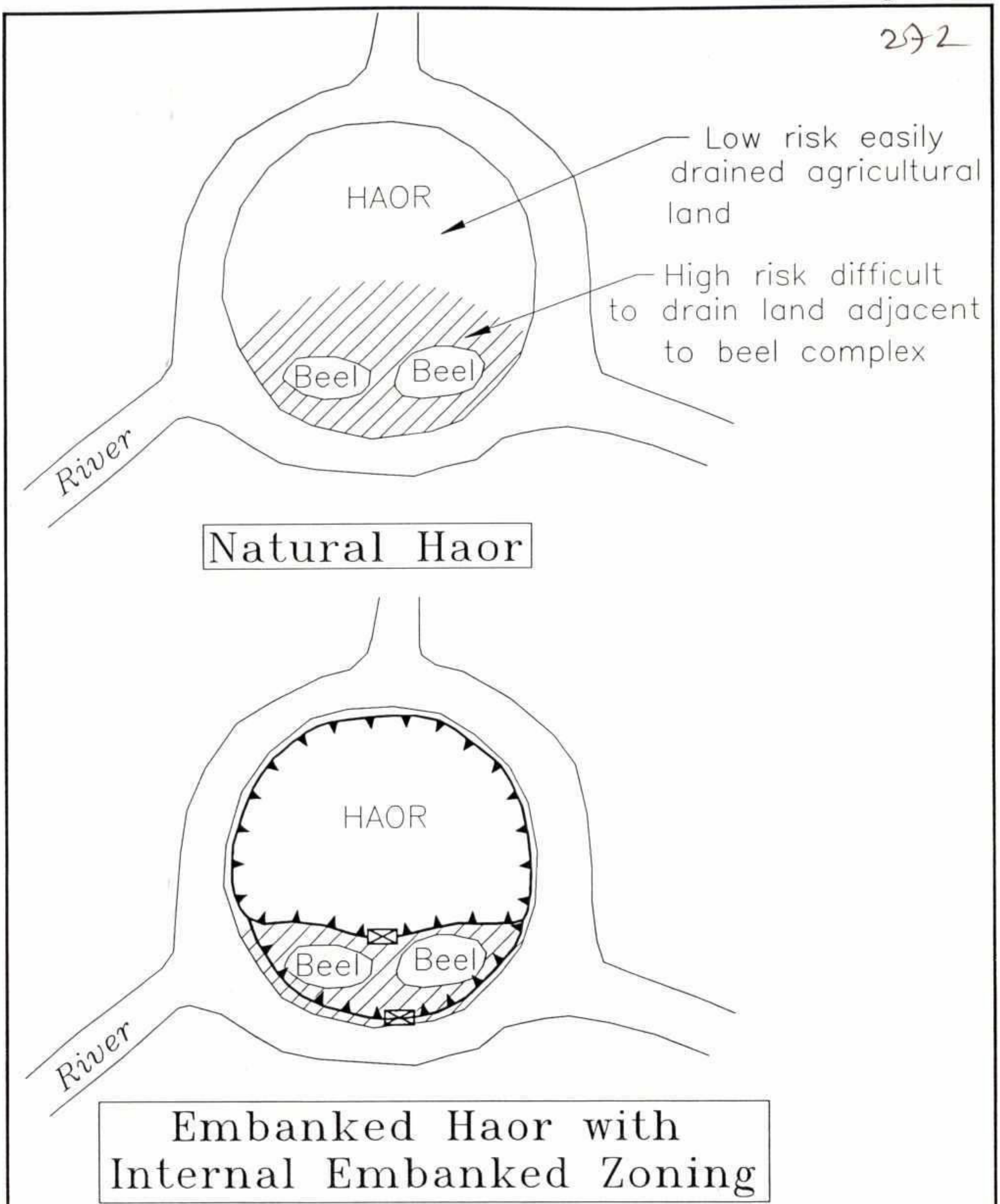
Northeast Regional Project

Example of Bund around Beel and along Khal with Hizal,Koroch trees & Nolkhagra Plantation

Prepared by: BNP/Jalal April 1993

FILE: FISH-126.DWG

272



Northeast Regional Project

Haor Zoning Scheme

Prepared by:	BNP/Mamun	April 1993

FILE: FISH-62.DWG

273

5.2.4 Haor zoning

A more complicated multipurpose approach to creating high producing fishery environments inside FCD/I projects is haor zoning. The concept is basically about subdividing haors into wetland and dryland zones which would be physically separated by an internal embankment. Regulators and drainage vents would be set into the peripheral and internal embankments so that the hydraulic operation of each zone could be managed separately so as to suit the differing needs of fisheries (in the wetland zone) and agriculture (in the dryland zone). From the fisheries perspective the objective would be to realize the potential benefits of beel bypass (easy access between beels and rivers for migrating fish stocks), as well as beel embankment (to maximize dry season water storage volumes in the beels, so as to increase the size of the dry season broodfish population). Haor zoning could also be extended to provide sub-zones allocated to livestock grazing and forestry/tree culture. Seasonal flooding of the wetland zone could also contribute to controlling flooding in the main rivers by means of peak-lopping. This concept could effect the transformation of the region by restoring its ecological balance and stimulating its economy.

The disadvantages of the haor zoning are:

- An increased length of embankment with higher capital costs and more maintenance work.
- Extra capital costs in excavating the inlet and outlet channels. Sediment may be deposited in the channels thus requiring an on-going programme to keep the channels open.
- Increased land acquisition for the approach channels and extra embankments.

The advantages of the scheme are:

- The beel system does not become delinked from the river network. Hence an improved fish habitat is provided during the critical dry season months.
- The operational aspects of the project are not made more complicated by additional gated structures.

The zoning of haors in this manner will likely only be economically viable for the larger schemes (for example, Pagner Haor, Deker Haor, Dharmapasha Rui Beel).

APPLICATION OF HAOR ZONING AT MANU RIVER IRRIGATION PROJECT

In order to give some focus to the haor zoning concept its potential application at the Manu River FCDI Project may be conceptualized. This project already has more infrastructure already in place than any other project in the region and, in addition, it has already experienced every problem that one of these projects can fall prey to. The basic hydraulic problem is overloading of the pumping station, caused by:

- apparently unplanned-for runoff into the project area from the Battera Hills,
- overtopping of the embankment running parallel to the Manu River,
- excessive input of irrigation water.

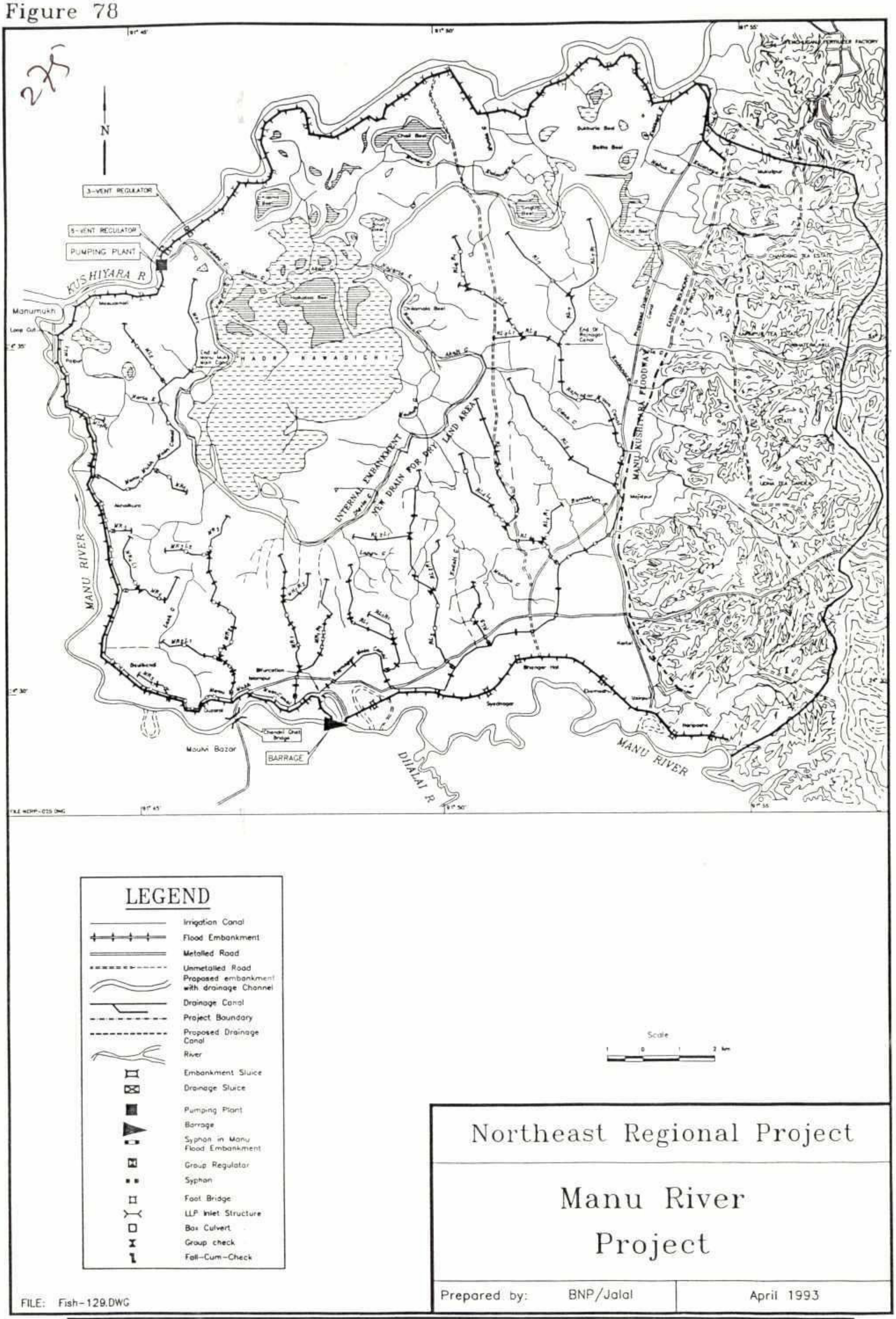
and solvable by:

- constructing an internal embankment to separate the lowest-lying lands from those served by the existing gravity irrigation system. The lowest-lying lands would then be operated as a wetland with Kushiyara River water flowing in and out through the existing 3-vent regulator. The higher lands would be operated as a dry land with Manu River water injected for irrigation as required via the existing barrage intake, and extracted via a new drainage channel running parallel to the internal embankment (and formed from its borrow pit) and leading to the existing 6-vent regulator and pumping station.

With these new works in place the area north of the internal embankment could be operated primarily as a fishery with floodplain forestry and water fowl sanctuary as additional important benefits. The area south of this embankment could be operated primarily as an irrigated agricultural zone producing up to 3 crops a year because of the total control of water made possible in this zone.

There are, of course, many variants of this basic scheme which could be considered, and of which one may offer the greatest benefit. For example, the southeastern stretch of the internal embankment could be located further to the northwest so as to exclude lands lying between Kawadighi Haor and the Digola River from the wetland zone. These lands would then lie in the dryland zone but would not readily be irrigable without expensive extension of the existing irrigation system, and might best, therefore, be used as a livestock grazing ground. Lands lying on the right bank of the Rajnagar Main Canal might also best be used for livestock grazing.

Figure 78



N
3-VENT REGULATOR
5-VENT REGULATOR
PUMPING PLANT
KUSHIYARA R
Manumukh
Loop Cut
HAOR KAWADIGHI
INTERNAL EMBANKMENT
NEW DRAIN FOR DRY LAND AREA
MANU KUSHIYARA FLOODWAY
MANU RIVER
Mouvi Bazar
Chandni Ghat Bridge
BARRAGE
DHALAI R
MANU RIVER
LEGEND
Irrigation Canal
Flood Embankment
Metalled Road
Unmetalled Road
Proposed embankment with drainage Channel
Drainage Canal
Project Boundary
Proposed Drainage Canal
River
Embankment Sluice
Drainage Sluice
Pumping Plant
Barrage
Syphon in Manu Flood Embankment
Group Regulator
Syphon
Foot Bridge
LLP Inlet Structure
Box Culvert
Group check
Fall-Cum-Check
Scale
1 0 1 2 km
FILE: Fish-129.DWG
Northeast Regional Project
Manu River Project
Prepared by: BNP/Jalal
April 1993

5.2.5 Compartmental Bunds

The construction of compartmental bunds inside haors is gradually becoming a component of FCD/I projects. These structures are of low elevation (circa 1-1.5 m) and are intended to contain flood or rain water within the compartment for irrigation and prevent wider crop damage inside the haor. An unintended result is poor drainage of the compartment during the post-monsoon and dry season, since farmers whose plots are located next to a flooded compartment and whose crops are not affected will oppose cutting of the bund. Poor drainage during the dry season promotes growth of dense aquatic macrophyte stands and wetland grasses (*Paura bon*), which can cause land clearing problems for farmers at a later date. Although the paura bon results in more fish production, low water quality also promotes outbreaks of ulcerative fish disease. All thing being equal however, the extension of the number of hectare-months of inundation caused by compartmental bunds realizes some increase in fish production.

5.2.6 Fishpasses

Fish need to be able to bypass embankments to carry out migratory phases of their life cycles.. Submersible embankments can be freely bypassed once they are overtopped, but at other times they can only be bypassed via the project's hydraulic structures(s) and/or by public cuts. The latter applies to full flood control embankments at all times. There are six types of hydraulic structures which, when open, allow the flow of water past an embankment or into a project area (and thus provide some opportunities for fish to do the same). These are:

- hydraulic regulator with fall-boards,
- hydraulic regulator with vertical lift gates,
- hydraulic regulator with flap gates,
- river barrage,
- drainage pipe sluice,
- irrigation inlet

All of these structures are purpose built to serve agricultural needs, and none have special features to increase their fisheries efficiency, or serve the needs of navigation. If existing structures address any valid fishery needs at all, it is by default only, and generally very poorly at that. In fact, flushing in river water through regulators is being practiced in some projects not to assist spawning migrations, but rather to catch large quantities of broodstock. Some public cuts are done to catch fish.

There are several options for providing fish pass facilities in FCD/I projects:

- relying on existing hydraulic structures to give passage to migrating fish (with perhaps some modification of structure operation to increase its fisheries efficiency),

- relying on public cuts to give passage to migrating fish,

- installation of appropriate purpose-built structures designed only for fish migration,

- modifying the design of hydraulic structures so that they are also highly efficient in giving passage to migrating fish (ie make them multipurpose),

- installation of navigation gates, and relying on them to give additional passage to migrating fish.

None of these options is problem-free, and no single option is likely to be completely successful. Under a multipurpose project planning approach, the criteria for fisheries must be integrated and made compatible with criteria for agriculture, navigation, and perhaps other sectors and needs. Each of these options is examined below.

Hydraulic structures

The poor fisheries efficacy of existing hydraulic structures in FCD/I projects is due to the design and the rules governing their operation. It is however also clear that existing gates do not function well even for agricultural objectives, and therefore the 'regulator gate problem' in the region is a more general problem which extends beyond the sectoral interests of fisheries. It follows that improving the performance of existing gates for agricultural objectives might also result in marginal gains for their fisheries efficiency. The principal agricultural criteria that the design and operation of these structures attempts to meet are as follows:

- In full flood protection projects, the hydraulic structures must keep out excessive river flood water at all times, permit controlled inflow of river water for irrigation as required and drain out excess rain water.

- In partial flood protection projects, the hydraulic structure must keep out river flood water up until about 15 May to allow the *boro* rice crop to be harvested. It must also allow the haor to drain as quickly as physically possible to allow planting of the *boro* crop. It must furthermore protect against unseasonal flash floods during the winter dry season.

Normally the hydraulic regulator would be situated across that khal which drains the lowest elevation beel in a haor (although other criteria might dictate another location). Two or more regulators are installed in some project.

<u>Regulators with fall-boards</u>: This is the simplest type of main hydraulic regulator, but it does not function particularly well. The guides slots in the structure may not be set square. As a result, it is difficult to get fall-boards in and out of the slots. Fall-boards are sometimes of very poor design and material, so much so that they are unlikely to survive for long even if the guide-slots are not skewed. Furthermore, operators who have to put them in, and take them out, may not have any tools to do the job other than their bare hands. Fall-boards can often not be found when needed (having been stolen by village people). During unseasonal floods, they may be difficult or impossible to insert due to the force of the flood water passing through the regulator opening. One criterion of a fish-friendly or fishery efficient structure is that it is one which fish can pass through without suffering physical damage. Fall-boards do not meet this criterion. When flooding of the haor on 16 May is begun it is only possible to remove the top few boards and this produces a high energy turbulent waterfall behind the regulator which can damage or kill fish fry being swept into the haor. Furthermore no fish attempting to migrate out of the haor will be able to ascend the waterfall. Fall-boards also leak profusely when hydraulic head is high (before 16 May) and framers construct earthen dams across khals to keep leakage water away from the lowland crops.

<u>Vertical lift gates</u>: A common steel gate is the vertical lift type. Steel gates have been identified

as a solution to the leaking, sticking fallboard problem. Steel gates allow opening and closing of regulators against virtually any hydraulic head, and they do not leak. The main problem with vertical lift gates, apart from high cost, is lifting them. Guide-slots must be set square if they are not to jam, and sediment must not accumulate against them when closed; either of these problems can render the gate practically immovable, and they are responsible for early failure of almost all screw-type lifting mechanisms through shearing-off of lifting screws). At present, power hoists are out of the question at most sites because there is no electricity supply. The vertical lift gate is slow to operate if electric power is not available. Sedimentation against the gate while closed often gives rise to a substantial cohesive force on the gate which is difficult to estimate and is usually ignored by designers; as a result the load on the lifting screw exceeds its design load when lifting is attempted, and the screw shears. The design and operation of steel gates becomes complicated if fisheries criteria are taken into consideration. During the premonsoon floods some species need to swim from the river in to the haor, while other species need to swim from the haor out to the river. During the premonsoon, partially opening a vertical lift steel gate results in a high velocity venturi undershot inflow of water. Fish could get passively swept from the riverside into the haor (although fish try to avoid being passively swept anywhere), but no fish will be able to swim against the venturi from the haor into the river. This means that all the major carp and large catfish broodstock present in the haor will be unable to swim to the river.

<u>Flap Gates</u>: These gates open and close in response to the pressure gradient across the structure. They tend to open fully only when the gradient is large, and slam shut as soon as the gradient is reversed. Under zero gradient, which will prevail much of the time, they remain closed. Thus, they do not easily meet fishery efficient or fish friendly criteria of easy access when migrating fish require it.

<u>Irrigation Inlets</u>: These structures are not often fish friendly. They may be designed to convey river water directly onto paddy fields for supplementary irrigation during the monsoon, often under high hydraulic head. As there is no tail water on the country side an impact type energy dissipator is usually provided. Any fish getting into the structure will be killed by hitting the energy dissipator.

<u>Gate Operating Rules</u>: Gate operating rules are not an appendage to successful project design, but is the basis for it. The rules have to be simple enough for the *khalashi* to follow, and for farmers, fishermen and boatmen to see why they should comply with them. They also have to be consistent with the requirements for flushing and draining the haor for agriculture, facilitating fish migrations (as opposed to fish harvesting) and facilitating in-haor navigation. The same rules should apply at all structures (regulators) within a given haor. Since the agro-hydraulic regimes within each project are unique, these operating rules need to be developed on a case-by-case basis.

Public Cuts

Public cuts fall into the category of fish bypass structures. Because they are far more numerous than hydraulic structures, it is reasonable to assume that they are currently the most important manner in which fish bypass embankments in the region other than swimming over submerged embankments. Public cuts should not be seen as a sabotage problem (such as a defeat of the planned purpose of an FCD/I structure), but as an attempt by local interest group(s) to modify the operation of a FCD/I structure so that it is more compatible with their needs. The location and motivations behind public cuts must be carefully studied and evaluated, and where feasible incorporated into permanent structures. Public needs are often more complex than what the FCD/I planning process chooses to respond to. In the haor basin public cuts are mostly made for navigation for the simple reason that FCD/I projects are not equipped with navigation gates. Fisheries cuts are usually made with the objective of catching migrating fish, and are not concerned with assisting reproductive migrations. It should be possible to make embankment cuts specifically for fisheries, supervised by the DOF. Such DOF-supervised fish migration cuts would be in strategic locations (such as deep khals blocked by embankments). This represents an immediate non-structural "fix" to the fish bypass problem for submersible embankments. DOF would be responsible for guarding the cut until the embankment was overtopped in June and then filling in the cut in January.

Fishpass Structures
To form an approach to providing structural fish bypass facilities at FCD/I projects, it is necessary to examine the various requirements of floodplain fish:

- During the early premonsoon, broodstock of major carps, *Chital, Air* and *Baghair* require access from floodplain beels to rivers. *Boromaach* broodstock attempting to migrate in the opposite direction (from rivers to floodplains) are *Boal* and *Ghonia*. Various *chotomaach* species migrate in one or the other direction.

- During the late pre-monsoon, fry of major carp being passively swept down rivers from the spawning grounds need access to floodplains.

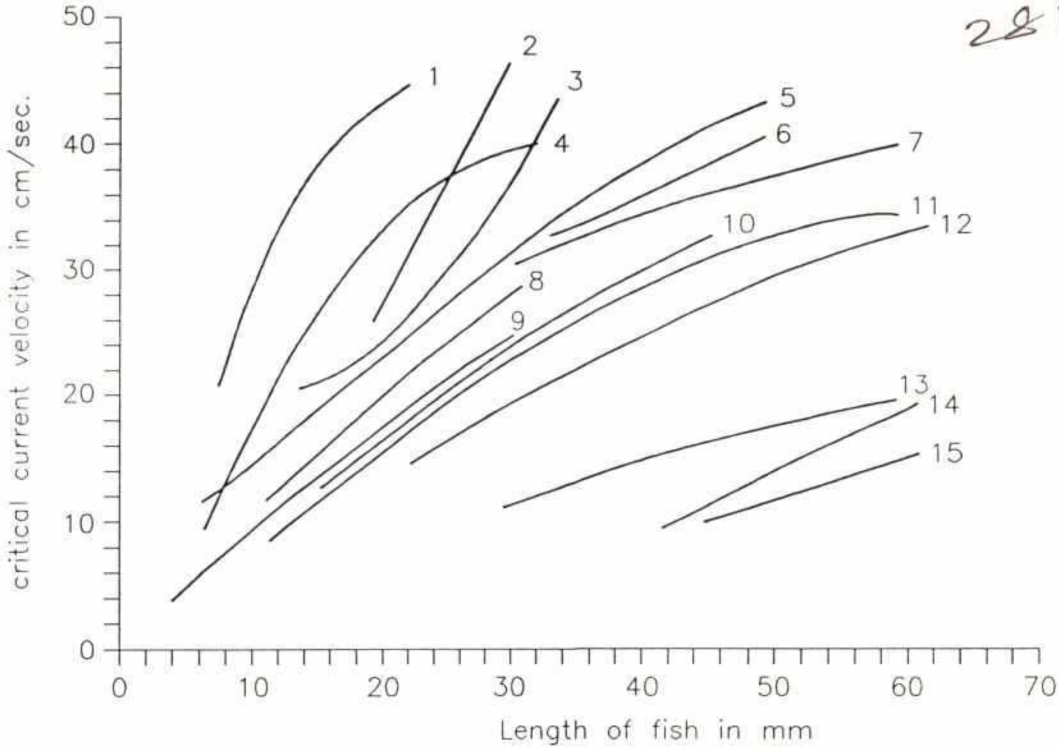
- It is likely that once spawning is completed, *boromaach* broodstock will attempt to return to deeper water, especially river *duars*, and thus need access from floodplain to river during the monsoon and post-monsoon.

The most important factor determining whether a particular species will be able to utilize a bypass structure is water velocity. Each species has a distinctive range of critical velocities (minimum current velocity at which a fish will begin to be carried away by the water flow) which represents the maximum velocities permissible through a bypass structure. Species inhabiting the surface layer have critical velocities 2-3 times higher than bottom dwelling fish. Critical velocity ranges also vary for different species. As an individual fish grows in size during its life span, its critical velocity increases (very quickly for some species, very slowly for others).

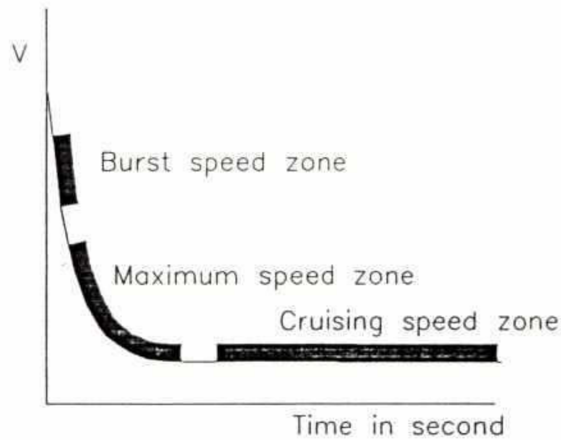
Analysis of swimming performance (the duration of active swimming as a function of a fish's speed) indicates an inverse relationship: the greater the swimming speed, the lower the swimming movement duration. Swimming performance is divided into three speed categories:

- <u>Cruising</u>: This is relatively slow swimming that can be kept up for long time periods, and the fish does not tire. General foraging or spawning migrations would be an example of this. Cruising speeds of bottom fish are generally 0.5-1 times body length per sec, and for pelagic species 3-4 times body length per sec.

280



Critical current velocities (ccv) for different species and sizes of fish: 1. Alburnus alburnus 2. Leucaspis delineatus 3. Rutilus rutilus caspius 4. Carassius carassius 5. Abramis ballerus 6. Perca fluviatilis 7. Vimba vimba 8. Nemachilus barbatulus 9. Cottus gobio 10. Rhodeus sericeus 11. Tinca tinca 12. Cobitis taenia 13. Acipenser guldenstadti 14. Huso huso 15. Acipenser stellatus. Pavlov,1989



The relationship between fish speed(V) and swimming duration(t). Pavlov,1989

Northeast Regional Project	
Relationship between ccv & fish; fish speed & swimming duration	
Prepared by: BNP/Mamun	April 1993

FILE: FISH-57.DWG

281

- Maximum: This is the fastest speed a fish would be able to maintain for a short time period, before tiring. An example would be swimming against localized high velocity currents during a spawning migration.

- Burst: This is the absolute highest possible speed a fish can attain and can only be sustained for one or two seconds at most. The most common use of burst swimming would be to evade a predator, catch a forage fish, leap out of the water over an obstruction, or overcome a high velocity venturi current.

Swimming performance graphs vary from species to species and for different stages in a particular fish's life span. If migrating fish encounter current velocities equal to or exceeding maximum swimming performance, they will move closer to the river banks seeking zones of lower current velocity. Whirlpools or circular currents disorient the migrants and they will delay and accumulate in such places. Studies elsewhere have also shown that upstream movement regularly alternates with active-passive downstream movement, probably because of exhaustion. As the spawning time draws near, this alternation can become more frequent, and as swimming performance is reduced fish can be passively carried into side khals, oxbows and beels where spawning may occur.

Table group 5.5 is a preliminary list of target species that carry out some form of breeding migration, and would be expected to require an embankment bypass facility. Maximum and minimum sizes, and expected maximum water velocity that can be negotiated in the upstream direction inside a fishpass have been estimated. Assuming a maximum water velocity of 150 cm/sec within the structure, not all target species would be predicted to be able to negotiate the structure. Among baromachh carp, it is predicted that all species except lachu and sarputi would be able to negotiate the fishpass at first maturity size (and larger sizes of lachu and sarputi would also be successful). Among non-carp baromachh, only chital and ilish would successful at first maturity size. Larger boal and baghair would also be successful, but air, ghagot, rita, and baim are expected to be completely unable to pass upstream. Among the chhotomachh, only foli is expected to be successful at first maturity size, but larger individuals of puti, pabda, bacha, garua and kaikka are also expected to be successful. Mola, chela, kani pabda, baspata, batashi, tengra, gulsha, rani, cirka baim, tara baim and chapila are not expected to be able to move up the fishpass. Altering the design to reduce water velocity to 125 or 100 cm/sec would allow more of the excluded species through.

All species could be expected to be able to move successfully in the downstream direction through the fishpass.

Opening the gates of conventional hydraulic regulators results in velocities through the regulators between 6.5 m/sec and 9 m/sec under differential heads across the regulator of 3.0-4.0 metres. This likely exceeds the swimming performance of all fish species in the region (except perhaps the largest chital).

Table 5.4: Swimming Speed of Carp Boromaach

TARGET CARP BOROMAACH SPECIES FOR FISHPASS

Group	Species	Type	Minimum Size *			Maximum Size **		
			TL	Vc	Vm	TL	Vc	Vm
Native Carp	Rui	P	43	150	300	85	300	600
	Catla	P	43	150	300	90	315	330
	Mrigel	P	38	135	270	80	280	560
	Kalibaush	P	28	100	200	50	175	350
Minor Carp	Gonia	P	22	80	160	40	140	280
	Lachu	P	17	60	120	25	90	180
	Sarputi	P	14	50	100	25	90	180
Exotic Carp	Carpio	P	24	85	170	50	175	350
	Silver Carp	P	38	135	270	80	280	560
	Grass Carp	P	53	185	370	85	300	600

P Pelagic species; B Benthic species; TL Total length (cm);

* Average size at first maturity; ** Average size of largest individuals in stock;

Vc Cruising swimming speed (cm/sec), estimated as 3.5 times body length per sec for pelagic species, and 0.75 times body length per sec for benthic species;

Vm Maximum swimming speed (cm/sec) is estimated as 2 times cruising speed. Vm is assumed to be the maximum water velocity that can be negotiated through the fishpass.

Table 5.5: Swimming Speed of Non-carp Boromaach

TARGET NON-CARP BOROMAACH SPECIES FOR FISHPASS

Group	Species	Type	Minimum Size *			Maximum Size **		
			TL	Vc	Vm	TL	Vc	Vm
Large Catfish	Boal	B	48	35	70	115	85	170
	Air	B	43	30	60	85	65	130
	Ghagot	B	43	30	60	80	60	120
	Baghair	B	80	60	120	180	135	270
	Rita	B	33	25	50	55	40	80
Knifefish	Chital	P	43	150	300	100	350	700
Herring	Ilish	P	28	100	200	45	160	320
SpinyEel	Baim	B	38	30	60	80	60	120

283

Table 5.6: Swimming Speed of Barb and Catfish Chotomaach

TARGET BARBS AND CATFISH CHOTOMAACH SPECIES FOR FISHPASS

Group	Species	Type	Minimum Size *			Maximum Size **		
			TL	Vc	Vm	TL	Vc	Vm
Small Barbs	Puti	P	3.5	10	20	25	90	180
	Mola	P	4.5	15	30	9	30	60
	Chela	P	5.5	20	40	15	55	110
Small Catfish	Kani Pabda	P	11	40	80	18	65	130
	Pabda	P	14	50	100	25	90	180
	Bacha	P	17	60	120	25	90	180
	Garua	P	16	55	110	25	90	180
	Baspata	P	7.5	25	50	10	35	70
	Batashi	P	5.5	20	40	7	25	50
	Tengra	B	9	5	10	15	10	20
	Gulsha	B	11	10	20	18	15	30

Table 5.7: Swimming Speed of Other Chotomaach

TARGET OTHER CHOTOMAACH SPECIES FOR FISHPASS

Group	Species	Type	Minimum Size *			Maximum Size **		
			TL	Vc	Vm	TL	Vc	Vm
Loach	Rani	B	7.5	5	10	12	10	20
Spiny Eel	CirkaBaim	B	14	10	20	25	20	40
	TaraBaim	B	14	10	20	28	20	40
Knifefish	Foli	P	21	75	150	27	95	190
Needlefish	Kaikka	P	18	65	130	25	90	180
Sardine	Chapila	P	11	40	80	15	55	110

Fish passes or fishways are channels or a series of pools installed to aid fish in overcoming natural or artificial obstacles to migration. A small amount of water is diverted from the river or forebay of a dam upstream of the obstacle. The diverted flow is controlled throughout the length of the fish pass by means of baffles, weirs or orifices so as to reduce the velocity to the point where the fish, in their upstream migration, can swim without too much exertion. Resting spaces between baffles or weirs are provided so fish can recover after darting or bursting from pool to pool.

The main concern in the hydraulic design of fish passes is to determine the best way to control the water flowing through the structure so as to dissipate its energy most efficiently without hindering the swimming ability of the fish. There is however, no rational approach to the problem of energy dissipation in a fish pass and most existing structures built have been copied from original designs made with the aid of hydraulic model studies. The pilot design would be a large scale model where flow patterns, energy dissipation and surface profiles can be observed with live fish and improvements made if necessary.

Apart from acceptable hydraulics, other general requirements are:

- Sediment bedload, debris and polluted water must not interfere with the flow
- The fish pass should be designed so that the least amount or at best no manual control would be required for maintenance of flow through the structure
- The operating water level range must satisfy fluctuations in headwater and tailwater
- The flow through the fish pass must be adequate to attract fish at the downstream end (fish entrance)
- The upstream end of the fish pass (fish exit) must be located so that fish leaving will not be swept down over obstructions or dams.
- The size of the fish pass must be based on the numbers of fish expected to use the facility.
- This last and probably most important aspect of fish pass design is the location of the fish entrance. Other than adequate attraction flow, the entrance should be located and aligned so that the migrating fish will not be delayed unduly by turbulence which confuse direction and cause "traffic jams".

285

In general, fish pass designs are of four main types:

Vertical Slot Fishways. These structures operate over a wide range of water levels without adjustments. Upright vertical panels and vertical full height slots are placed at intervals between fish entrance and exit and dissipate flow energy, and allow resting in pools between vertical panels. Short jets of water at low head through the slots enable the fish to dart or burst very short distances (1m ±) from pool to pool. Vertical slot fishways are used extensively in Europe, North America, Australia and Japan to bypass river obstructions, diversion dams and power dams.

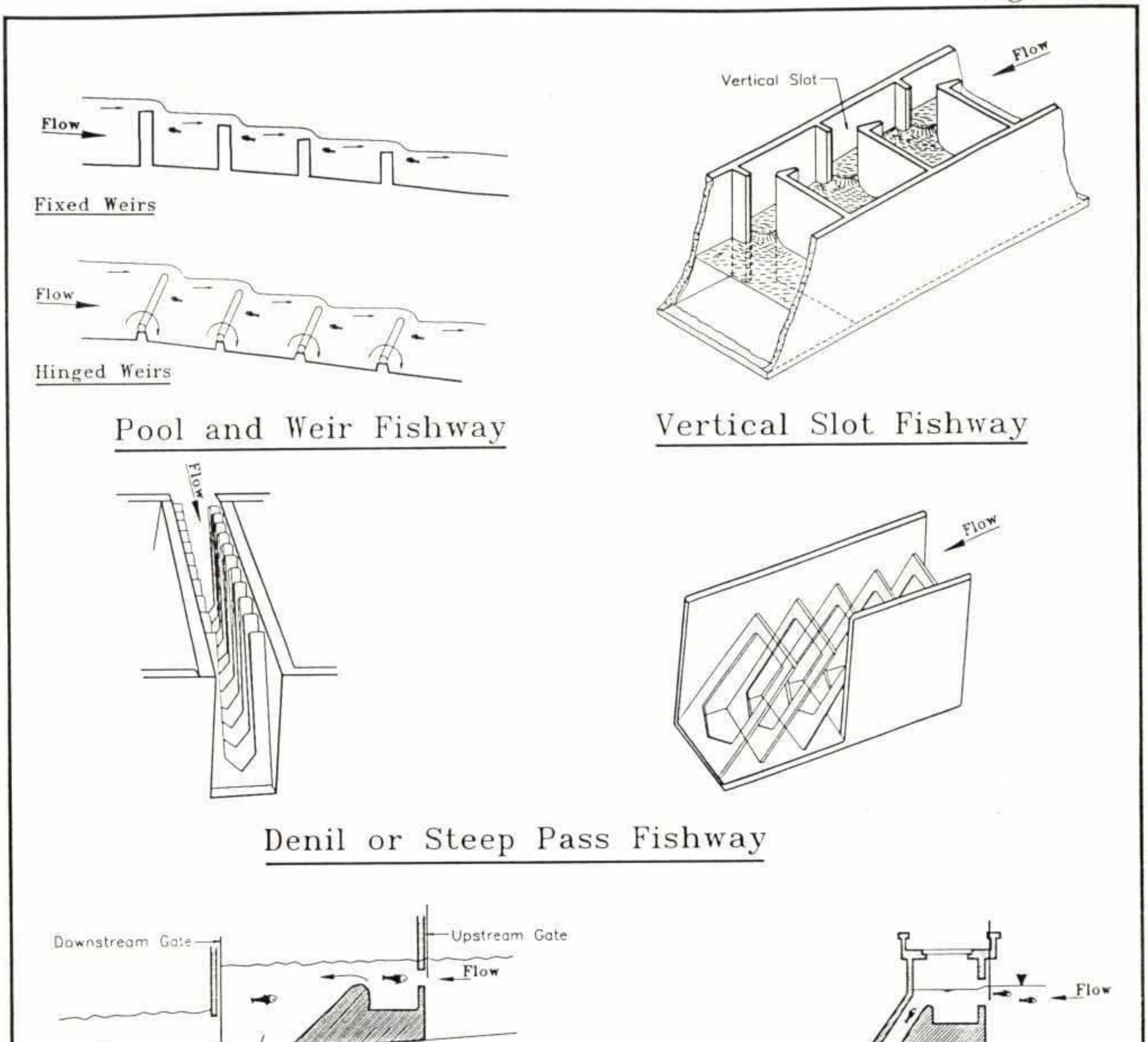
Pool and Weir Fishways. These structures resemble staircases of water and are usually built when water levels at upstream and downstream ends do not fluctuate widely during the period that fish are migrating. A series of partitions or weirs are installed across the fish pass channel with water cascading over the crest from pool to pool. The head across the weirs is designed to suit the fish type(s) which require passage assistance. The overflow could be free fall or submerged. Fish will jump over the weirs from pool to pool or orifices could be provided in the baffle wall for swim-through. The pool and weir type of fishways could be adapted for variable head and tailwater levels by telescoping weir crests or adjustable hinged weirs. Adjustable weirs require continuous mechanical or manual operation and are costly.

Denil Fishway or steep pass fishways are narrow channels with closely spaced baffles on both sides and bottom and set at an angle to the axis of the aligned structure. The baffles form secondary channels at an angle with the main central flow and the energy is dissipated by intense mixing. This fishway type is generally used with a small run of fish, on a temporary basis and are not conducive to variable head or tailwater levels.

Fish Locks as the name implies will move fish in and out as well as up or down over obstructions and dams. The structure requires entry, exit and bypass gates or sluiceways by mechanical or manual operation. The main drawback is interrupted passage and lack of attraction flow.

For conceptual and pilot project purposes in aid of fish passage across embankments, the vertical slot fishpass is considered the most appropriate as the forebay levels (river side) normally vary independently of tailwater (haor side) during the pre-monsoon period. Sizing of vertical slot fishways is normally based on hydraulic considerations from model tests and by the required capacity for moving fish over an obstruction.

Figure 80


Flow
Fixed Weirs
Flow
Hinged Weirs
Pool and Weir Fishway
Vertical Slot
Flow
Vertical Slot Fishway
Flow
Flow
Denil or Steep Pass Fishway
Downstream Gate
Upstream Gate
Flow
Water bypass Gate
Fishlock with bypass
Flow
Fishlock (Borland)
Flow
Circular Fishway
(Ver. slot or pool & weir)
Not to Scale
Northeast Regional Project
Fishways–Alternative Structures
Schematic Views
Prepared by: PBS
June 1993
Drawn By: Mamun
AutoCAD Drawing
FILE: FISH-89.DWG

287

The basic configuration of the vertical slot fishway pools and slots is shown in the text figures. The discharge through the vertical slot varies with depth and is calculated by Equation I : $Q = C_d(D+h)W\sqrt{2gh}$.

Where

Q	=	discharge (m^3/s)
C_d	=	coef. for discharge through orifices $\approx$ 0.75
W	=	total width of slot (m)
D	=	depth of water at downstream side of battle (m)
h	=	drop in water surface from the upstream to the downstream side of a baffle (m)

The calculated discharge is approximate only since approach velocities are not accounted for. The velocity of the water jet through the vertical slot in the baffle is determined by Equation II : $V = C_d\sqrt{2gh}$. The velocity of the water jet through the slot is independent of water depth.

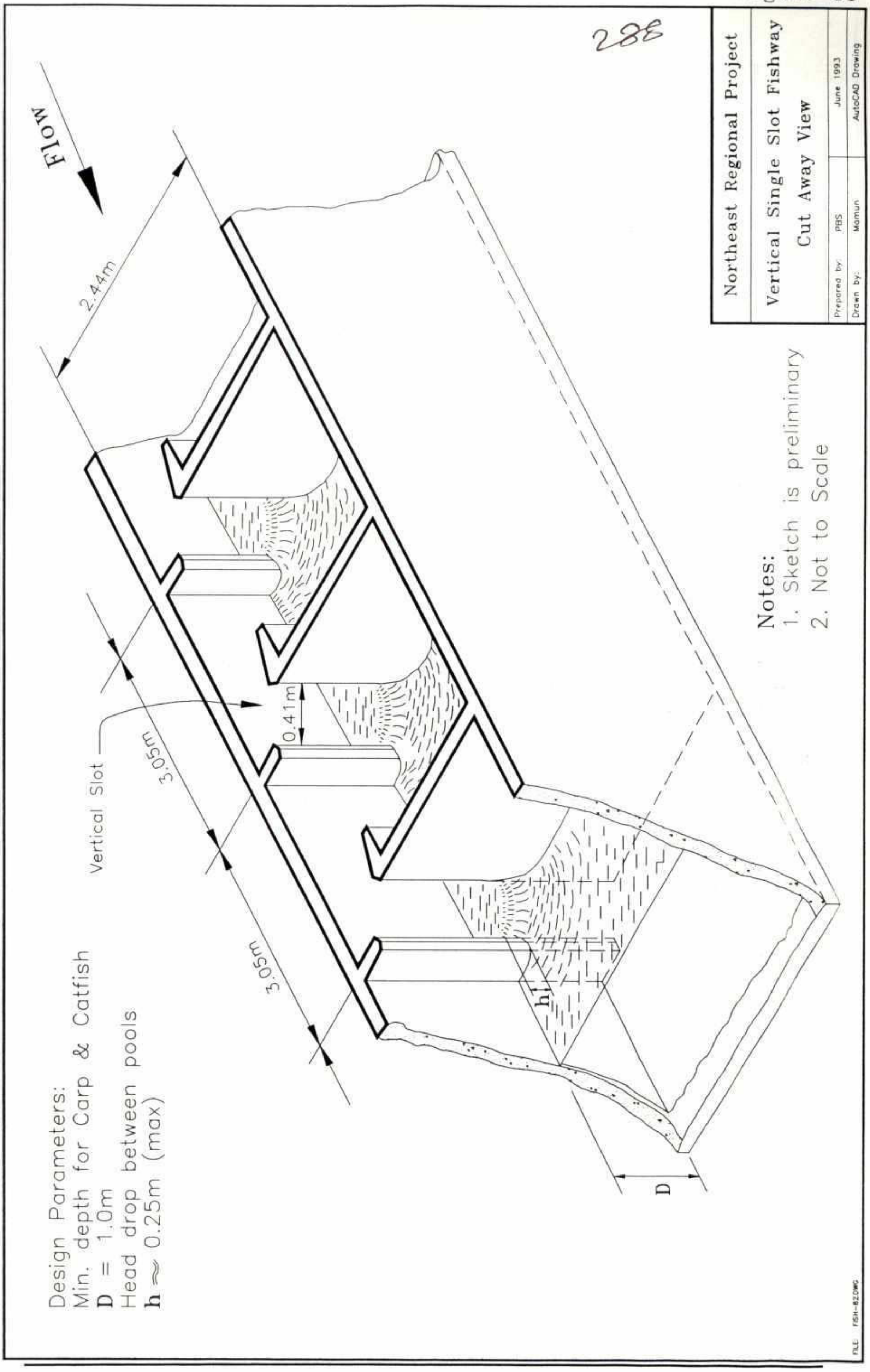
The minimum volume of water through the fishway or min. depth of water depend on species of fish which migrate. For carp and catfish the minimum depth is assumed as one metre. The migration capacity of a fishway depends on the acceptable density of fish within a pool during ascent and the swimming ability of the fish (rate of travel in m/minutes) through the structure.

A poorly located fish entrance which is avoided by or delaying the migrants could reduce these theoretical capacity numbers. Conversely good location and alignment choices could possibly improve the capacity.

Fish passes located at regulators between rivers and haors would have to accommodate fluctuations in head water levels of up to 3-3.5 m during the pre-monsoon period. Fish migrating from the haor to the river (out-migration) would ascend from low to high water levels whereas in-migrating fish would move downstream in the opposite direction (from river to haor).

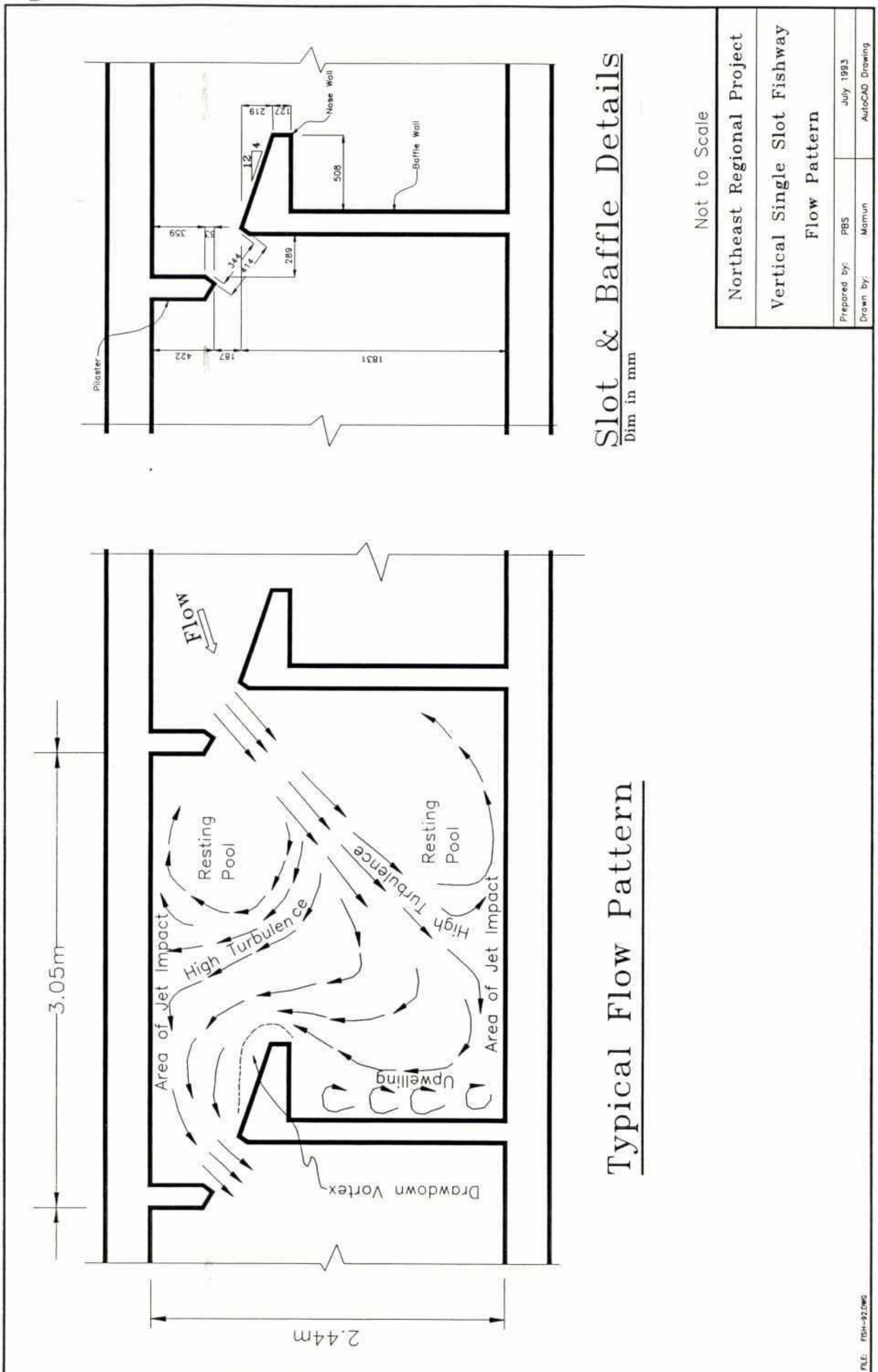
Out-migration (upstream moving fish) can be accommodated by a vertical slot fishway which operates at variable water depths as proven on many occasions. However, downstream passage of fish (in-migration) at the same time is more questionable. Small fish, fry and fingerlings have been known to enter upstream ends of fishways and either get flushed or swim with the flow. No records are available indicating that adult fish will do the same or if they would be adversely delayed and possibly injured by moving down a fishway. However, in some instances fish migrating up a fishway during the daytime have been known to turn around and swim back down the fishpass if passage has not been completed by nightfall.

Figure 81



Northeast Regional Project
Vertical Single Slot Fishway
Cut Away View
Prepared by: PBS
June 1993
Drawn by: Mamun
AutoCAD Drawing
288
Flow
2.44m
0.41m
Vertical Slot
3.05m
3.05m
h
D
Notes:
1. Sketch is preliminary
2. Not to Scale
Design Parameters:
Min. depth for Carp & Catfish
D = 1.0m
Head drop between pools
h ≈ 0.25m (max)
FILE: FISH-82.DWG

Figure 82


Slot & Baffle Details
Dim in mm
Pilaster
Nose Wall
Baffle Wall
422
187
1831
359
53
344
414
289
508
12
4
219
127
Not to Scale
Northeast Regional Project
Vertical Single Slot Fishway
Flow Pattern
Prepared by: PBS
July 1993
Drawn by: Mamun
AutoCAD Drawing
Typical Flow Pattern
Flow
Resting Pool
Resting Pool
High Turbulence
High Turbulence
Area of Jet Impact
Area of Jet Impact
Upwelling
Drawdown Vortex
3.05m
2.44m
FILE: FISH-92.DWG

Plans and general details for an 11 pool, 12 baffle fishway structure, fish sluiceway passage and fence for guiding the migrants are shown for two configurations. Alternate I layout, is a straight alignment with the fish entrance and exit a distance away from the regulator. In-stream fencing using bamboo, steel or other suitable material would guide out-migration from the haor at the downstream end and in-migration from the river at the upstream end (down fish exit). It is proposed that a fish sluice gate be incorporated with the regulator control if adult in-migrating fish will not enter the fishway and move down with the flow. The fish sluiceway layout includes allowance for a stilling basin at the tailwater end. The stilling basin or deep pool at the tailwater end of the fish sluiceway, will dissipate the high velocity flow under the gate and provide a transition for the migrants to swim down the khal into the haor. The fish sluice gate or any other regulator sluiceway gate should be fully open when fish are present to avoid injuries to the migrants. Flow out of the stilling basin across slots in the wall will be adjusted by stoplog control. After initial setting to suit tailwater conditions no further adjustments should be needed.

Upstream (and downstream) passage of migrant fish through the fishway depend on adequate depth of water over the forebay and fishway invert levels. Adequate passage is expected with submergence of one metre.

Ideally for a vertical slot fishway which is self regulating the forebay (fish exit) and tailwater (fish entrance) levels change by equal amounts and the water depths and flow are the same at each baffle slot. However, at regulator structures at haors the forebay in the initial flood stages rises faster than the tailwater. To prevent hydraulic drawdown in the upper pools when water starts flowing through the fishway, the water levels at the fish entrance need to be adjusted. The adjustment can be made by telescoping weir(s) at the fish entrance operated by float control at the forebay or otherwise by manually correcting using stoplogs in the fish entrance slots.

The stream channel (khal) downstream of the fish entrance might have to be trenched and/or provided with berm weirs to facilitate a channel with adequate depth of water for fish to swim to or from the fishway.

If not used for passing fish the sluice gate could be used to provide attraction water at the fish entrance. Such additional flow would also benefit fish migrating up or down the khal within the haor.

Fishway layout, Alternate II depicts a folded alignment of the vertical slot structure shown for Alternate I. Hydraulically the structures are similar. Alternative II provides a more integrated structure with the regulator, and provides downstream fish passage (river to haor) exclusively through a fish sluiceway on the river side opposite the vertical slot fishway. The stilling basin at the downstream end of the fish sluice is similar for both layouts. The fish migrants are guided by fences constructed using bamboo, steel or other suitable materials.

It is apparent that the fish entrance and exit areas, the pools within the fishway and the finger gate openings in the fences upstream and downstream of the structure would be attractive locations for catching fish. Therefore, it will be imperative that rules and regulations are adopted to prohibit any commercial or subsistence fishery or fishing by individuals in the vicinity near the fish pass facilities. Effective policing and enforcement will be required.

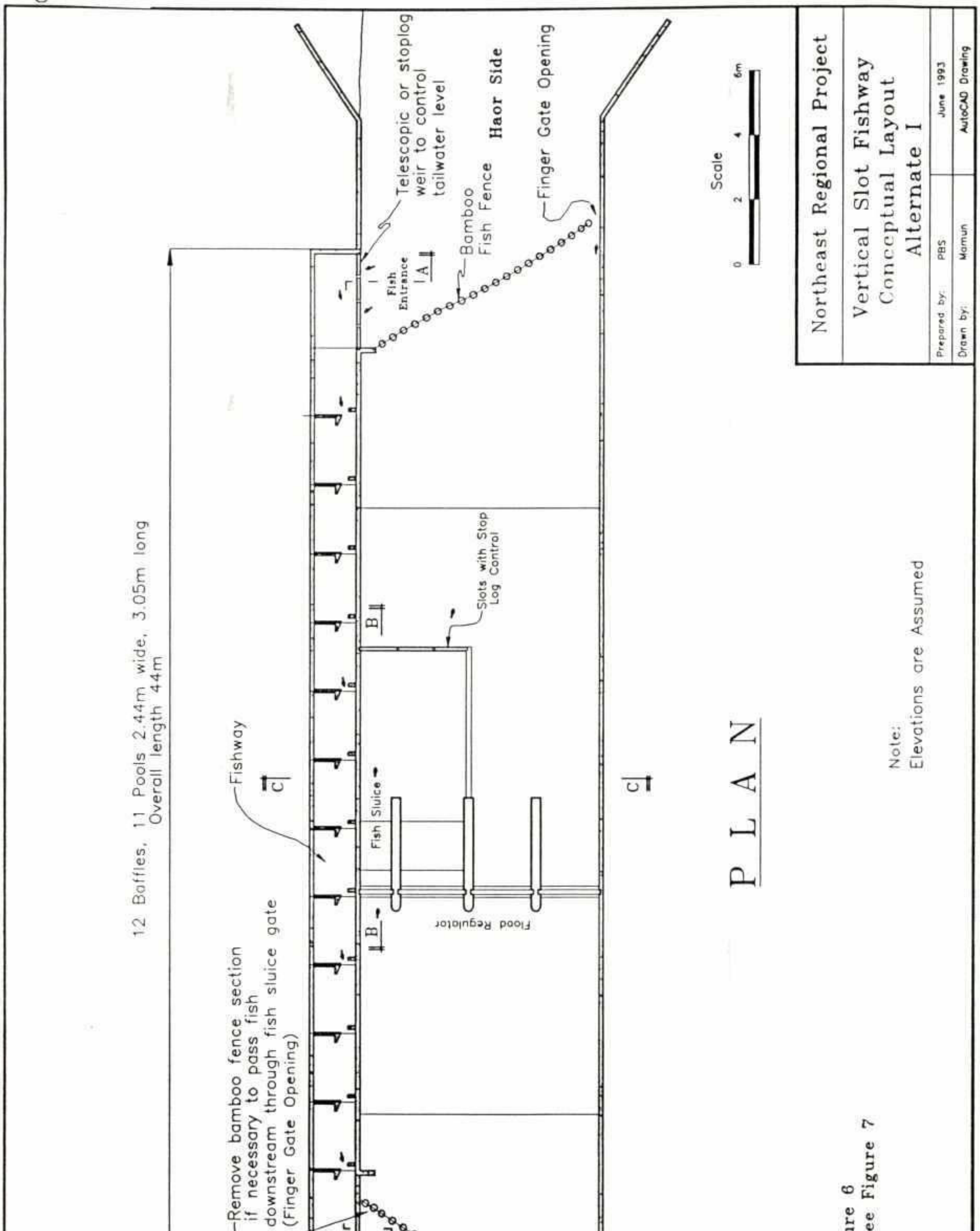
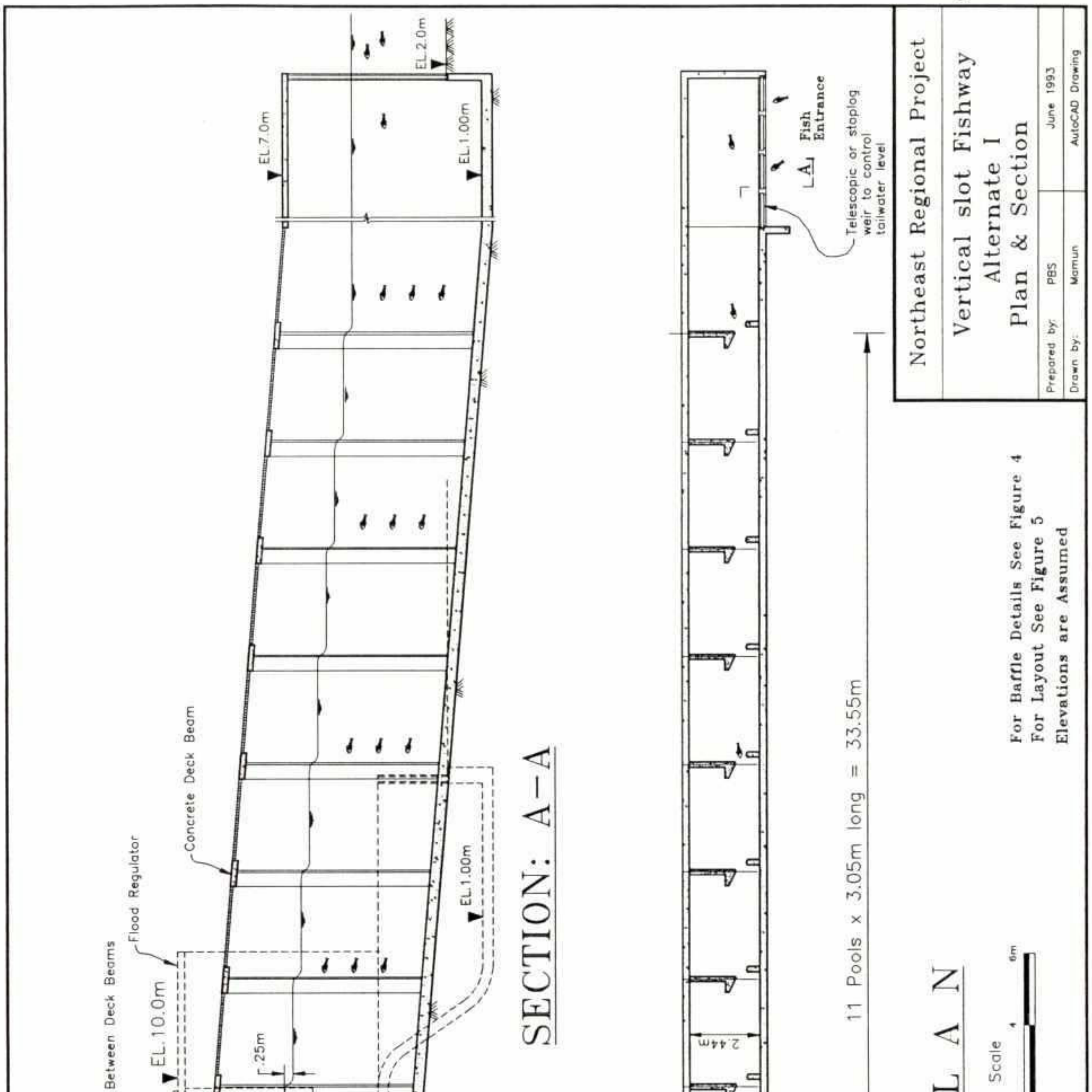
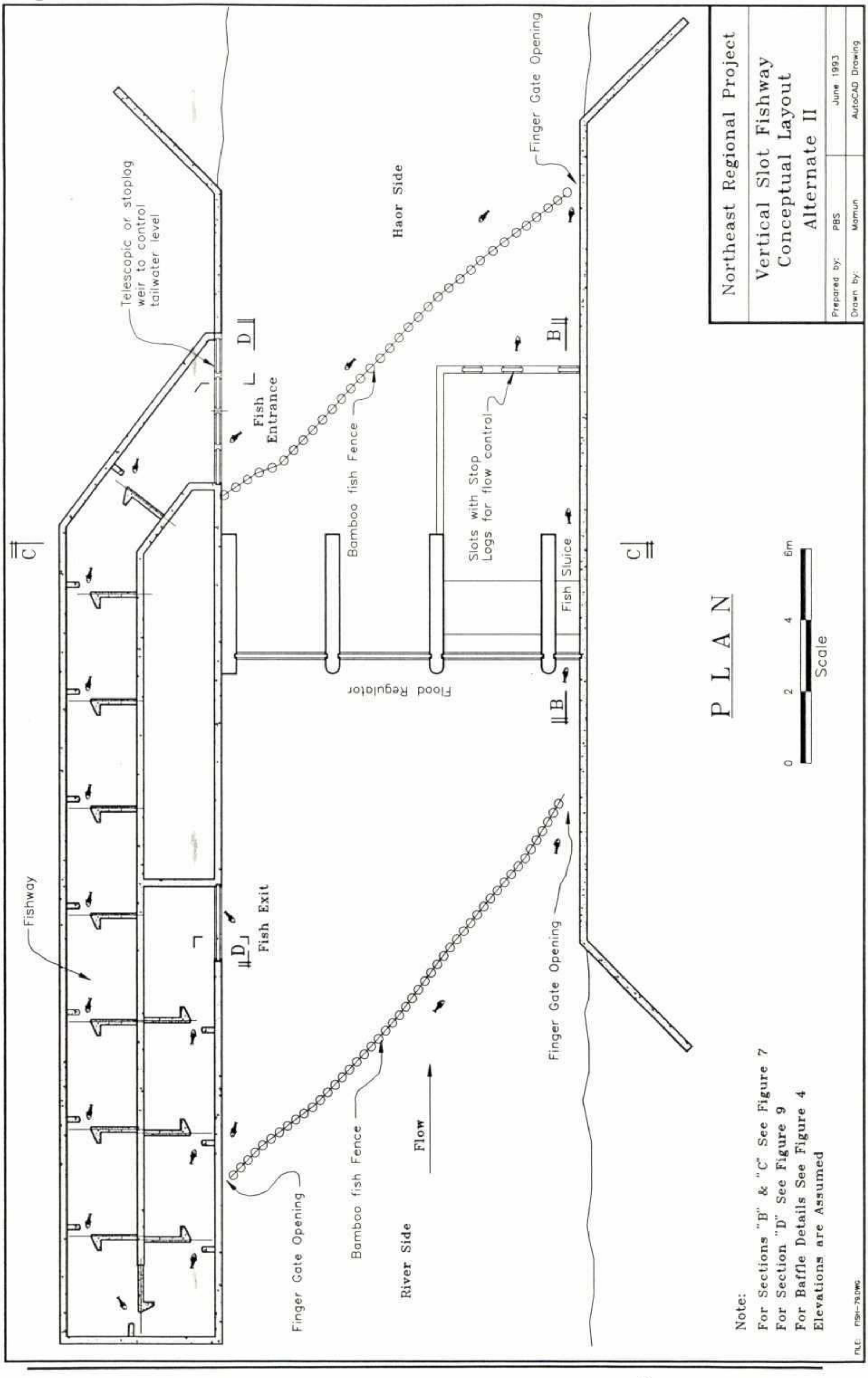

12 Baffles, 11 Pools 2.44m wide, 3.05m long
Overall length 44m
Remove bamboo fence section
if necessary to pass fish
downstream through fish sluice gate
(Finger Gate Opening)
Fishway
Telescopic or stoplog
weir to control
tailwater level
Fish Entrance
A
Bamboo
Fish Fence
Haor Side
Finger Gate Opening
Slots with Stop
Log Control
B
C
Fish Sluice
Flood Regulator
Fish Exit
Bamboo
Fish Fence
Flow
River Side
PLAN
Note:
Elevations are Assumed
Drawing Reference:
For Section "A" See Figure 6
For Section "B" & "C" See Figure 7
Scale
0 2 4 6m
Northeast Regional Project
Vertical Slot Fishway
Conceptual Layout
Alternate I
Prepared by: PBS
June 1993
Drawn by: Mamun
AutoCAD Drawing

Figure 84



Northeast Regional Project
Vertical slot Fishway
Alternate I
Plan & Section
Prepared by: PBS
June 1993
Drawn by: Mamun
AutoCAD Drawing
SECTION: A–A
Typical:
Steel Grating Between Deck Beams
Flood Regulator
Concrete Deck Beam
EL.10.0m
.25m
EL.1.00m
EL.7.0m
EL.2.0m
EL.1.00m
EL.10.0m
EL.4.00m
PLAN
11 Pools x 3.05m long = 33.55m
2.44m
Fish Entrance
Telescopic or stoplog weir to control tailwater level
Fish Exit
For Baffle Details See Figure 4
For Layout See Figure 5
Elevations are Assumed
For Dewatering or Shut off of flow thru Fishway install Stop Logs or Sluice gates at Fish Exit
Scale
0 2 4 6m


Northeast Regional Project
Vertical Slot Fishway
Conceptual Layout
Alternate II
Prepared by: PBS
June 1993
Drawn by: Mamun
AutoCAD Drawing
PLAN
Scale
0
2
4
6m
Haor Side
River Side
Flow
Fishway
Fish Entrance
Fish Exit
Fish Sluice
Flood Regulator
Bamboo fish Fence
Bamboo fish Fence
Finger Gate Opening
Finger Gate Opening
Finger Gate Opening
Telescopic or stoplog weir to control tailwater level
Slots with Stop Logs for flow control
Note:
For Sections "B" & "C" See Figure 7
For Section "D" See Figure 9
For Baffle Details See Figure 4
Elevations are Assumed
FILE: FISH-79.DWG

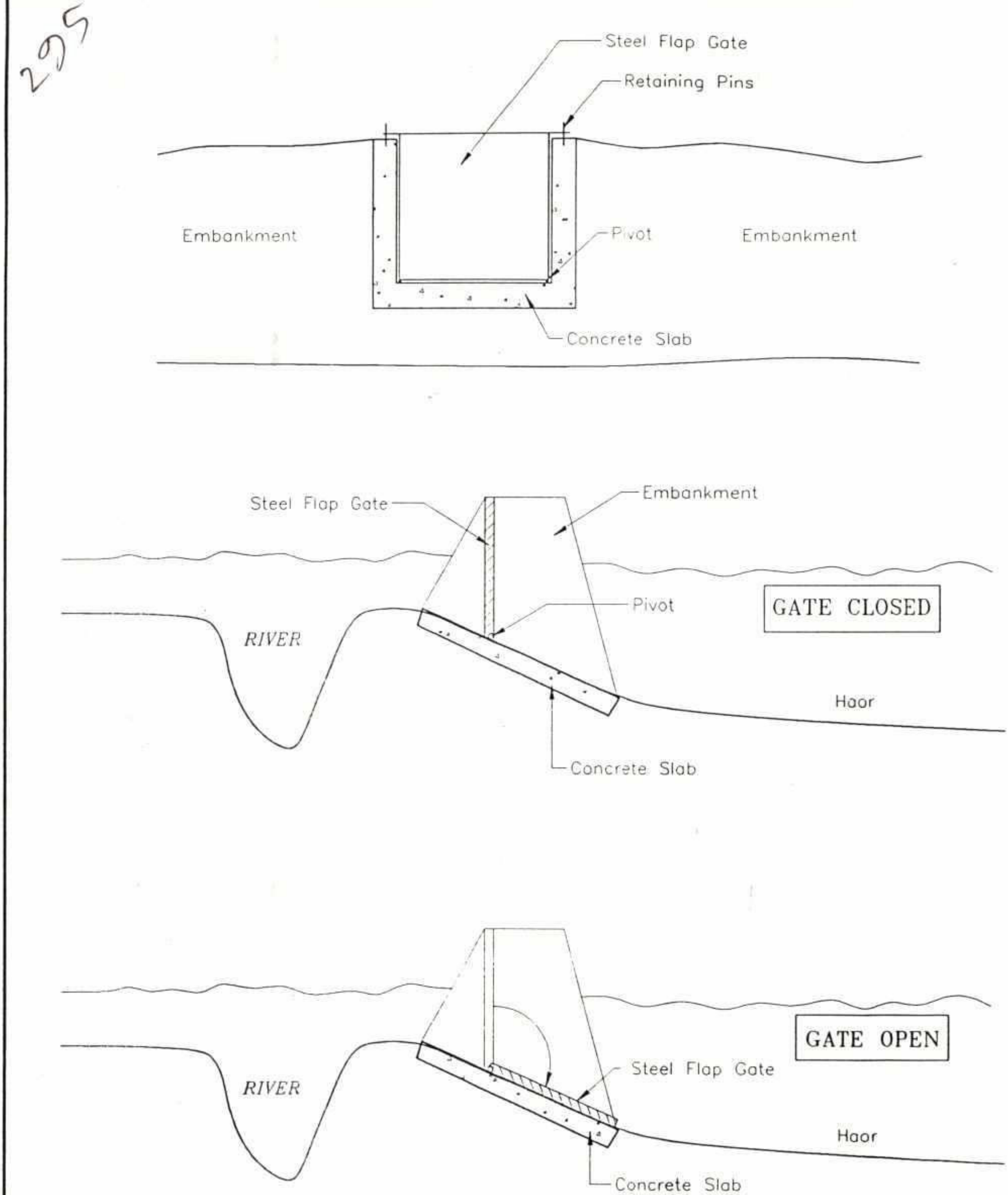
Navigation Gates

A shortcoming of many projects in the region is neglecting to cater to the needs of the navigation sector, which provides much of the short, medium and long distance transportation services during the 7-8 months of the flood season and perhaps 80% of long distance transport during the 4-5 months of dry season. To cut costs and improve economic efficiency, boats have to traverse haors, and to do this they have to cut embankments because no navigation gates are installed in partial flood protection projects. Boats can usually ride over the top of the embankment from mid June to mid October (4 months). However, the water level can fluctuate from one day to the next. Falling water levels will cause embankment crests to emerge, while rainfall will re-submerge them. Thus, even during the full flood season, embankments still cause problems for navigation. One solution employed is to cut the embankment on 16 May at strategic places so there will be easy entry and exit to and from the haor. By about mid-October the water starts draining out of the haor and the top of the embankment becomes exposed. However there is still sufficient water in the haor to allow for navigation for at least another month or month and a half and substantial savings to navigation are still possible from cross-haor navigation. Again embankment cuts take care of the problem and extend the cross-haor navigation season by up to one and a half months in the year. There is thus a real need to provide embankment bypass facilities for navigation if the incidence of public cuts is to be reduced. Public cuts make the boro crop vulnerable to unseasonal winter flash flooding. In the event of an unseasonal flood they are impossible to close quickly. Because navigation gates are not provided, boatmen feel free to take matters into their own hands. This leads to a proliferation of navigation cuts - more than are actually necessary, and all the more cuts to try to fill in under an emergency situation. The mid-February 1993 flood at Shanir Haor led to 25% crop loss because of failure to close the cuts in time. At Matian haor, the loss was total. Farmers are occupied with agricultural tasks early in the dry season, and therefore are unable to carry out embankment repair. Well designed navigation gates, located at the main cross-haor navigation entry/exit points and under the control of a haor management committee would be much more efficient than not providing any gates at all and relying on the annual embankment-cutting-followed-by-repair cycle (with all its attendant costs, inefficiencies and high risks it poses to the boro crop).

A simple design for a navigation gate calls for a 5 m wide steel flap gate, hinged at the bottom and pinned into place at the top. The gate would be:

- closed about 1 February, or as soon as all the boro is planted,
- opened 1 June, or once there is about one meter or so of tail water on the haor side, so as to cushion the gate against the pressure of the inrushing river water and prevent it from being damaged by being slammed against its concrete base.

Figure 86



Northeast Regional Project	
Navigation Flap Gate	
Prepared by: BNP/Jalal	April 1993

FILE: FISH-118.DWG

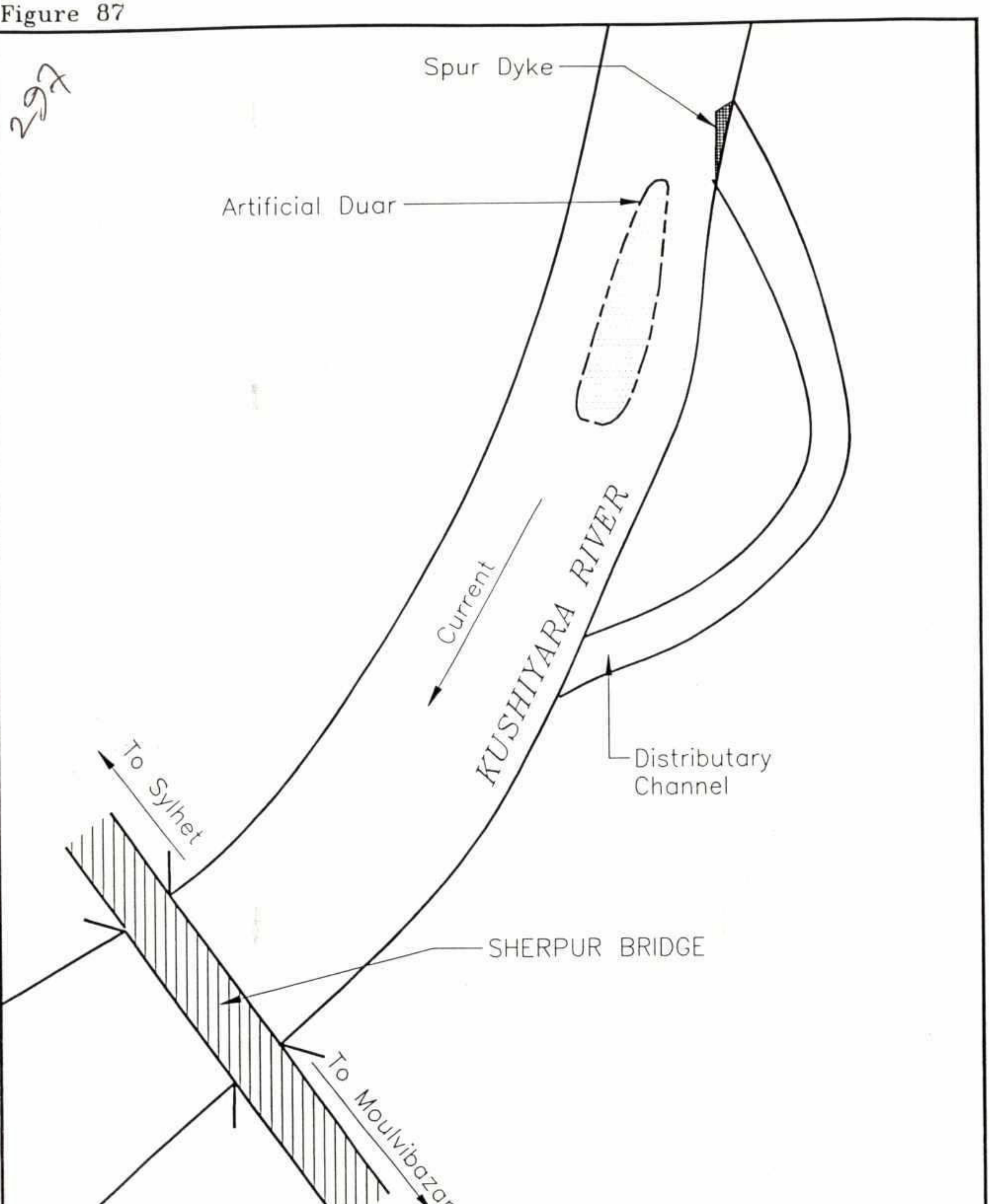
Thus the gate would remain opened during the monsoon to allow boat passage, as well as more rapid initial flooding (to the benefit of navigation and fisheries) and faster draining of the haor in the autumn (to the benefit of agriculture). It would remain tightly closed throughout the entire dry season (thus absolutely protecting boro from any unseasonal flash floods). Navigation gates (perhaps three, four or more per project) would be located where they best serve the needs of navigation (and by so doing, act as a deterrent to further proliferation of embankment cutting). The locations would be determined by interviews with boatmen and a comprehensive site study of monsoon season navigation patterns and routes. The gates will probably not be located where they will best serve the needs for draining the lower parts of the haor. It is precisely those parts that are most difficult to drain and yet are the most desirable for boro. Simple low cost navigation gates can probably not be easily and safely opened under high hydraulic head differences. Thus, while navigation gates do serve some hydraulic functions, there is still a need for hydraulic gates or regulators in flood protection embankments.

The navigational requirement for a gated regulator is that, when the gate is open, the waterway will be wide enough and deep enough for a country boat to pass through. Country boat beams are about 5 m and their draft, when fully loaded, is about 1 m. A navigation gate might cost only a third as much as a gate for flushing and draining the haor. The fact remains, however, that navigation gates all represent additional costs to a project which must be met by the compensatory benefits derived from them. It is important to correctly estimate the navigational benefits. If a country boat journey can be considered to start at Ranjibanpur and end at Tahirpur (in the Shanir Haor case) then the saving on distance travelled in about 50%, and this is worth having. On the other hand, a boat originating at Sunamganj (travelling via the southwest side of Halir Haor because the Rakti River is blocked with sediment at Jamalganj) may well proceed to points upstream of Tahirpur. In this case the saving in distance travelled may be less than 5%. This illustrates the need for some care in evaluating the navigational benefit.

Multiple Gates
Even if an ideal multipurpose gate could be designed which would be highly efficient in meeting all important agricultural, fisheries and navigation needs, construction of only a single structure at a FCD/I project is not realistic. The facilitation of fish migrations and navigation cannot be focused at one site on the haor perimeter. There is a need for multiple access to/from the haor if embankment cutting to facilitate these activities is to end. However, the more gates accepted as necessary, the greater the cost added to the project. To be economically justified, the project benefit/cost ratio must remain positive. Under a multipurpose approach, this implies that the full array of marginal benefits to agriculture, fisheries and navigation of each additional gate need to be evaluated against its costs. Generally, the number of gates per project has, as a matter of economic principle, to be minimized.

5.2.7 Artificial duars
Given the importance of river duars as overwintering habitat for broodstock, and the fact that many duars are disappearing due to siltation, a strategy for duar management needs to be formulated. Obviously, river works such as loop cutting to straighten rivers should be stopped. The possibility of creating artificial duars so as to increase the area of duars in the region needs to be assessed. Excavation of artificial duars would seem not to be viable because they would probably fill in again fairly quickly.

Figure 87



Northeast Regional Project

Artificial Duar in the Kushiyara River Near Sherpur

Prepared by:	BNP/Jalal	April 1993

FILE: FISH-117.DWG

However, an existing example in the Kushiyara (5 km upstream from Sherpur) shows how an artificial *duar* can be induced to form in a major river at a relatively minor cost. To close an old distributary of the river a spur dyke was built at Brahmangaon which juts out into the river and acts like a flow obstructor. This deflects the river current and has induced the formation of a large 32 m deep scour hole in the middle of the channel where previously water depth was around 9 m. Interestingly, this artificial *duar* is much deeper than the natural *duars* in this reach of the river (<20 m) which are mostly situated in the river bends. Flow obstructors of this sort are relatively simple and inexpensive to construct. Adequate design specifications would call for a sand or soil backfilled core covered with a layer of stone mattressing. The structure would be 100 m long, 35 meters high and require a stone mattress 0.3 m thick. The slope of the outer stone cover of the flow obstructor should be 2:1. The major materials cost would be for the stone (including transport, dumping and placement): Tk 260,000-315,000 for 1000 m^3. This cost compares favourably with the range of annual yield values from a river reach containing *duars* presented in Section 2.5.6 above (and the structure would have an operating life of many years). The dimensions of the flow obstructor would have to be carefully controlled so as not to induce unwanted erosion and damage to property on the opposite bank. Spur dykes have been used at a number of other loop cut sites in the Kushiyara and Baulai to deflect river flow, and this has caused the scouring out of artificial duars downstream.

Bottom sills are also technically feasible as a means of creating an artificial scour hole. An example exists at the Juri River railway bridge at Continala where a scour hole exists which is some 10 to 15 m below the normal channel bottom and 50 to 100 m long. This has formed downstream of a concrete bottom sill. Other alternatives include bank revetments at a bend and piers to create a small scour hole. The design and cost effectiveness, of course, would be site-specific.

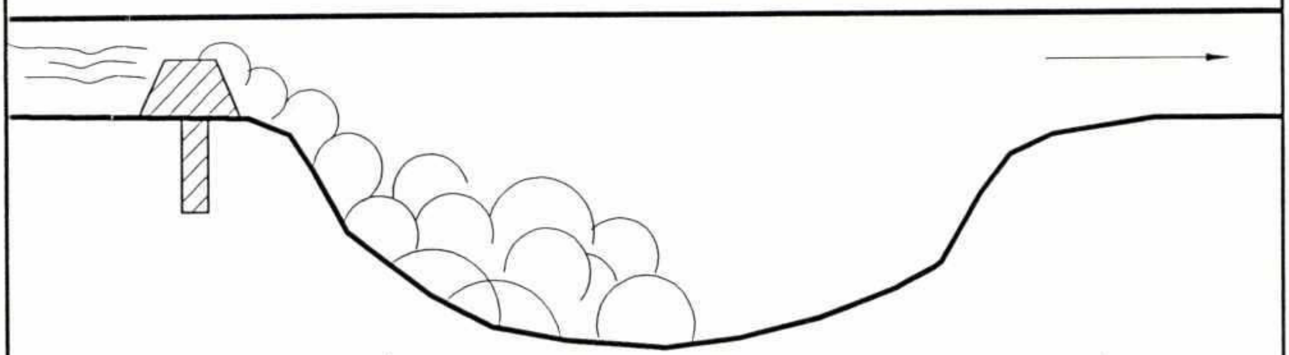
Given the efficacy of installing flow obstructors and other structures to create artificial duars, they should be considered as fundamental structural measures for rehabilitation of the riverine habitat for fisheries. It would also seem possible that they might be useful for relieving localized sedimentation problems which interfere with navigation in tributaries.

5.3 FISHERIES MANAGEMENT MEASURES

5.3.1 Fish sanctuaries in river duars

There is a widespread awareness among fishermen of the importance of *duars* for conserving fish stocks in order to sustain production at a high level. Fishermen in many areas advocate exempting important deeper *duars* from the present revenue collection system and creating *duar* fish sanctuaries under biological management. For example, fishermen state that if the Ranichapur and Dhalimati fisheries of the Kaliajuri area are turned into fish sanctuaries by GOB, then the fish abundance in the whole area would increase. Fishermen in Hakaluki and Tangua haors also advocate setting up duar sanctuaries.

Figure 88

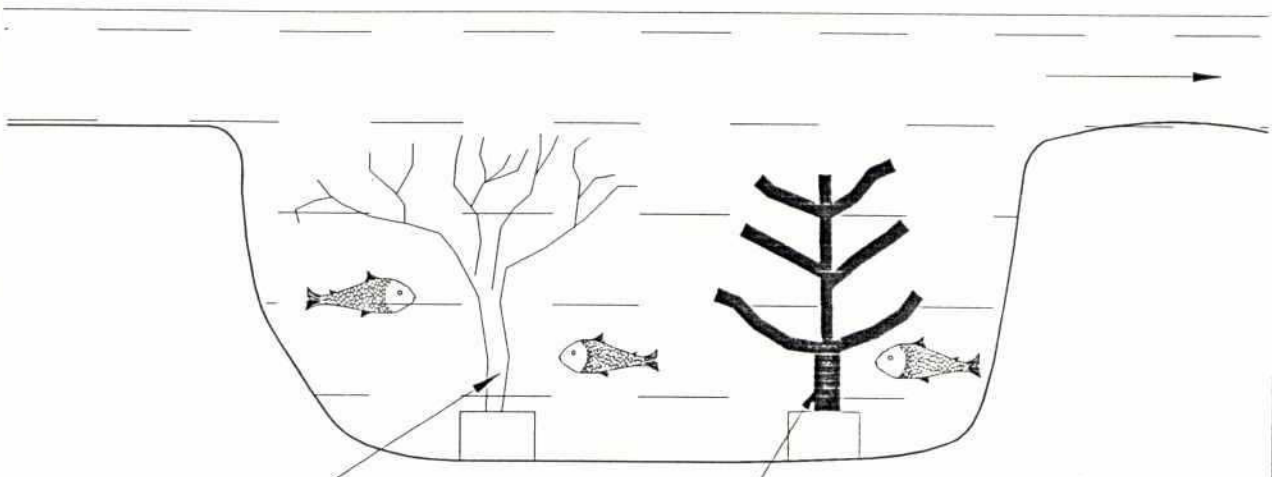


299

Northeast Regional Project	
Bottom Sill Design to Create an Artificial Duar	
Prepared by: BNP/Jalal	April 1993

FILE: FISH-116.DWG

300



TOW TYPES OF GEAR FOULING DEVICES WHICH COULD BE INSTALLED IN DUARS TO DETER FISHING

Northeast Regional Project

TOW TYPES OF GEAR FOULING DEVICES WHICH COULD BE INSTALLED IN DUARS TO DETER FISHING

FILE: FISH-114.DWG | Prepared by: BNP/Jalal | April 1993

301

Duar fish sanctuaries would require surveillance and enforcement in the form of fish guards, appointed either by DOF or by local fishing communities to prevent fishing during the dry season. The feasibility of installing passive net and line fouling devices into the duar should also be assessed. Concrete ballasted *hijal* trees are one option, but these will rot after 2-3 years. They may also snag nets, which when abandoned by fishermen will continue to catch and kill broodstock. A costly but more efficient structure would be a welded steel device. Such a device would be longer lasting and could be designed not to snag gear, or resist being easily pulled out of the duar. They will tend to collect debris which may help to deepen the duar and enhance the habitat by creating greater structural complexity. The gear fouling device needs to be sufficiently submerged so as not to create a problem for navigation, in the dry season when river depths are minimal.

5.3.2 Fish sanctuaries in beels

Fish sanctuaries also need to be established in beels. There are three important reasons:

- Many species of *chotomaach* are limited to the beel/floodplain habitat and will derive no direct benefit from river duar sanctuaries. These species are especially important for maintaining the subsistence catch. Although conventional wisdom has it that chotomaach stocks are extremely resilient, there are examples in the region of declining populations due to overfishing and other causes.

- A substantial proportion of juveniles *boromaach* (major carp, *Chital, Boal Air*) do not return to rivers during their first and second years but overwinter in the deeper beels.

- The use of *katha* in beels causes some *boromaach* broodstock to remain in the beels during the winter. A large proportion of this overwintering broodstock is fished out from the beels every year (between January and April) by leaseholders before they have an opportunity to breed.

Fishermen are aware of these facts and advocate establishment of sanctuaries in beels. Some examples of *jalmohals* identified by fishermen for sanctuary designation are:

- Gorumarar khal and Boro khalar muk in the Bengla fishery.
- Sainna beel near Dhanpur bazar (Dhanu River), Itna.
- Bhanda beel near Ajmiriganj (Kalni River), Derai thana.
- Rangchapur area near Laipsa bazar (Dhanu River), Khaliajuri thana.
- Dhalimati area near Chakua (Dhanu River), Khaliajuri thana.
- Chunia area near Chakua, Khaliajuri thana.
- Moragang near Ballavpur, Khaliajuri thana.
- Kalarduar near Pachhat, Itna thana.
- Gorumarar khal and Bara khalar muk (Ghorautra River), Bajitpur.
- Chatla beel in the Hakaluki haor (Juri River), Kulaura.
- Kalapani in the Hakaluki haor (Juri River), Baralekha.
- Chinaura beel in the Hakaluki haor, Borolekha.
- Rangamati in the Dekker haor, Sunamganj.
- Shaldigha boalpushi near Dabar, Sunamganj.

- Kawnai nadi *jalmohal*, Dharmapasha.
- Kautski fishery, Dawarabazar.

Two possible approaches to creating fish sanctuaries in beels are considered below:

Total ban approach: This would aim to prohibit all fishing in selected beels during the dry season. In each haor one or two beels could be designated fish sanctuary beels and DOF fish guards stationed there to prevent fishing activity from December to June. Gear fouling devices such as *hijal* branches or more permanent metal devices heavily ballasted with concrete) could be installed in the central part of the bee to deter poaching. The shallow marginal area should still be left open for subsistence fishing of *chotomaach* by the local population. The main benefit which will accrue to the entire haor fishery will be that during the monsoon more eggs will be spawned by *boromaach* and more *boromaach* juveniles will subsequently be present in the haor, thus giving a higher yield of commercially valuable species to fishermen during the open water fishery phase of the annual haor fishing cycle (specifically when there is open access to the general public to the haor's fishery resources). More *boromaach* will also survive to adulthood, thus building up the total brood stock abundance in the haor over the space of several years. A further expected benefit is that *chotomaach* abundance will also increase because the gear fouling devices will act as artificial habitats which provide more food and shelter for fish, and it is known that this increases ichthyoproductivity. In order for fish sanctuary beels to produced a marked improvement in overall brood stock survival and fish catches in a haor, the sanctuary beel surface area might have to occupy up to 20% of total beel surface area in any one haor.

Protected *katha* approach: Another option is rather than to ban fishing completely in designated beels, fishing will continue to be allowed in all beels, but the DOF would install protected *katha* in all important beels. The rational is as follows: the principal method of harvesting *boromaach* from beels is to use *katha*. Each beel usually has several installed and together these attract virtually all of the broodstock present in the beel. If 20% of all *katha* mass installed in a beel is DOF-protected permanent sanctuary *katha*, it follows that at least 20% of broodstock in the beel will escape capture each year when they take refuge in the protected kathas.

Both options would achieve roughly the same result, but there are some anticipated differences:

- Resistance from fishermen: An advantage of the protected *katha* over the total ban approach is that it would likely not provoke the same level of resistance from local fishermen who previously fished in those beels which come under total bans.

- Number of fish species protected: Under the total ban approach there is the possibility that not all species residing in the haor will be present in the beel(s) selected for protection. In contrast, the protected *katha* approach would give comprehensive coverage of all species, as each beel would be included.

- DOF fish guards: Only one fish guard would need to be posted at a banned beel, while several would have to be deployed in the case of protected *katha*. However, illegally harvesting a sanctuary *katha* would be a major labour-intensive and time-consuming operation (which includes manual removal of the *hijal* branches and setting of blocking nets) which DOF guards carrying out surveillance could easily protect.

303

Assuming that the benefits expected from either approach actually materialize, the improvement in catches that local fishermen will experience over a 3-5 year period after sanctuary establishment will be directly attributable to the sanctuaries (assuming that this is the only intervention). It is expected the this result will win the loyalty and support of the fishing community for sanctuaries and that incidences of attempted vandalism or poaching would decline. A program of fishing community education should precede implementation of sanctuaries. Eventually, authority for protection of sanctuaries might be transferred to fishermen cooperatives and associations.

A special problem is the floodplain *chotomaach* used for subsistence consumption. At present no *chotomaach* sanctuaries exist in the region (or the country). For several reasons, some of the *chotomaach* species have declined and some species are on the point of extinction (*Bheda, Koi, Sarputi* among others). It is suggested that in every haor there be one shallow beel reserved as a *chotomaach* sanctuary. These sanctuaries will serve as overwintering grounds for *chotomaach*. For example, Ashkuria beel of Atpara might be a good sanctuary for *chotomaach*.

5.3.3 Carp spawning ground sanctuaries

Floodplain spawning fish species are generally not very selective as to spawning location and thus have most of the floodplain open to them as spawning habitat. In sharp contrast, river breeding major carp (and perhaps several other *boromaach* species) are highly selective as to their requirements for spawning habitats, and are thus much more vulnerable during this critical life stage. There is a need to identify all existing carp spawning localities and bring them under sanctuary status. Steps have already been taken by the DOF by declaring the Luba River a sanctuary. This programme should be extended to cover all known (or suspected) carp spawning localities in the region. These are generally located at the margins of the floodplain, where tributary rivers discharge high quality runoff from India. It is also crucially important that the migratory pathways come under protection. A comprehensive management system needs to be developed to protect the overwintering and breeding grounds and the migratory routes which connect the two.

5.3.4 Stocking

The serious decline in abundance, and in some instances extinction, of some fish species in the region is likely due to a combination of overfishing and environmental degradation. Without amelioration of these causal factors it would seem unlikely that any artificial stocking will have a lasting impact. At best, the stocked fingerlings would be fished out or succumb to environmentally-induced mortality (such as chemical toxicity, and disease) within one or two years. Rather than tending toward a self sustaining naturally reproducing stock, the species would require continuous stocking year after year to maintain worthwhile levels of yield to the fisheries. Such put-and-take fisheries can operate at some semblance of economic efficiency in certain restricted situation where a high percentage of the stocked fish accrue to the fishery, but it is unlikely than this would be anything other than a huge economic loss on a large floodplain such as the Upper Meghna.

The purpose of stocking and similar artificial propagation programmes should be to build up the natural broodstock of threatened species, and not to attempt to substitute for it by delivering spawn to the floodplain. Such an approach would require a shift in objectives and field activities of the current DOF floodplain stocking programme to the following:

- Identify those endangered species which are of economic importance and require assistance to rebuild declining stocks (*Mohashol, Nandina, Sarputi, Angrot, Mrigel, Pangas*);

- Identify critical habitats and localities of individual endangered species and implement a programme of environmental rehabilitation and protection, including restoration of native floodplain forest, reed and grassland species assemblages. In some cases artificial habitats might have to be provided (ie artificial *kaphs* for *Nandina*). The localities should be designated as fish sanctuaries;

- Develop techniques for artificial propagation of endangered species where these are lacking, and begin releasing juveniles into the fish sanctuaries once these have been rehabilitated to an acceptable level of quality. Environmentally friendly techniques for stocking which do not render stocked fish vulnerable to high rates of natural mortality need to be developed. The practice of poisoning beels with rotenone (and thus corrupting fish biodiversity still further) is an ecologically and socially irresponsible practice and should be terminated immediately.

- A complete moratorium on introduction or further intra-country transfers of exotic species.

The impact of the stocking programmes on fish catches should be monitored by the DOF District and Thana level administration.

5.3.5 Community-based New Fisheries Management Policy

There has been a misguided approach to artisanal fisheries management implemented in many parts of the world during the last few decades based on the assumption that such fisheries are best managed by a central government authority. The almost absolute failure of this approach worldwide suggests that this is not the best approach, and that it has almost no capability of exerting any real management effect on the fishing effort or the fish stocks whatsoever. In implementing central authority fisheries management, efficient pre-existing community-based management (CBM) structures and measures were routinely attacked and in many instances obliterated as central government extended its bureaucratic authority. The almost rampant overfishing and resource mining taking place in the region is evidence that this management approach has served no better in Bangladesh.

It is becoming increasingly clear that a fundamental change in GOB perception of its role in fisheries management has to take place if artisanal fisheries are to remain healthy and productive. This requires government to relinquish primary management responsibilities and return these to the communities which use the resource. Simultaneously, ownership of the resource must also be returned to the fishing communities as usufructuary regimes cannot operate efficiently under the incongruity of the owner and the utilizer of the resource being two different entities. Fishermen will only be motivated to direct a portion of the fish stock (leave it unharvested) into "bio-capital" savings for investment in future years' fish crops if they are 100% assured and secure that they will be able to harvest those next years' fish crops (that they will have fishing rights). They need security of tenure over the resources for a multi-year period, as some species need several years to mature. If their production and management practices are efficient, then the assured tenure period should be lengthy (10-15 years, if not perpetuity) as there can be no

385

good justification for disrupting an efficiently and sustainably operating fishery yielding significant benefits to producers and consumers alike.

The community-based management approach in fisheries is now gaining wide acceptance in many parts of the world, in both developing and developed countries. Fishing communities must themselves determine and enforce management measures limiting fishing effort and protecting broodstock. They are the only agency capable of carrying out cost effective management. It is the fishing communities who will suffer the economic consequences of bad management and stock depletion, and therefore only they will have sufficient incentive to carry out effective management. Closed fishing communities can be expected to limit entry, determine and enforce closed seasons, delimit prohibited fishing grounds, allocate resource exploitation spaces among its members and test and share new technologies. As a political unit, they will also possess increased lobbying power to pressure government for needed support policies and services. Fishing groups must be given long term responsibility for management and conservation of the fishery resources of their jalmohals, including monitoring, surveillance and control. Licensed fishermen coops are already setting up their own surveillance system to prevent fishing by unlicensed fishermen or villagers (spontaneous CBM). There is need to establish a new set of customary fishing rules (building on the existing) which everyone will generally accept and adhere to.

Some examples of community-based management of fisheries still exist in the region and these should be carefully studied. The structures they contain can be of use in setting up the broad architecture of a fisheries CBM system tailored to the particular socioeconomic and environmental conditions of the region. However, it would be an error to be overly concerned with recussitating older local forms of CBM as the only models for a new CBM regime. Fishing communities are quite inventive and once given the opportunity to gain full ownership and management control of local fishery resources they quickly formulate rules and measures (normally featuring both high economic efficiency and high equity) out of their own current needs and conditions. A diversity of CBM forms can thus be expected to emerge. It only remains for GOB to provide the fishing communities with such an opportunity.

The best way for GOB to proceed is to:

- Modify NFMP to include broad CBM regulations;
- Reduce licence fees to a nominal level;
- Implement NFMP over an accelerated timetable to bring most of important jalmohals under nitimala over approximately a 5 year period.

No single measure will suffice, but an integrated multi-component package of management measures and structural adjustments of fisheries tenure and jurisdictions needs to be put in place — in a decisive single process, and not as individual experimental policies. The role of DOF (and other government agencies) must change to a supportive role, responsive to the identified needs and requests of fishing communities, rather than the current executive roles of command, control and rent extraction. Public institutions must support the private sector (ie genuine fishermen) and not seek to usurp their political power or economic output.

Within the context of a CBM-improved NFMP, GOB must establish real plan targets for employment creation, income growth and improved living standards (literacy, education, health and other services of society) for the production and post harvest sectors. This must be actualized through provision of credit, training and human resource development, supply of social services and productivity increases (output per workers) through investment in better technology. A considerable and uncompromising effort must be made to strengthen the position of women in the post harvest sector (processing and marketing) and in net making and repair. Lean fishing period employment needs to be developed (such as handicrafts and vegetable gardening). There needs to be involvement of NGOs in group formation, motivation and cohesion because NGOs have extension-work capabilities that central government cannot compete with. Formation of groups, collection of savings, literacy and other income generating activities will help fishing communities to achieve better living conditions.

A scenario example of a CBM/NFMP improvement for the region is if AFI and KCS "transfer" the leases for the 100+ jalmohals that they now hold to the fishermen who actually do the catching of the fish. The fishermen would benefit greatly because they would receive the full value of the fish they catch, rather than just a small wage or share. AFI and KCS might suffer a loss in so far as they would not have to pay more for their raw material, but the overall net loss would in fact not be that great since they already purchase a substantial portion of their raw material on open markets. As a duopoly AFI and KCS would act to keep prices low. They would also not have to pay the hefty lease fees GOB demands. The net loss to AFI would likely not be that great, and certainly much less than the net gain to the fishermen (provided that the *jalmohals* go under *nitimala* and the government reduces licence fees). An overall gain in social efficiency would be realized.

Older systems of management such as reserve fisheries were religious (Hindu, Muslim) and caste (*Koiborto, Maimol*) based pseudo-privatized systems in the hands of local status quo. These are not especially suited to modern conditions because high population growth pressure has made equity a major issue. Society also no longer has the "luxury" of allowing fish stocks to grow 7 or more years before harvesting. In practice, reserve fisheries may now lead to violent conflicts and thus are not efficient.

5.4 OTHER MEASURES

5.4.1 Floodplain afforestation

Afforestation of the Upper Meghna floodplain is a high priority need which is not yet being addressed. Its importance is highlighted by the fact that local people themselves consider it important and plant *hijal* and *koroch* on a limited scale without any GOB promotion or support. The potential benefits of a floodplain afforestation programme are multifaceted. A support programme should not be limited to particular near-pristine wetland sites (important though these may be) but to all haors in the region. Forests are an important component of fish environments in the haor area. Those haors containing more forests are able to produce more fish. Trees not only produce more fish food in the aquatic habitat (through decomposition of epithelial tissue of branches and fallen leaves), they also serves as a good substrate for periphyton. Moreover birds take shelter on trees, and their droppings help to generate fish food organisms in the aquatic habitat. Due to several reasons, wetland trees in the haor area have been cut down and no new plantation programmes have been taken up (with a very few exceptions) by any organization.The economics of wetland forest plantations are quite favourable. Costs are low. For example, Table 5.8 illustrates costs associated with 7000 *hijal* planted in Tangua Haor in 1992.

302

About 1 month is required for watering of the plants and space required for each plant is about 1-2 sq m.

In the Sunamganj area, probable costs and income from mixed *hijal* and *koroch* plantations on one ha of *khas* land are as in Table 5.9.

The number of branches coppiced and sold would increase as the tree grows. Thus annual incomes in succeeding years would increase. A period of five to six years might be required to fully amortize the investment, after which profit levels would be substantial. A fully mature tree yields on average 6 branches every three years, valued at Tk 300 (at a price of Tk 50 each for large branches). The mean annual return would be Tk 100 per tree, equivalent to Tk 24,300 per ha per year. It may be expected that improved silviculture techniques could result in even higher yields, perhaps 8-10 branches every three years. In view of the high net value of the product, some research into improving hizal silciculture would appear warranted.

Table 5.8: Costs of Planting *Hijal* in Tangua Haor

Cost Items	Cost per Tree (Tk)
Tree	10
Labour	10
Watering	5
Cost of mortality	10
TOTAL	35

Table 5.9: Economics of *Hijal* and *Koroch* Plantations

Parameter	Item	Cost (Tk)
Costs	Planting (270 plants x Tk 5 per plant)	1,350
	Guards (3 years x Tk 12,000 per year)	36,000
	Other	600
	Total Cost	37,950
Benefits	Sale of branches (after 3rd year - 4 per tree per year x Tk 35 per branch)	140
	Total Sales (from 243 trees)	34,020

Notes : Plant type : *Hijal* and *Koroch*
Total area : About 1 ha
Plant to plant distance: 5 m
Total plant required: 270
Survival: 90% (= 243 trees)

The issues of hizal plantation tenure period and management regime are important to the future growth of the lowland forestry sector. Clearly long period (20-25 years) of plantation stewardship are needed. Plantation stewardship systems used elsewhere for mangroves should be tested for management and exploitation of this important wetland forestry resource. Community tenure of plantations is already going on, and is rational and appropriate given that some of the types of benefits which plantations give rise to are shared within the community and given that mostly public khas lands would be used for plantations.

The planting of hizal by fishing communities to produce branches for use in katha can also be an important factor in promoting greater economic equity within the fisheries sector. Katha fishing is the most expensive (but also the most productive) of all openwater fishing methods and requires a substantial capital investment. (Tk 1-5 lakh) which can equal or exceed the amount of lease/licence fees. Poor fishermen are thus unable to gain entry into katha fishing and must be satisfied with cheaper but less productive gears. This type of economic marginalization denies fishermen access to higher productivity means of fishing and mires them in a self perpetuating poverty trap. Fortunately there is a way around this problem of capital scarcity: grow the katha branches, rather than buy them. By establishing hizal plantations around fishing villages, poor fishermen would be in a position to grow their own means of production at low cost and thus be able to use the highly productive katha fishing system. A greater share of the total fish stock would be caught by poor fishermen, and this would represent a progressive redistribution of benefits within the fisheries sector. The motto could be: Grow trees to catch fish to become wealthy.

At present most flood protection embankments are free of trees because they present certain problems:

- They obstruct the movement of vehicles used for inspection and emergency repair.
- The tree root system can introduce seepage paths through the embankment. Under high differential head, water particles find easy passage along the interface of the embankment soil and root system to seep into the protected area and cause piping which leads to embankment failure.
- *Hijal* planted within the river's floodway and near the embankment may deflect the flow causing erosion. In addition, the plants increase resistance to flow, creating eddies and aggravating erosion and flooding. It is thus preferable to keep waterways clear.

A special need associated with afforestation is the need to increase the abundance of reeds in beels within the region. Virtually every beel in the region would benefit from a dense growth of reeds around the margin. The objective should be broader than that of maintaining a single representative reedland ecosystem somewhere in the region. Reeds are needed in every haor, and every beel. They should be part of a fully integrated wetlands CBM package for the entire region.

5.4.2 Effluent treatment

Industrial water pollution requires immediate attention. A turn-key tertiary treatment system should be installed at the Chhatak pulp mill. The plan to shut down the Fenchuganj fertilizer plant should proceed. Consideration could be given to building a new plant using modern environmentally friendly process technology to minimize pollution generation at source.

Sewage treatment in the region is at its infancy. The health risk to the rural public is high during the premonsoon. For small rural point sources sewage should be treated and disposed of diffusely underground. For larger municipal loads, there should be centralized collection and high grade treatment systems to stabilize the effluent and reduce the BOD prior to controlled disposal into major rivers. The river plankton and fish will benefit from the controlled eutrophication and so will the estuarine fisheries once the rivers reach the sea.

5.4.3 Post harvest sector

There are important issues in the post harvest sector which demand a strategic programme response:

- the constrained role of women;
- declining consumption;
- unrealized benefits from fish imports;
- declining fish exports.

Role of Women

There is significant scope to improve and diversify processing methods with much greater participation and income generation for women. Apart from upgrading sun dried products through better hygiene and preservation, opportunities exist for fermented products, salted and smoked products, semi-wet preservation, and a wide host of other processes practiced at artisanal small scale level throughout the world. Women do not work as fish vendors in markets. For a fisherman to spend a significant amount of his time trading fish is a poor use of his time since it interferes with fishing operations and the production of raw material (on which the whole market pyramid rests). A better approach might be to vertically integrated production with processing, transport and marketing within family (extended family) units, as this would allow them to capture the full retail value of the products. The fact that women do not retail fish in markets because of religious and social mores is a major impediment to such a development. The DOF should actively promote fish trading as a profession for women as this is a key potential growth element for the fisheries sector. This would free male labour for more physically arduous tasks in fisheries, and ensure that finance management and capital accumulation is carried out more effectively, as women have demonstrated their superiority in this area in artisanal fisheries in many other developing countries.

Declining Consumption

The future trend of fish consumption in the region will undoubtedly be influenced by population growth (which will tend to a decrease in per person supply) and increased demand from large urban centres outside of the region (further decreasing local regional supply). Increased marketing of miscellaneous species is already occurring, and this trend can be expected to continue. The result will be less fish available for subsistence consumption and greater commercialization of catch. Unless there is a substantial increase in the purchasing power of the rural population of the region, increased transport of fish out of the region is the most likely future scenario. The present population of the region of 17.66 million is likely to increase by 20% over the next decade. Thus by 2001/2 population will reach circa 21.2 million. Assuming that the current estimated nominal per person supply of 6 kg/yr is approximately correct, production from all sources would have to increase by 20,000 t or more just to maintain per person supply at this level.

Increasing capture fishery production would in theory be possible through effective fishing effort management, stock rehabilitation, civil engineering works to increase dry season water hectare-months and installing fish bypass structures. A nominal yield of about 57 kg/ha/yr (compared to the current 45 kg/ha/yr) would need to be achieved to meet in full the projected increase in demand. However this would require a massive structural change, from *jalmohal* leasing and government revenue collection to community-based management and tenure, coupled with a large support programme from the DOF and BWDB. There is no indication that GOB is willing to give up revenue collection from *jalmohals* and transfer ownership of the fishery resources to genuine fishermen, so there are no grounds for optimism that capture fishery production will accelerate in the medium term future. Any increase in the supply of major carp resulting from the current floodplain stocking effort will most likely not be consumed within the region but find its way to more lucrative markets outside the region. Increases in pond culture production might fill part, but not all, of the supply deficit. Pond production is tending to fall back because of diversion of fry to the floodplain stocking programme.

The government's goal nationally over the next decade should be, at the least, to maintain per person fish consumption at its current nominal level. Ideally, a more ambitious goal of increasing per person supply would be desirable but may be unrealistic in the short and medium term. Given the real degree to which government can effectively attempt to stimulate fisheries production in the region and elsewhere in Bangladesh, it seems practically unavoidable that a serious fish supply deficit will materialize during the next decade which will directly and negatively impact consumption.

Fish Imports

The most pragmatic solution to filling the predicted production deficit may be to import cheap and good quality food fish such as frozen small pelagics. The objective should be to achieve a highly positive nutritional balance of trade (import much larger quantities of fish than are exported) given that now Bangladesh exports much more fish product than it imports. The government will need to ensure that imported fish does not destroy market incentives of domestic producers, and that imported frozen species are accepted by consumers (through a concerted effort at market niche development). The market entry point for imported small pelagics could be as frozen fish. Alternatively, imported fish could be thawed and processed into a substitute for the dried sardines and anchovies (*Phasa*) originating from Chittagong which can be found at practically any fish market in the region. As a nationwide marketing and finely-webbed distribution network already exists for this product, a similar imported substitute product would have a ready made market niche and marketing system. It would likely not disrupt domestic production and prices of other fish species which occupy different market niches as the Bangladesh fish market is highly segmented, but only augment the supply of an existing market niche. GOB needs to take two steps to allow this to happen:

- Reduce the current import tariff from 70% to 25% or less (as this tariff acts as a barrier);
- Allocate foreign exchange to finance fish imports.

Declining Fish Exports

Fish imports need not necessarily be financed from export earnings derived from fish exports. Any source of foreign exchange within the macro-economy will do. However, in so far as fish exports contribute to foreign exchange earnings, there is cause for concern in the deteriorating state of prawn and finfish exports from the region. The decline in prawn exports is linked to hydrological factors, and presumably a recovery in production will occur in coming years of high discharge. The decline in finfish is more serious and is systemic in nature. The high prices of raw material are due to both reduced production (combination of deteriorating environment and overfishing) and strong domestic demand (due to population growth). It is not easy to see how the region can once again regain a competitive position in the export market for finfish in the medium term given that the domestic market appears to control prices and forces them above world market prices. Population growth is slowing measurably, but this will not necessarily lead to decreasing demand. Rather, if incomes increase faster than population (the most probable scenario) demand will increase and prices along with it. Higher prices should stimulate production from all sources. But as long as domestic prices remain above world market prices, there will be little incentive to export and products will remain within the country. It would seem that any strategy to increase finfish exports would not be viable under the existing or any likely future macroeconomic conditions (barring a major devaluation of the Taka).

5.4.4 Aquaculture

Although beyond the openwater capture fishery scope of this report, conventional pond culture and other forms of aquaculture need to be taken into account in the formulation of a regional strategy for the fisheries sector. While unsuitable to deeply flooded areas, pond culture production has shown good growth in the last decade on marginally flooded land and flood-free uplands, and steps need to be taken to sustain this growth. A key factor is the supply of seed. Aquaculture is supported by some 20 public sector hatcheries in the region. Hatcheries have now been designated as an industry by the Government, thus qualifying for low interest loans and other incentives. The supply of seed for village ponds is a lucrative and developing business. It was claimed that due to uncontrolled smuggling of fry from India (during the month of May-July), most of the fish seed farms in the Moulvibazar area are now facing a problem of seed marketing as Indian seed is cheaper than Bangladesh seed.

The low level of utilization of many ponds in the region (including derelict GOB-owned ponds) presents additional opportunities for increasing culture fish production.

One possibility for increasing fish production above the natural level is through the use of *katha* as a biological production system, rather than only its current use as a simple fish aggregating device. *Katha* can increase biological production in three ways:

- It creates more secure and diverse spawning habitat for some species. Thus reproductive success is increased.
- It creates more secure nursery habitat by lowering predation rates (the vulnerability of fingerlings to predation is reduced in *katha*). Fry and fingerling survival is thus increased.
- It creates a large food resource due to the growth of periphyton/aufwuchs on the greatly increased surface area of the *katha* brush, upon which juveniles and adults alike feed. This is "free" high quality natural food. Thus, fish growth and condition are increased.

Studies on brush park fish production systems (such as acadja in West Africa) clearly indicate their capability to increase fish production above natural levels. Typical average yields are in the order of 6,000 kg/ha/yr, and under exceptional circumstances up to 26,000 kg/ha/yr has been recorded. A new system is now being developed in Cote d'Ivoire using bamboo stakes in place of brush. Approximately 10 stakes per sq m are required, but bamboo life span in water substantially exceeds that of brush. Current floodplain yield in the region is 45 kg/ha/yr. If large bamboo *katha* were to be installed in key beels, yields could be significantly increased. The bamboo *katha* also has other potential applications: in roadside borrow pits, in aquaculture ponds, and in irrigation canals and khals.

Aquaculture does appear to offer various opportunities for growth in the region's fish production. These can usefully supplement floodplain capture fishery production, although it would perhaps only be a distant long term possibility for culture fishery production to equal or surpass capture fishery production. Euphoric assessments of the "huge potential" type should be tempered by critical assessment of the constraints acting on the aquaculture subsector.

313

6. RECOMMENDED PROJECT PROPOSALS AND MEASURES

6.1 FISHERIES ENGINEERING

A set of projects, pilot projects and initiatives is proposed which are designed to implement the strategy developed in Section 5.2 above. These include:

- Adoption of multipurpose approach to FCD/I planning;
- Beel bypass pilot projects;
- Beel embankment projects;
- Haor zoning pilot project;
- Assessment of efficacy of existing examples of compartmental bunds in haors;
- Vertical slot fishpass pilot projects;
- Pilot project to test navigation gates, within the context of a multiple gates arrangement;
- Pilot project to create artificial duars using spur dykes and bottom sills;

6.2 FISH SANCTUARIES

A fisheries sanctuary programme would have four elements, based on the strategy developed in Sections 5.3.1, 5.3.2 and 5.3.3 above:

- creation of river duar sanctuaries;
- pilot project to test different approaches (total ban, protected *katha*) to creating sanctuaries in larger deeper beels;
- pilot project to create *chotomaach* beel sanctuaries.
- creation of fish sanctuaries at all known or suspected carp breeding localities.

Tentative location for the sanctuary programme are as follows:

Sunamganj District:

- Alam *duar*, Rupa bhui, Nazarkhali, Kawakhal, Barbaria and Ruhar *duar* in Tangua haor, (Tahirpur and Dharmapasha thana).
- Ahmakkhalir *koor* (15m deep) in Shanir haor, (Tahirpur thana).
- Pasuar beelar duba in Pasuar haor, (Dharmapasha thana).
- Dwarabazar duar (26m deep) infront of Dwarabazar market and Bhramangaor *duar* (13m deep) near Sunamganj, Jamlabazar *duar* (15 m deep) near Jamalganj in the Surma.
- Narsingpurar *duar* (11-12m deep) in the Old Surma River, (Sullah thana).
- Digholbagar *duar* (32m deep), Roailar *duar* (31m deep) and Ranigangar *duar* (22m deep) in the Kushiyara, (Jaganathpur thana).
- Guzzia beel, Hingir duba and Tintangiar Kalaram in Konoskai beel, (Dwarabazar thana).
- Mukshedpurar dighor (22m deep), Milanpurar *duar* (22m deep) and Daulatpurar *duar* (13m deep) in the Kawnai River (Dharmapasha thana).
- Chilaura beel in Chilaura haor. (Jaganathpur thana).

315

Moulvibazar District

- Poradair (12m deep) near Islampur, Chorkir duar (21m deep) near Abdullahpur in the Kushiyara. (Rajnagar thana).
- Part of Katasingra, Shalkatua and Mazarbhanga beel in Kawadighi haor (Rajnagar thana).
- Part of Chatal beel, Dulla beel, Parjalla beel, Baghalkuri beel and Tural beel in Hakaluki haor (Barlekha and Kulaura thana).
- Gopla river (4th part) and beel duba in Hail haor. (Srimangol thana).

Sylhet District

- Telanjir *duar* (25-26m deep), Jalmarar *duar* (20-23m deep), Bhuktar *duar* (15-17m deep) in the Hari-Goyain River. (Jaintapur thana).
- Kukubarir *duar* (12-14m deep), Baganar *duar* (12-14m deep), Bagbarir *duar* (15-16m deep),Barar *duar* (27-30m deep), Mainrir *duar* (27-30m deep) in the Lubha. (Kanaighat thana).
- Nogrir *duar* (10m deep) in front of Goyainghat and Dhumkhalar *duar* (10m deep) in front of Zilkar haor sluice gate in the Sari-Goyain River.
- Charir *duar* (15-17m deep) and Kakordir *duar* (15-16m deep) in the Kushiyara River. (Beanibazar thana).
- Digholir *duar* (10-11m deep) in the Surma near Sylhet.
- Part of Rauchunni beel in Goyainghat thana.

Kishoreganj District

- Mendipurar *duar* and Echordir *duar* in the Upper Meghna. (Bhairab bazar thana).
- Kuniartak in the Kali River. (Kuliarchar thana).
- Garumarar khal, Barakhalar muk and Dighirparar *duar* in the Bengla fishery and the Ghorautra (Bajitpur thana).
- Part of Raoda beel in Bajitpur thana.
- Part of Aharma and Khoilla beel in Karimganj thana.
- Itnar *duar* in the Dhanu River, (Itna thana).

Netrokona District

- Chorkir *duar*, Boiragir khaw, Shaintar *duar*, Katwagarar khaw and Elonguri fishery in the Piyain (Khaliajuri thana).
- Bandukkhalir duba (9-10m deep), Kolomduar (9-10m deep) in the Kangsha (Purbadhala thana).
- Amirkhar duba (9-10m deep) and Gulduba (9-10m deep) in the Bishnai (Atpara thana).
- Kalibarir *koor* (10-11m deep), Nazirgangar *koor* (9-10m deep) and Parashkhilar duba (10-11m deep) in the Mogra (Atpara thana).

6.3 FISH BIODIVERSITY

The strategy to rebuilding the stocks of threatened species in the region (Section 5.3.4) should be actualized through a project with the following elements:

- Creation of protected areas and enhancement of habitat for threatened species;

- Artificial propagation and stocking of protected areas with threatened *boromaach* and *chotomaach*;

6.4 FISHERIES MANAGEMENT

GOB should create a new fisheries tenure and management regime based on the strategy developed in Section 5.3.5 above. This should include the following elements:

- Upgrading NFMP to include CBM approach, including investing resource tenure and management authority rights with fishing communities;
- Reduction of licence fees to nominal amounts;
- Redefinition of GOB role in management as one mainly supportive of local community initiatives, rather than as executing its own initiatives;
- Accelerate timetable of transfer of jalmohals from leasing system to NFMP;
- Formulation of a job creation and manpower development plan.

6.5 FISHERIES POST HARVEST SECTOR

The strategy for the post harvest sector (Section 5.4.3) should be implemented by two projects:

- Women fish traders project, to improve and diversify artisanal fish processing and develop business and fish marketing skills for women;
- Importation and marketing of frozen small pelagics.

Policy adjustments to reduce import tariffs and release foreign exchange will be require to carry out the latter project.

6.6 PUBLIC FISHERIES INSTITUTIONS

Implementation of the above projects, programmes and initiatives will require structural changes to the fisheries sector. This will necessitate changes to the organization and functions of public fisheries and related institutions (DOF, BFDC, FRI, BWDB, DOFr and others), both to carry out new supportive mandates and to facilitate and enable the structural changes to come about. Some key changes required are:

- NFA: Strengthening its capabilities to carry out its mandate as the organization representing fishermen at national, district and local thana levels.
- DOF: Establishment of new units to implement projects in fisheries engineering and CBM-improved NFMP; better staff training and incentives.
- BFDC: Divestment and privatization of Dabor Fish Marketing facility.

- FRI: Increased research focus on floodplain fisheries, with emphasis on stock dynamics, biodiversity and water/habitat quality.
- BWDB: Establishment of a fisheries engineering unit.
- DOFr: Establishment of a floodplain afforestation unit.

3̶1̶7̶

6.7 POTENTIAL INITIATIVES LISTED BY DISTRICTS

6.7.1 Moulvibazar District

Problem: Overfishing reduces brood fish stock, which leads to low recruitment on the floodplain.

Initiative: Establishment of fish sanctuaries in the river duars and selected beels.

Tentative locations:

For carp and large catfish:

- Kushiyara river: Koradair near Islampur village and Chorkir *duar* near Abdullahpur village in Rajnagar thana.
- Kawadighi haor: Part of Katasingra, Shalkatua and Mazarbhanga beel in Rajnagar thana.
- Hakaluki haor: Part of Chatal beel, Dulla beel, Parjalla beel, Baghalkuri beel and Tural beel in Barlekha and Kulaura thana.

For smaller species of fish and catfish:

- Hail haor: Gopla river (4th part) and beel duba in Srimangal thana.

Description: Survival of overwintering broodstock is a controlling factor of openwater fisheries productivity. To enhance survival, this program would establish fish sanctuaries in key habitats in the floodplain areas.

Impacts: Increased brood fish conservation and sustainable new recruitment to the floodplain.

Problem: FCDI projects create obstacle to fish migration, to spawning, grazing, and overwintering grounds which leads to reduced fish production.

Initiative: Construction of fish bypass structure at selected FCD/I projects.

Tentative locations: Munia River mouth near Jahidpur, Koradair near Pump house and Masuakhali canal of Kawadighi haor, Rajnagar thana.

Description: Replacing of some existing fall boards and one way type steel gates into appropriate fish bypass structures would facilitate fish migration in and out of the beels/haor during the pre-monsoon and post monsoon period.

Impacts: Facilitate fish breeding and reduce brood fish catches during the migration period.

Problem: Expansion of agricultural land leads to extensive and rapid deforestation as well as a reduced fish habitat by shrinking water bodies during the dry season.

Initiative: Construction of bunds and or embankments around beels or beel clusters from the paddy lands.

Tentative Locations: Hail haor main basin in Srimangal thana.

Description: Includes both the conventional peripheral submersible embankment and the beel bypass structure. The conventional embankment with regulators between the beel complex and the river will maximize dry season water storage volume. It will physically separate the dry and wet lands of the haor area.

Impact: Loss of fish production can be compensated to some degree by increasing the areas of water bodies during the monsoon.

Problem: Rapid deforestation (trees and reeds) on the floodplain causes fish loss by reducing fish refuge area, fish food organisms, and breeding places for fish.

Initiative: Massive afforestation program in the wet land and canal/river embankment areas. Maintenance of brush and reed lands in each haor.

Tentative locations: High lands around Chatal beel, Dulla beel, Kalapani, Bagholkuri beel, Pliaula, Pulabhanga, Tural beel, Barajalla, Parjalla, Pinglerkona Hawakhal, Sakua beel, Abonya beel, Tekoni beel of Hakaluki haor area in Barlekha and Kulaua thana.
Description: At least 15-20 ha of Government *khas* land is required in each haor to be used as brush and reed (such as *Chailla bon, echor, nolkhagra, binna*) sanctuary. River, canal and beel area embankments would come under *Hijal, Koroch* and other water resistant tree planting programs.
Impact: Give refuge to larger fish populations during the flood season and serve as a substrate for fish food organisms.

Problem: The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.
Initiative: Establish community fisheries centres near cluster fishermen villages.
Tentative Locations:

- Baruna or any other fishermen village around Hail haor in Srimangal Thana;
- Antahori village in Kawadighi haor in Rajnagar Thana;
- any other fishermen village Hakaluki haor in Barlekha or Kulaura Thana.

Description: A low-cost fishing centre (building) where fishermen can meet to discuss, among other things, problems and plans related to *jalmohal* management. The centre would also serve as a training centre and repository for pertinent records related to local fisheries. The centres would be established on *khas* land and be managed by the fishermen who use it.
Impact: Improved planning, coordination, and overall management of fisheries resources.

Other problems:

Illegal fishing gears such as current *jal, kona ber jal*, and *Jam jal*, catch all juveniles, under sized, and brood fish. Such gears are operated mainly on the floodplain, rivers, and *duars*. Although current *jal* is illegal, it is sold openly at markets in the area. Strict restriction of production and marketing of all illegal gears is urgently needed.
Fishing system: Annual fishing and fishing by draining of beels causes the maximum harvest or total harvest of the fish stock without keeping any broodstock for future production. Prohibition of drying or poisoning of beels should be strictly enforced.
Jalmohal leasing system: Short term leasing and insufficient security encourages over exploitation. The majority of the *jalmohals* are under the economically unsound *jalmohal* leasing system. The New Fisheries Management Policy (NFMP) represents the main hope for instituting a new fisheries tenure, access and management regime which is capable of achieving socially and economically sound resource management and conservation. Lack of strong homogenous fishermen group is a major constraint to implement the *nitimala*. Community Based Fisheries Management (CBFM) is the best alternative to the ineffectual conventional central authority based management regime. The fishery resource must be owned by the real fishermen themselves.

Industrial pollution: Water pollution from the Fenchuganj fertilizer factory (which discharges toxic ammonia, sulphuric acid, caustic soda and other chemicals) has severe negative impacts on fisheries in the Kushiyara and its floodplain. The plant is scheduled to be closed and this should be carried out as planned. In the interim, a more effective treatment procedure for the effluent should be employed.

319

6.7.2 Sunamganj District

Problem: Overfishing reduces brood fish stock which leads to low recruitment on the floodplain.

Initiative: Establishment of fish sanctuaries in the river duars and selected beels.

Tentative location:

For carp and large catfish:

- Tangua haor, Tahirpur and Dharmapasha thana: Alam *duar*, Rupa bhui, Nazarkhali, Kawakhal and Ruhar dair area.
- Pasuar haor, Dharmapasha thana: Pasuar beelar duba.
- Surma river: Dwarabazarar *duar* in Dwarabazar, Bhramangaor *duar* in Sunamganj thana.
- Kushiyara river: Roailar *duar* and Ranigangar *duar* in Jaganathpur thana.
- Konoskai beel: Guzzia beel, Hingir duba and Tintangiar Kalaram in Dwarabazar thana.
- Mukshedpurar dighor in Dharmapasha thana.

For smaller species of fish:

- Chilaura haor; Chilaura beel in Jaganathpur thana.

Description: Survival of overwintering broodstock is a controlling factor of total open water fisheries productivity. To enhance survival, this program would establish fish sanctuaries in key habitats in the floodplain areas.

Impacts: Increased broodfish conservation and sustainable new recruitment to the floodplain.

Problem: FCD/I projects create obstacle to fish migration to spawning, grazing and overwintering grounds which led to a reduction in fish production.

Initiative: Construction of fish bypass structure at selected FCD/I projects.

Tentative locations: Boiggani fishery, Morala, Tahirpur in Shanir haor, Kalner haor sluice gate in Sunamganj, Gazaria regulator-Pagner haor in Jamalganj, Phata beel regulator-Naluar haor in Jaganathpur.

Description: Replacing of some existing fall boards and one way type steel gates with appropriate fish bypass structures would facilitate fish migration in and out of the beels/haors during the pre-monsoon and post monsoon period.

Impacts: Facilitate fish breeding and reduce brood fish catches during the migration period.

Problem: Expansion of agricultural land leads to extensive and rapid deforestation as well as a reduction in fish habitat by shrinking of water bodies during the dry season.

Initiative: Construction of bunds and/or embankments around beels or separation through zoning of beel clusters from the rice fields.

Tentative Locations: Shanir haor in Tahirpur, Bhanda beel in Sullah, Dhankunia beel (Dhankunia haor) in Sunamganj, Pasuar beel (Gurmar haor) in Dharmapasha, Karchar beel in Bishwambarpur, Jaydhona beel in Dharmapasha thana.

Description: Includes both the conventional peripheral submersible embankment and the beel bypass structure. The conventional embankment with regulators between the beel complex and the river will maximize dry season water storage volume. It will physically separate the dry and wet lands of haor areas.

Impact: Loss of fish production can be compensated to some degree by increasing the areas of dry season water bodies.

Problem: Rapid deforestation (trees and reeds) on the floodplain causes fish loss by reducing fish refuge areas, fish food organisms, and fish breeding places.

Initiative: A massive afforestation program in the wet land and canal/river embankment areas. Maintenance of brush and reed lands in each haor.

Tentative locations: Almost all haor areas in the district.

Description: At least 15-20 hectares of Government khas land is required in each haor to be used as brush and reed (such as *Chailla bon, echor, nolkhagra, binna*) sanctuaries. River, canal, and beel area embankments would come under *Hijal, Koroch* and other water resistant tree planting programs.

Impact: Give refuge to large fish populations during the flood season and serve as a substrate for fish food organisms.

Problem: The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.

Initiative: Establish community fisheries centres near cluster fishermen villages.

Tentative Locations:

- Cluster fishermen villages around Tanguar haor, Matian haor and Shanir haor in Tahirpur Thana;
- cluster fishermen village around Pagnar haor, Halir haor area in Jamalganj Thana;
- cluster fishermen village around Bhanada beel area in Sullah Thana;
- Markuli village near Tanguar haor, Baram haor, Chaptir haor or any other place in Derai Thana;
- cluster fishermen village around Gurmor haor, Sonamoral haor, Togar haor and Rui beel area in Dharmapasha Thana.

Description: A low-cost fishing centre (building) where fishermen can meet to discuss, among other things, problems and plans related to *jalmohal* management. The centre would also serve as a training centre and repository for pertinent records related to local fisheries. The centres would be established on *khas* land and be managed by the fishermen who use it.

Impact: Improved planning, coordination, and overall management of fisheries resources.

6.7.3 Sylhet District

Problem: Overfishing reduces brood fish stock which leads to low recruitment on the floodplain.

Initiative: Establishment of fish sanctuaries in the river duars and selected beels.

Tentative location:

For carp and large catfish:

- Telanjir *duar*, Jalmarar *duar*, Bhuktar *duar* in the Sari Goyain, Jaintiapur Thana;
- Kukubarir *duar*, Baganar *duar*, Bagbarir *duar*, Barar *duar* and Mainrir *duar* in the Lubha, Kanairghat Thana;
- Charir *duar* and Kakordir *duar* in the Kushiyara, Digholir *duar* in the Surma, Sadar Thana;
- Ruila beel, Companiganj Thana.

For smaller species of fish:

- Rouchunni beel, Titkuri beel and Silchand beel in Goyainghat Thana;
- Panichapra beel in Companiganj Thana;
- Maijal beel in Balaganj Thana.

321

Description: Survival of overwintering broodstock is a controlling factor of total open water fisheries productivity. To enhance survival, this program would establish fish sanctuaries in key habitats in the floodplain areas.

Impacts: Increased broodfish conservation and sustainable new recruitment to the floodplain.

Problem: FCD/I projects create obstacle to fish migration to spawning, grazing and overwintering grounds which led to a reduction in fish production.

Initiative: Construction of fish bypass structure at selected FCD/I projects.

Tentative locations: Dhum khalar regulator of the Zilkar haor project, Sadar Thana.

Description: Replacing of some existing fall boards and one way type steel gates with appropriate fish bypass structures would facilitate fish migration in and out of the beels/haors during the pre-monsoon and post monsoon period.

Impacts: Facilitate fish breeding and reduce brood fish catches during the migration period.

Problem: Rapid deforestation (trees and reeds) on the floodplain causes fish loss by reducing fish refuge areas, fish food organisms, and fish breeding places.

Initiative: A massive afforestation program in the wet land and canal/river embankment areas. Maintenance of brush and reed lands in each haor.

Tentative locations: *Khas* lands of Medholhaor, Kawadighi haor, and Hakaluki haor.

Description: At least 15-20 hectares of Government khas land is required in each haor to be used as brush and reed (such as *Chailla bon, echor, nolkhagra, binna*) sanctuaries. River, canal, and beel area embankments would come under *Hijal, Koroch* and other water resistant tree planting programs.

Impact: Give refuge to large fish populations during the flood season and serve as a substrate for fish food organisms.

Problem: The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.

Initiative: Establish community fisheries centres near cluster fishermen villages.

Tentative Locations: Cluster fishermen village in Goyainghat; Islampur village in Fenchuganj; Thana headquarters in Balaganj, Biswanath, and Miragoan.

Description: A low-cost fishing centre (building) where fishermen can meet to discuss, amoung other things, problems and plans related to *jalmohal* management. The centre would also serve as a training centre and repository for pertinent records related to local fisheries. The centres would be established on *khas* land and be managed by the fishermen who use it.

Impact: Improved planning, coordination, and overall management of fisheries resources.

6.7.4 Habiganj District

Problem: Overfishing reduces brood fish stock which leads to low recruitment on the floodplain.

Initiative: Establishment of fish sanctuaries in the river duars and selected beels.

Tentative location:

For carp and large catfish:

- Morka Kalni Gulma River in Salimpur and Masumpur, Nabiganj Thana;
- Dhaleswari (part 4) from Madna to Astagram, Lakhai Thana.

For smaller species of fish:

- Ballo-Poaballow beel, Kakdor beel and Chatal beel in Mokar haor, Nabiganj Thana;
- Berri beel and Chapra beel in Gungagajuri haor, Nabiganj and Baniachong Thanas;
- Shagor Bhanga beel and Jharar beel, Baniachong Thana.

Description: Survival of overwintering broodstock is a controlling factor of total open water fisheries productivity. To enhance survival, this program would establish fish sanctuaries in key habitats in the floodplain areas.

Impacts: Increased broodfish conservation and sustainable new recruitment to the floodplain.

Problem: Rapid deforestation (trees and reeds) on the floodplain causes fish loss by reducing fish refuge areas, fish food organisms, and fish breeding places.

Initiative: A massive afforestation program in the wet land and canal/river embankment areas. Maintenance of brush and reed lands in each haor.

Tentative locations:

- *Khas* land in Ganjiajuri and Mokar haors;
- Along the left bank of the Kushiyara from Bheramona to Madna;
- Around the Kodalia fishery near Jalsuka village, Ajmiriganj Thana;
- Sutki embankment, Baniachong thana.

Description: At least 15-20 hectares of Government khas land is required in each haor to be used as brush and reed (such as *Chailla bon, echor, nolkhagra, binna*) sanctuaries. River, canal, and beel area embankments would come under *Hijal, Koroch* and other water resistant tree planting programs.

Impact: Give refuge to large fish populations during the flood season and serve as a substrate for fish food organisms.

Problem: The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.

Initiative: Establish community fisheries centres near cluster fishermen villages.

Tentative Locations:

- Dhaleswari/Upper Meghna River site in Lakhai thana;
- Mokar haor and Gungajuri haor sites in Nabiganj and Baniachong thana.

Description: A low-cost fishing centre (building) where fishermen can meet to discuss, amoung other things, problems and plans related to *jalmohal* management. The centre would also serve as a training centre and repository for pertinent records related to local fisheries. The centres would be established on *khas* land and be managed by the fishermen who use it.

Impact: Improved planning, coordination, and overall management of fisheries resources.

6.7.5 Kishoreganj District

Problem: Overfishing reduces brood fish stock which leads to low recruitment on the floodplain.

Initiative: Establishment of fish sanctuaries in the river duars and selected beels.

Tentative location:

For carp and large catfish:

- Sainna beel and adjacent linked canal near Shaila village, Itna Thana;

323

- Part of Bangla fishery in Humaipur haor (Boali-Shibpur village), Bajitpur; Ainargoop, Chatalpar and Mendipurar *duar* in the Upper Meghna, Astagram and Kuliarchar Thanas;
- Kunnartak area in the Kali River, Kuliarchar Thana;
- Part of Boribari area in the Narsunda near Tarail Thana.

For smaller species of fish:

- Roadha beel, Aharma beel, Khoilla beel and Dudha beel in Bajitpur, Karimganj and Astagram Thanas respectively.

Description: Survival of overwintering broodstock is a controlling factor of total open water fisheries productivity. To enhance survival, this program would establish fish sanctuaries in key habitats in the floodplain areas.

Impacts: Increased broodfish conservation and sustainable new recruitment to the floodplain.

Problem: FCD/I projects create obstacle to fish migration to spawning, grazing and overwintering grounds which led to a reduction in fish production.

Initiative: Construction of fish bypass structure at selected FCD/I projects.

Tentative locations: Barabari beel regulator of the Dewghar haor project, Astagram Thana; Barakhal regulator near Boali-Shibpur village in Humaipur haor project, Bajitpur Thana.

Description: Replacing of some existing fall boards and one way type steel gates with appropriate fish bypass structures would facilitate fish migration in and out of the beels/haors during the pre-monsoon and post monsoon period.

Impacts: Facilitate fish breeding and reduce brood fish catches during the migration period.

Problem: Expansion of agricultural land leads to extensive and rapid deforestation as well as a reduction in fish habitat by shrinking of water bodies during the dry season.

Initiative: Construction of bunds and/or embankments around beels or separation through zoning of beel clusters from the rice fields.

Tentative Locations: Boro beel and Gazaria beel in Gazaria beel project Karimganj Thana.

Description: Includes both the conventional peripheral submersible embankment and the beel bypass structure. The conventional embankment with regulators between the beel complex and the river will maximize dry season water storage volume. It will physically separate the dry and wet lands of haor areas.

Impact: Loss of fish production can be compensated to some degree by increasing the areas of dry season water bodies.

Problem: Rapid deforestation (trees and reeds) on the floodplain causes fish loss by reducing fish refuge areas, fish food organisms, and fish breeding places.

Initiative: A massive afforestation program in the wet land and canal/river embankment areas. Maintenance of brush and reed lands in each haor.

Tentative locations:

- Humaipur haor embankment in Bajitpur Thana;
- Kanda's of Sainna beel and Firagang area in Itna Thana;
- Dewghar haor embankment near Echordia, Astagram Thana.

Description: At least 15-20 hectares of Government khas land is required in each haor to be used as brush and reed (such as *Chailla bon, echor, nolkhagra, binna*) sanctuaries.

River, canal, and beel area embankments would come under *Hijal, Koroch* and other water resistant tree planting programs.

Impact: Give refuge to large fish populations during the flood season and serve as a substrate for fish food organisms.

Problem: The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.

Initiative: Establish community fisheries centres near cluster fishermen villages.

Tentative Locations:

- Dighirpar/Ahsanpur/Boali-Shibpur village around the Bangla fishery, Bajitpur Thana;
- Bangalpara or Echordia village near the Upper Meghna River, Astagram Thana;
- Kuliarchar fish market, Kuliarchar Thana;
- Dhailong village, Itna Thana.

Description: A low-cost fishing centre (building) where fishermen can meet to discuss, amoung other things, problems and plans related to *jalmohal* management. The centre would also serve as a training centre and repository for pertinent records related to local fisheries. The centres would be established on *khas* land and be managed by the fishermen who use it.

Impact: Improved planning, coordination, and overall management of fisheries resources.

6.7.6 Netrokona District

Problem: Overfishing reduces brood fish stock which leads to low recruitment on the floodplain.

Initiative: Establishment of fish sanctuaries in the river duars and selected beels.

Tentative location:

For carp and large catfish:

- Chorkir *duar*, Boiragir khaw, Shantir *duar*, Katwagarar khaw and Elonjurir *duar* in the Piyain River, Kaliajuri Thana (Laipsa area);
- Ballavpurar *duar* in the Mora Dhanu River, Kaliajuri Thana;
- Nawtanar *duar* and Jaganathpurar *duar* in the Dhanu River, Kaliajuri Thana;
- Badukkhalir *duba* and Kolomar *duar* in the Kangsha River, Purbadhala Thana;
- Amirkhar *duba*, Gulduba, Nazirgangar *koor* and Kalibarir *duba* in the Bishnai/Mogra River, Atpara Thana.

For smaller species of fish:

- Part of Sitli beel in Durgapur Thana; Uglar beel in Kalmakanda Thana;
- Askuri beel in Atpara Thana;
- Part of Makhnai beel and Ratna beel in Kaliajuri Thana.

Description: Survival of overwintering broodstock is a controlling factor of total open water fisheries productivity. To enhance survival, this program would establish fish sanctuaries in key habitats in the floodplain areas.

Impacts: Increased broodfish conservation and sustainable new recruitment to the floodplain.

Problem: FCD/I projects create obstacle to fish migration to spawning, grazing and overwintering grounds which led to a reduction in fish production.

Initiative: Construction of fish bypass structure at selected FCD/I projects.

Tentative locations: Nawtana regulator in the Nawtana project, Kaliajuri Thana.

Description: Replacing of some existing fall boards and one way type steel gates with appropriate fish bypass structures would facilitate fish migration in and out of the beels/haors during the pre-monsoon and post monsoon period.

Impacts: Facilitate fish breeding and reduce brood fish catches during the migration period.

Problem: Rapid deforestation (trees and reeds) on the floodplain causes fish loss by reducing fish refuge areas, fish food organisms, and fish breeding places.

Initiative: A massive afforestation program in the wet land and canal/river embankment areas. Maintenance of brush and reed lands in each haor.

Tentative locations:

- *Khas* lands in Pangasiar haor (around the Laipsa, Jaganathpur, Elongjuri, Faridpur, Rangchapur, Rautala villages), Chella piya (around Adampur Goalbari, Ballavpur, Kartikpur), Nawtana embankment in Kaliajuri Thana;
- *Khas* lands of Kalmakanda, Durgapur, Purbadhala, Atpara and Madan Thanas.

Description: At least 15-20 hectares of Government khas land is required in each haor to be used as brush and reed (such as *Chailla bon, echor, nolkhagra, binna*) sanctuaries. River, canal, and beel area embankments would come under *Hijal, Koroch* and other water resistant tree planting programs.

Impact: Give refuge to large fish populations during the flood season and serve as a substrate for fish food organisms.

Problem: The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.

Initiative: Establish community fisheries centres near cluster fishermen villages.

Tentative Locations:

- Roail beel area within Nawtana project, Laipsa bazar in Kaliajuri Thana;
- Thana headquarters in Kalmakanda Thana;
- Jaria bazar in Purbadhala Thana;
- Jahangirpur in Madan Thana;
- Kalibari in Atpara Thana.

Description: A low-cost fishing centre (building) where fishermen can meet to discuss, amoung other things, problems and plans related to *jalmohal* management. The centre would also serve as a training centre and repository for pertinent records related to local fisheries. The centres would be established on *khas* land and be managed by the fishermen who use it.

Impact: Improved planning, coordination, and overall management of fisheries resources.

6.7.7 Narsingdi District

Problem: Overfishing reduces brood fish stock which leads to low recruitment on the floodplain.

Initiative: Establishment of fish sanctuaries in the river duars and selected beels.

Tentative location:

For carp and large catfish:

- An area of about 2 km^2 from Bandarghat to Merakhali via Napitar char ferry ghat and another area of about 2 km^2 from Bajnar *natun* bazar to Chandipara in Arial kha River, Belabo Thana;
- An area of about 2 km^2 near Nurpur village and another area between Srinagar and Jagatpur village along the Upper Meghna in Raipura and Sadar Thanas;
- An area of about 6 km^2 between Meratali and Domrakanda village along the Old Brahmaputra, Belabo Thana.

Description: Survival of overwintering broodstock is a controlling factor of total open water fisheries productivity. To enhance survival, this program would establish fish sanctuaries in key habitats in the floodplain areas.

Impacts: Increased broodfish conservation and sustainable new recruitment to the floodplain.

Problem: Expansion of agricultural land leads to extensive and rapid deforestation as well as a reduction in fish habitat by shrinking of water bodies during the dry season.

Initiative: Construction of bunds and/or embankments around beels or separation through zoning of beel clusters from the rice fields.

Tentative Locations:

- Bhatarchar boro beel (Narayanpur union) and Borodaha beel (Binnabath union) in Belabo Thana;
- Chandul beel, Kala beel and Sonaikandi beel in Raipura Thana;
- Nali beel in Monohordi thana and Shilmondi beel in Sadar Thana.

Description: Includes both the conventional peripheral submersible embankment and the beel bypass structure. The conventional embankment with regulators between the beel complex and the river will maximize dry season water storage volume. It will physically separate the dry and wet lands of haor areas.

Impact: Loss of fish production can be compensated to some degree by increasing the areas of dry season water bodies.

Problem: The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.

Initiative: Establish community fisheries centres near cluster fishermen villages.

Tentative Locations:

- Baharchar or Muradnagar fishermen village, Sadar Thana;
- Meratali fishermen village in Belabo Thana.

Description: A low-cost fishing centre (building) where fishermen can meet to discuss, amoung other things, problems and plans related to *jalmohal* management. The centre would also serve as a training centre and repository for pertinent records related to local fisheries. The centres would be established on *khas* land and be managed by the fishermen who use it.

Impact: Improved planning, coordination, and overall management of fisheries resources.

322

6.7.8 Narayanganj District

Problem: Overfishing reduces brood fish stock which leads to low recruitment on the floodplain.

Initiative: Establishment of fish sanctuaries in the river duars and selected beels.

Tentative location:

For carp and large catfish:

- Nunartakar *duar* (Boiddarbazar) in the Upper Meghna, Sonargaon Thana

Description: Survival of overwintering broodstock is a controlling factor of total open water fisheries productivity. To enhance survival, this program would establish fish sanctuaries in key habitats in the floodplain areas.

Impacts: Increased broodfish conservation and sustainable new recruitment to the floodplain.

Problem: Rapid deforestation (trees and reeds) on the floodplain causes fish loss by reducing fish refuge areas, fish food organisms, and fish breeding places.

Initiative: A massive afforestation program in the wet land and canal/river embankment areas. Maintenance of brush and reed lands in each haor.

Tentative locations: Plantation of *Hijal/Koroch* along the Upper Meghna River near Boiddar bazar area, Sonargaon thana

Description: At least 15-20 hectares of Government khas land is required in each haor to be used as brush and reed (such as *Chailla bon, echor, nolkhagra, binna*) sanctuaries. River, canal, and beel area embankments would come under *Hijal, Koroch* and other water resistant tree planting programs.

Impact: Give refuge to large fish populations during the flood season and serve as a substrate for fish food organisms.

Problem: The absence of strong leadership, poor communication facilities, and inadequate infrastructure prevents the fishing community from adequately defending its interests.

Initiative: Establish community fisheries centres near cluster fishermen villages.

Tentative Locations: Ananda bazar or Boiddar bazar ghat and a cluster village near Nunartak in Sonargaon Thana.

Description: A low-cost fishing centre (building) where fishermen can meet to discuss, amoung other things, problems and plans related to *jalmohal* management. The centre would also serve as a training centre and repository for pertinent records related to local fisheries. The centres would be established on *khas* land and be managed by the fishermen who use it.

Impact: Improved planning, coordination, and overall management of fisheries resources.

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329

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