
Government of Bangladesh
Ministry of Fisheries and Livestock
Department of Fisheries

World Bank

**FOURTH
FISHERIES
PROJECT PREPARATION**

**Annex 9:
Environmental Assessment**

Draft Final Report

Prepared by
Garry M Bernacsek
GLOBAL AQUATIC CORPORATION Pty Ltd
Sydney, Australia
and

Yusuf Sharif Ahmed Khan
Institute of Marine Sciences
Chittagong University
Chittagong

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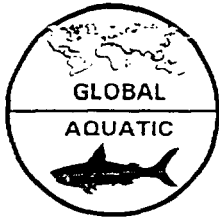
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PRELIMINARY REPORT

By

DETECON for the World Bank

December 1997



GLOBAL AQUATIC CORPORATION Pty.Ltd.

SOLUTIONS FOR ENVIRONMENT & FISHERIES

9 Dec 1997

Mr Nasir Uddin Ahmed
Director (Inland Fisheries)
Department of Fisheries
Matshya Bhaban
Dhaka

Dear Mr Ahmed

Subject: **Fourth Fisheries**
Annex 9: Environmental Assessment
Draft Final Report

It is my pleasure to submit to the Department of Fisheries the master copy of the above report. I enclose also a computer disk with the report files.

Thank you for the opportunity to work on this interesting and important project. I hope that the work of Global Aquatic and our cooperating partner is to your satisfaction, and we await your comments.

With best regards,

A handwritten signature in cursive script, appearing to read "Garry Bernacsek". The signature is written in black ink and is positioned above a horizontal line.

Garry Bernacsek
Executive Director

NOTE TO READER

Due to time and logistic constraints this draft final report is incomplete in certain respects. Indicated items will be completed by February 1998 by the national consultant.

Four regional workshops and one national workshop will be held during December 1997 and January 1998. Their outputs will be used to modify the final report.

ACRONYMS AND ABBREVIATIONS

BCG	Bangladesh Coast Guard
BIWTA	Bangladesh Inland Water Transport Authority
CAS	Catch assessment survey
CBA	Cost-benefit analysis
CO	Community Organizer
DC	District Commissioner
DFO	District Fisheries Officer
DOE	Department of Environment
DOF	Department of Fisheries
DOFr	Department of Forestry
DORH	Department of Roads and Highways
EAG	Environmental Advisory Group
EIG	EMP Implementation Group
EMONP	Environmental Monitoring Plan
EMP	Environmental Management Plan
ESC	Environmental Steering Committee
ESR	Environmental Status Report
EUS	Epizootic ulcerative syndrome disease
FAP	Flood Action Plan
FCDI	Flood control, drainage & irrigation project
GOB	Government of Bangladesh
GON	Government of the Netherlands
IBJRC	Indo-Bangladesh Joint Rivers Commission
IDA	International Development Association
IRR	Internal rate of return
LGED	Local Government Engineering Department
MOFL	Ministry of Fisheries and Livestock
MOL	Ministry of Land
NFMP	New Fisheries Management Policy
NPV	Net present value
O&M	Operation and maintenance of water management structures
SWMC	Surface Water Modelling Centre
TFO	Thana Fisheries Officer
WB	World Bank

GLOSSARY

<i>aaratdar</i>	Trader with a space for storing commodities
<i>abadi</i>	Outside settler
<i>akai</i>	Gleaning of submerged rice
<i>aman</i>	Monsoon rice crop harvested in November/December
<i>barga</i>	Share cropping
<i>barman</i>	Hindu sub-caste whose major profession is fishing
<i>beel</i>	Floodplain lake which may hold water permanently or dry up during the winter season
<i>bepari</i>	Harvester of <i>boro</i> rice who generally comes from outside the area
<i>bhagi</i>	Share cropping
<i>bhasha</i>	One method of fishing
<i>bigha</i>	Local unit of land measurement (one <i>bigha</i> = 0.13 ha)
<i>bisra</i>	Area adjacent to a homestead and intermediate in height between the homestead and rice fields, on which vegetables are grown
<i>biyash</i>	A tree species used as fuelwood (<i>Salix tetrasperma</i>)
<i>boro</i>	Rice grown in the dry season and harvested in April/May
<i>borun</i>	A tree species used as fuelwood (<i>Crataera nurvala</i>)
<i>chaila</i>	A long grass grown in lowlands (<i>Hematheria potensa</i>)
<i>chada</i>	Contribution
<i>changari</i>	Platform made to dry fish
<i>chhon (ululbinna)</i>	A grass used to thatch house rooves
<i>chukti</i>	Seasonal lease of agricultural land with an agreed fixed amount of the produce to be paid after the harvest
<i>chula</i>	Cooking place (oven)
<i>dair/chhit</i>	Terrace of shallow channels within a rice field
<i>dalal</i>	Commission agent
<i>deta</i>	Rice straw
<i>dhara</i>	Bamboo mat
<i>doaba</i>	Smaller water body
<i>don</i>	An indigenous method of manual irrigation
<i>duar</i>	Deep scour hole in a river, usually at a bend or a confluence
<i>durba</i>	A kind of grass (<i>Cynodon dactylon</i>)
<i>ejmali</i>	Jointly owned by co-sharers/villagers
<i>gola</i>	Granary
<i>haal</i>	Local unit of land measurement (1 haal = 12 <i>kare</i> = 1.44 ha)
<i>haor</i>	Depression on floodplain, located between two or more rivers, which functions as a small internal drainage basin
<i>hati</i>	Continuous group of homesteads occupied by a social group sharing lineage and/or other factors
<i>hizal</i>	A wetland tree species used for fuelwood and <i>katha</i>

	(<i>Barringtonia acutangula</i>)
<i>icha</i>	Collective name for several species of small prawns
<i>jagli</i>	An indigenous variety of <i>boro</i> rice
<i>jal</i>	Fishing net
<i>jala</i>	Seedlings
<i>jalmohal</i>	Fishing ground
<i>jangal</i>	Dyke-cum-road across crop fields
<i>kaiborta</i>	Hindu sub-caste whose major profession is fishing
<i>kamla</i>	Wage labourer
<i>kanda</i>	Ridges that are higher than the <i>haor</i> basin but lower than homestead land
<i>katha</i>	Branches of trees or bamboo piles placed in water to provide shelter for fish
<i>kare</i>	Local unit of land measurement (one <i>kare</i> = 0.12 ha)
<i>khal</i>	Drainage channel running across a <i>haor</i> , connecting a <i>beel</i> to a river
<i>khalashi</i>	Sluice gate operator
<i>kharif</i>	Monsoon crop season, including Aus and Aman crop season
<i>khas</i>	Government-owned land
<i>katha</i>	Bush park type fish production system
<i>khet</i>	Agricultural land
<i>khola</i>	Temporary dry season fishing camp
<i>kona jal</i>	A kind of seine net
<i>koroch</i>	A wetland tree species used as fuelwood and for <i>katha</i> (<i>Pongamia pinnata</i>)
<i>mahajan</i>	Local money/rice lender
<i>maimol</i>	Muslims whose major profession is fishing.
<i>majhi</i>	Boatman
<i>maund</i>	Local unit of measurement (one <i>maund</i> = 37.5 kg)
<i>mehagani</i>	A tree species with high timber value
<i>mera</i>	A tree species used as fuelwood
mother fishery	An area with a dense concentration of diverse high quality fishery habitats which controls fish abundance over a much larger area
<i>namasudra</i>	Hindu sub-caste with low status
<i>nara</i>	Rice straw
<i>nikari</i>	Fish retailer
<i>nolkhagra</i>	One type of wild plant used for homestead protection
<i>paharadar</i>	Fish guard
<i>parishad</i>	Council
<i>patam</i>	Wooden platform of boat
<i>patni</i>	Hindu sub-caste whose major profession is boat plying
<i>pon pratha</i>	Dowry system
<i>purdah</i>	Seclusion
<i>rabi</i>	Dry season

<i>rangjama</i>	Seasonal lease of agricultural land with an agreed advance in cash
<i>samity</i>	Cooperative society
<i>sampad</i>	Resource
<i>shail</i>	A variety of <i>boro</i> rice
<i>shak</i>	Leafy vegetable
<i>shidal</i>	Semi-fermented fish
<i>shutki</i>	Sun-dried fish
<i>singra</i>	A type of water chest nut (<i>Trapa maximawiczee</i>)
<i>sona bang</i>	A frog species (<i>Rana tigrina</i>)
<i>tab</i>	Bamboo poles to shelter fish
<i>thana</i>	Smallest administrative unit; below district (formerly <i>upazila</i>)
<i>ujaiya</i>	Movement of fish against water current
<i>union parishad</i>	Local government council at union level
<i>uthan</i>	Courtyard
<i>zamindar</i>	Feudal landlord
<i>zirati</i>	Immigrant cultivators

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(to be completed)

LIST OF FIGURES

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EXECUTIVE SUMMARY

1. REPORT LAYOUT

The environmental assessment of the propose Fourth Fisheries Project consists of four main items:

- Environmental Impact Assessment of proposed project
- Terms of reference for environmental subprojects
- Review and evaluation of environmental legislation and regulations
- Linkages to other Environmental Projects

Appendices present:

- Record of persons met
- Bibliographic references
- Figures
- Tables
- Photographs

2. ENVIRONMENTAL IMPACT ASSESSMENT OF PROPOSED PROJECT

2.1 Project Setting

The proposed Fourth Fisheries Project is a follow-up project to the Third Fisheries Project. The project goal is to directly improve the physical, biological and socioeconomic environments and conditions pertaining to the fisheries sector, and indirectly benefit related sectors and communities. The principal project objective is to advance toward this goal through focused infrastructure, environmental, technical, social and economic interventions in the various fisheries subsectors. Specific project objectives are as follows:

1. Rehabilitate and enhance openwater floodplain fisheries.
2. Further extend high yielding carp and prawn freshwater pond culture methods.
3. Improve infrastructure, extensive culture methods, and seed supply for brackishwater shrimp farmers,
4. Redefine and strengthen the capacity of government fisheries institutions and NGOs.

The methodology adopted for environmental assessment of the proposed project by the EIA Team consists of an iterative process of information collection and fact finding (with emphasis on beneficiary group sources) to identify environmental issues and possible solutions, analysis of potential impacts and identifications of mitigation measures, reporting of preliminary results to beneficiary and interested groups, and modification of project design. The EIA Team worked closely with the project component preparers to assess and comment on all aspects of project design during the formulation phase.

The EIA Team consisted of the following individuals: Garry Bernacsek, International Environmental Specialist (GLOBAL AQUATIC CORPORATION Pty Ltd, Sydney, Australia) and Yusuf Sharif Ahmed Khan, National Environmental Specialist (Institute of Marine Sciences, University of Chittagong, Chittagong). The technical assistance budget for the EIA was \$ xxxxxx, while the operational budget (EIA share out of total project preparation budget) for fieldwork, meetings and materials was \$ xxxxxx. Person months allocated for the EIA were International Environmental Specialist (2 p/m) and National Environmental Specialist (4 p/m). The EIA was carried out during the period 12 October 1997 to 28 February 1998, corresponding to the late monsoon and winter dry seasons. Implementation of the EIA was constrained by inadequate allocation of manpower, budget and time.

2.2 Policy, Legal and Administrative Framework

The MOFL currently lacks a fisheries policy *per se*. A draft fisheries development policy has been prepared but has yet to be adopted by the GOB. The Environmental Policy of the GOB was adopted in 1992. Specific policy measures relevant to fisheries and fisheries environments include: Water Development, Flood Control and Irrigation, Land use, Forest, Wildlife and Biodiversity protection, Fisheries and Livestock: Coastal and Marine Environment: Institutional Arrangements: DOE will make final review and approve all environmental impact assessments (EIAs).

Detailed EIA guidelines have been produced by the Department of Environment (DOE) but not for fisheries development projects. FPCO guidelines for environmental impact assessment as representative of GOB EIA requirements. The general environmental assessment guidelines of World Bank are contained in Operational Directive 4.01: Environmental Assessment (including Annexes A to F), dated October 1991. Additional detailed sectoral guidelines for fisheries development projects are contained in World Bank Technical paper no 140: Environmental Assessment Sourcebook, Vol II: Sectoral Guidelines.

Environment-related projects and programs (outside of production activities) within the fisheries sector come under the mandate of several GOB agencies: DOF, MOL, DOE, DOFr, BWDB, SWMC and WARPO, LGED, The Electricity Board. The individual mandates of agencies sometimes overlap and conflict (for example MOL and DOF jurisdiction over fisheries management) resulting in government-induced inefficiency, inequity and conflict within the fisheries sector.

2.3 Project Alternatives

A reasonable scenario of the future without project interventions is as follows (based on forward projection of existing trends within the fisheries sector): Continuous decline and possible extinction of native carp stocks in most parts of the country; Overfishing of fish overwintering areas and spawning areas resulting in heavy mortality of broodstock and national extinction of some fish species; Continued siltation of rivers and access canals, resulting in reduced migration of fish; Continued construction of FCDI projects without fishpass facilities resulting in further reduction of fish migration and massive fish loss inside the project areas; Slow growth in productivity of pond culture; Decline in vitality of fingerlings for pond stocking sourced from hatcheries; Overharvesting of shrimp seed from wild sources, resulting in decline in shrimp stocks and catches, and declines in stocks of fish and other species present in seed by-catch; Increased social conflict over use of private farm lands inside coastal polders for shrimp grow-out, due to lack of control over activities of shrimp farmers; Increased insecurity of supply of larvae for shrimp and prawn farming, resulting in erratic production, and imports of possibly diseased larvae from other countries; Slow growth in productivity of prawn farming, and increased incidence of disease and mortality due to poor management practices; Increasing rejection of exported shrimp by importing countries due to poor quality and inadequate hygiene standards at shrimp depots and at processing plants; Increasingly ineffectual performance of fisheries institutions; Continuing decline in fish biodiversity and local and national extinction of fish species; Continued degradation of fisheries environments from deforestation, agrochemicals, dewatering, loop cutting of rivers, industrial effluence and water hyacinth infestation; Increasing conflict between jalmohal leaseholders/capital investors and genuine fishermen over access and tenure of openwater fisheries resources; Increasing incidence of disease pandemics in fish and crustacean stocks, resulting in large economic and nutritional losses. The damage track of each subscenario will vary, but the cumulative effect of all subscenarios is more likely than not to be quite significant.

An alternative approach to management and conservation of indigenous fish stocks and fisheries environments is to focus entirely on openwater stocking with indigenous and non-indigenous species (while ignoring natural reproduction and recruitment), and to meet any shortages in supply which may be develop through importation of cheap frozen food fish (such as small pelagics from Chile and Peru). At the same time, increased consumption of other sources of protein (pulses, poultry) could be promoted.

The approximate cost of the alternative proposed above would be as follows: \$450,000,000. Not included in this estimate are the social costs of displaced fishermen and fishing input suppliers, subsistence losses in terms of nutrition, and costs of creating alternative employment for large numbers of people (1.2 million). This would substantially raise the true cost of the alternative. The cost of the proposed project is \$70,000,000, which is only 16% of the nominal

cost of the alternative. The analysis suggests that the alternative is not viable and should be rejected in favour of the proposed project.

2.4 Project Description

The project is a capital loan project type which will be financed by the IDA. Additional sources of finance for technical assistance will be sought from other donor agencies. The project is a fisheries development and conservation project. It contains components which will improve the environment, increase production and increase product value. A large portion will be in the form of credit and extension. Some infrastructure construction will also take place, for fishpasses, canal re-excavation, prawn pond water supply and drainage, and prawn and shrimp hatcheries.

The proposed project will consist of the following components:

- Activities in Inland Openwater Capture Fisheries: Floodplain Stocking Component, Fish Sanctuaries Component, Canal Re-excavation Component, Fishpass Construction Component.
- Activities in Freshwater Finfish Aquaculture: Intensive Pond Culture Demonstration and Credit Component, Intensive Cage Culture Demonstration and Credit Component, Semi-Intensive Pen Culture Demonstration and Credit Component, Broodstock and Hatchery Component, Contract Research Component.
- Activities in Crustacean and Brackishwater Aquaculture: Sustainable Shrimp Seed Collection Component, Integrated Coastal Zone Planning Component, Private Hatcheries for Shrimp and Prawns Component, Improved Freshwater Prawn Culture Component, Improved Shrimp Processing Practices Component.
- Activities in Institutional Development: Vocational School for Aquaculture Component, Fisheries Management Information System Component, Environmental Management System Component, Seafood Products Quality Control Improvement Component, Evaluation and Restructuring of Fisheries Development Agencies Component, Evaluation and Restructuring of Fisheries Research Agencies Component, Human Resources Development Component.
- Activities in Environmental Management: Fish Biodiversity Conservation Subproject, Fisheries Environments Improvement Subproject, Community-Owned Fisheries Pilot Project, Fish and Shrimp Disease Control Subproject, Water Quality and Quantity Monitoring Program Subproject.

2.5 Predicted Impacts

Impacts in Inland Openwater Capture Fisheries

- Floodplain Stocking Component: This component has a potential for negative impact on native *chotomach* species due to competition from stocked non-indigenous species. The degree of impact could depend on stocking density, and possibly the quality of ancillary management efforts. There exists a potential for a negative impact on the genetic diversity of wild stocks of indigenous carp species (*ruí, catla, mrigel*) due to stocking of large numbers of fingerlings of these species derived from relatively few hatchery resident broodstock. The wild stocks of native carp are currently much reduced in abundance due to overfishing and environmental degradation. Hatchery-produced fingerlings would likely greatly outnumber wild fingerlings wherever large scale stocking of floodplains is carried out, and very quickly dilute wild genetic diversity with less diverse hatchery gene pools. There exists a potential for a negative impact on wild fish stocks by transmission of disease from hatchery stocks. Entry of new disease into Bangladesh through importation of broodstock could result in new pandemics.
 - Fish Sanctuaries Component: No negative environmental impacts are expected from the establishment of fish sanctuaries.
 - Canal Re-excavation Component: There exists a potential for a negative impact on the stored volume of water in beels and baors during the dry season due to improved drainage capacity of the canal. This could result in reduced area/volume of dry season refuge habitat for fish, increase environmental stress on fish populations (likely leading to outbreaks of disease and significant fish mortality) and increase the probability that dewatering would be used to do a complete fish harvest.
 - Fishpass Construction Component: There exists a minor potential for a negative impact on boro and aus rice production during the premonsoon and early monsoon periods due to entry of water through the
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fishpass into the FCDI project area. The magnitude of this potential impact is very variable and difficult to predict, and in the majority of cases the impact will be nil.

Impacts in Freshwater Finfish Aquaculture

- Intensive Pond Culture Demonstration and Credit Component: There exists a potential for negative impacts on wild fish stocks in adjacent rivers and floodplains due to escape of fish from ponds. The impact can be in the form of disease transmission and/or in the form of establishment of undesirable non-indigenous species in openwater habitats.
- Intensive Cage Culture Demonstration and Credit Component: There exist potentials for negative impacts which are similar to those noted above for the intensive pond culture component. The risk to native fish stocks and aquatic habitat due to escape from cages into surrounding rivers, beels or baors is considered to be greater than for ponds.
- Semi-Intensive Pen Culture Demonstration and Credit Component: There exist potentials for negative impacts which are similar to those noted above for the intensive cage culture component. The risk to native fish stocks and aquatic habitat due to escape from pens into seasonally connected rivers, beels or baors is considered to be marginally greater than for ponds, but less than for cages.
- Broodstock and Hatchery Component: There exists a potential for negative impacts on wild fish stocks as well as pond stock due to disease transmission, especially new diseases brought in by imported broodstock.
- Contract Research Component: There exists a moderate potential for negative impacts on wild fish stocks through disease transmission or competition with non-indigenous species resulting from escape or deliberate dumping of fish into the natural environment.

Impacts in Crustacean and Brackishwater Aquaculture

- Sustainable Shrimp Seed Collection Component: No negative environmental impacts are expected from this component. an increase in stock abundance.
- Integrated Coastal Zone Planning Component: No negative environmental impacts are expected from this component.
- Private Hatcheries for Shrimp and Prawns Component: There exists a potential for a negative impact on farm and wild shrimp and prawn stocks by transmission of disease from hatchery stocks.
- Improved Freshwater Prawn Culture Component: There exists a potential for negative impacts on water quantity and quality from increased water supply and drainage of prawn ponds. The pumping of groundwater through tubewells for pond water supply in areas where insufficient surface water exists could result in depletion of freshwater and intrusion of saline water into the groundwater aquifer. The discharge of metabolic waste products during pond drainage could have a negative effect on receiving waters. There also exists a potential for negative impacts on wild snail populations which are used for food for prawns. The largest fraction of prawn feed is made up of snail meat. Expansion of prawn farming has increased the harvesting rate of snails from natural sources. This has resulted in depletion of some snail populations, and supplies are now augmented with illegal imports from India.
- Improved Shrimp Processing Practices Component: No negative environmental impacts are expected from this component.

Impacts in Institutional Development

- Evaluation and Restructuring of Fisheries Development Agencies Component: No negative environmental impacts are expected from this component.
- Evaluation and Restructuring of Fisheries Research Agencies Component: No negative environmental impacts are expected from this component.
- Human Resources Development Component: No negative environmental impacts are expected from this component.
- Vocational School for Aquaculture Component: No negative environmental impacts are expected from this component.

- Fisheries Management Information System Component: No negative environmental impacts are expected from this component.
- Environmental Management System Component: No negative environmental impacts are expected from this component.
- Seafood Products Quality Control Improvement Component: No negative environmental impacts are expected from this component.

Impacts in Environmental Management

- Fish Biodiversity Conservation Subproject: No negative environmental impacts are expected from this component.
- Fisheries Environments Improvement Subproject: No negative environmental impacts are expected from this component.
- Community-Owned Fisheries Pilot Project: No negative environmental impacts are expected from this component.
- Fish and Shrimp Disease Control Subproject: No negative environmental impacts are expected from this component.
- Water Quality and Quantity Monitoring Program Subproject: No negative environmental impacts are expected from this component.

Impacts Associated with Natural Physical Environment

1. Beel and Baor Hydrology: Increased drainage and/or dewatering of beels and baors due to improved channel flow capacity from canal re-excavation, leading to reduced dry season refuge habitat and increased mortality of overwintering fish stocks.
2. FCDI Project Hydrology: Marginal increase of water level inside FCDI projects due to entry of water into area through fishpass during premonsoon and early monsoon floods, possibly threatening some rice crops planted around margin of internal beels and lowlying areas.
3. Water Course Eutrophication: Variable degree of eutrophication of natural water courses from pen and cage culture and from prawn farms due to overfeeding and metabolic waste products excretion.
4. Groundwater Extraction: Depletion of freshwater groundwater supply and intrusion of saline water due to use of tubewells as water supply to prawn farms situated near coastal areas.

Impacts Associated with Natural Biological Environment

5. Submerged Macrophytes: Decrease in submerged macrophyte abundance in beels and baors due to stocking of grass carp and common carp, leading to decline in chotomach abundance and catch.
6. Competition for Plankton: Decrease in abundance of indigenous plankton-eating fish in beels, baors and floodplains due to competition from stocked non-indigenous planktivorous carp (silver, bighead).
7. Genetic Diversity: Loss of genetic diversity in wild major carp stocks (rui, catla, mrigel) on floodplains due to dilution from stocking with hatchery reared stock of limited genetic diversity.
8. Disease Transmission: Fish and crustacean disease transmission resulting in pandemics of new diseases or re-infection with existing diseases of wild and cultured fish and crustacean stocks: a) from hatcheries during stocking of floodplains or aquaculture grow-out facilities with disease animals, b) from hatcheries due to importation of new broodstock which is diseased, and c) from escapage or deliberate dumping of diseased animals from hatcheries, aquaculture ponds, floating cages or pens.
9. Snail Stock Depletion: Overharvesting of snail populations used for prawn feed, and transmission of diseases from illegally imported snails from India.

Impacts Associated with Socio-Economic Environment

10. Disenfranchisement: Displacement of some fishermen from the areas designated as fish sanctuaries (including access channels of fishpasses) and the areas used for pen culture.
11. Navigation: Interference with navigation routes in areas used for pen culture.

Impacts Affecting the Boundary Regions

- Downstream water course eutrophication beyond project boundary from pen and cage culture and from prawn farming.
- Loss of genetic diversity in migratory fish stocks beyond project boundary due to out-migration and mingling on remote spawning grounds of hatchery-sourced major carp (*ruoi*, *catla*, *mrigel*) used in floodplain stocking.
- Disease outbreaks beyond project boundary.
- Out-migration of undesirable introductions beyond project boundary.
- Pressure on Indian snail stocks due to importation to Bangladesh for prawn feed.

2.6 Information Deficiencies and Requirements

Comprehensive assessment and quantification of the 11 principal potential project impacts that have been identified is not readily possible. Reliable quantification is hampered by lack of information.

2.7 Cumulative Impact Assessment

Project Area Impacts

Improved drainage through canal excavation could put stress on dry season beel and baor water volumes, that would be intensified by further water extraction by farmers for boro rice irrigation. This could increase the likelihood that dewatering for complete fish harvesting would be carried out because of the low cost of pumping out the small amount of water remaining.

The water entering into an FCDI project through a fishpass might be sufficient to cause increased crop damage if accompanied by simultaneous sustained heavy rainfall inside the project area.

Groundwater extraction for aquaculture would be additive to existing groundwater extraction for crop irrigation and other water supply uses such as for domestic and industrial applications. The effect would be to more rapidly deplete groundwater aquifers, resulting in possible lowering of water tables, aquifer exhaustion and/or saline water intrusion.

A complex of factors negatively impact native chotomach and planktivorous fish stocks, including FCDI development, deforestation, agrochemicals, industrial pollution, sedimentation, disease, overfishing and dewatering. This has already led to heavy pressure on many populations resulting in local stock depletion. Intensified openwater fisheries stocking could lead to further pressure on these fish stocks and accelerate stock collapse.

Both natural and culture fish and crustacean stocks have suffered severe disease outbreaks during the last decade (ie EUS, white spot). This has resulted in major economic and nutritional losses in the past. The transmission of new diseases or mutated strains of existing diseases would lead to further economic and nutritional losses in the future.

Worldwide Climate Change

There is an increasing trend in rainfall in some parts of Bangladesh and the surrounding catchment region over the last 30 years. This is leading to intensified and more prolonged flooding. The cumulative impact of increased flooding with project impacts is mainly in the greater impact on rice cultivation inside FCDI projects due to greater head differences across fishpasses (leading to increased discharge through the structure).

Upper Riparian Activities

Increasing deforestation in the catchments (especially in India and Nepal) of the main rivers of Bangladesh will further intensify fish an systemic flooding and sedimentation. An increase in water pollution from human sewage and industrial development can also be expected. Cumulative impacts in combination with project externalities will be on hydrology (as per the previous paragraph), and on water quality (derived from aquaculture discharges).

Lower Riparian Pollution Transport

Water course eutrophication from aquaculture would be additive to eutrophication and pollution from other sources. Aquaculture discharge water could contain high biological oxygen demand from uneaten food, nitrogen and ammonia.

from metabolic wastes, and toxic or otherwise harmful chemicals from biocides, lime and other pond preparation and treatment measures. The cumulative effect could be to render water courses unfit for aquatic life for some distance downstream.

Cumulative Impacts Relevant to Other Regions

Large-picture cumulative impacts of the proposed project in association with the major environmental issues of Bangladesh is related to population growth. Increase in urban population (Dhaka, Khulna, Chittagong) - bolstered by in-migration of increasing number of rural landless people - will lead to greater demand and more intensive mining of fish resources in the mainly rural project area to provide food for the relatively wealthier urban population. Thus the principal desirable impact of the project (increased food fish production and better nutrition) could feed back negatively to the environment in the form of increased fishery resource exploitation pressure.

An increasing population that relies heavily for food on the intensified fish production that the project aims to achieve would be put at greater risk if production was disrupted by natural disasters such as the cyclones and floods that Bangladesh is particularly prone to, or by outbreaks of new and highly virulent diseases. Increased risk would appear to be inherent to some degree in intensification of fish production. Intensification of production is more sustainable if adequate precautions are taken to minimise risk.

2.8 Public Consultation

Public Meetings with Local Residents

Third Fisheries carp fingerling supplier, private carp hatchery, Dhaka. Discussed with hatchery owner problems of seed production. Daria Kandi village, near Kishoreganj. Discussed with 2 fishermen the impact of re-excavation of Gonokhali canal. Balukber village, near Kishoreganj. Discussed with 10 local residents (mostly farmers) the impact of re-excavation of Bardal Khal. Karimganj village, near Kishoreganj. Discussed with 15 local residents (fishermen, boatmen, traders) the potential for a fish sanctuary in the Dhanu River at Beel Boyar Duar. Faltita village, near Bagerhat. Discussed with 10 *golda* farmers, and DFO and TFO *golda* farming impacts and *bagda* seed collection. Faltita village, near Bagerhat. Discussed with 40 *golda* farmers and other local residents, and DFO and TFO *golda* farming impacts and potential for snail culturing (for *golda* feed). Khulna. Discussed with 40 *bagda* farmers, shrimp processors, DD, DFO and TFO. Beel Dakatia. Discussed with one local resident (ex-BWDB regulator operator) problem of waterlogging, siltation, FCDI, fish shelters, and wetland trees. Paikgachha. Discussed with two *bagda* seed collector in Shibsra River various methods of seed collection and utilisation. Paikgachha. Discussed with a *behundijal* fishermen in Shibsra River impact of *bagda* seed collection on fish stock abundance. Paikgachha. Discussed with 15 *bagda* farmers and rice farmers impact of *bagda* farming on rice production. Kaliganj near Satkhira. Discussed with 20 rice farmers and *bagda* farmers impacts of *bagda* farming on rice cultivation, and water supply problems from BWDB infrastructure. Shyamnagar, Polder 5, near Satkhira. Discussed with 5 shrimp farmers impact of *bagda* farming on rice production. Buri Goalini, near Satkhira. Discussed with shrimp farmer problem of shrimp disease in 3rd Fisheries semi-intensive ponds. Buri Goalini, near Satkhira. Discussed with 5 shrimp farmers and tana administrator problem of 3rd Fisheries/BWDB regulator failure. Nasti Baor, near Jessore. Discussed with 5 fishermen impact of stocking on indigenous species, need for fish sanctuary, and possibility for wetland tree plantations. Shachta Baor, near Jessore. Discussed with project staff control of aquatic macrophytes to improve habitat. Char Bagadi pumphouse, Chandpur FCDI project. Discussion with 12 fishermen and other local residents movement of *golda* fry in and out of FCDI project. Seafood Corporation Ltd, Chandpur. Discussed with processing plant manager and staff local supply of *golda*. Feni River barrage, Muhuri FCDI project. Discussion with 20 fishermen and other local persons the impact of the barrage on the movement fish and fish catches. St Martin's Island. Discussed with 10 fishermen about fish catches and coral reef. Large shrimp farm owner, Cox's Bazar. Discussed impact of disease on intensive shrimp production. Meghna Shrimp Farm, Cox's Bazar. Discussed with farm manager and two foreign buyers Coastal channel, Cox's Bazar. Discussed with 4 bagnet fishermen the impact of shrimp farm development on fish catches. Niribili Shrimp Culture Farm, Cox's Bazar. Discussed with farm manager shrimp seed collection, mangrove die-off, and shrimp disease. Cox's Bazar. Meeting with 10 shrimp hatchery owners, shrimp farmers and shrimp processors to discuss problems of disease, seed collection and mangrove deforestation. BFDC Fish Landing and Market Hall, Cox's Bazar. Discussion with trader on fish catch and potential for eco-tourism development (possibilities for billfish charters).

Meetings with Special Interest Groups, Donors and NGOs

Bangladesh Frozen Foods Exporters Association, Dhaka. Discussion about *bagda* disease problem and impact of *bagda* farming on rice production. Caritas, Dhaka. Discussion about *bagda* seed collection impacts and impact of *bagda* farming on rice production. Prism Bangladesh, Dhaka. Discussion about impact of GOB taxation on fish producers. Center for National Research for Sustainability, Dhaka. Discussion about re-excavation of canals. Surface Water Modelling Centre, Dhaka. Discussion about hydrology data and modelling. BWDB, Planning Scheme 1, Dhaka. Discussion about FCDI projects requiring fishpasses and khal re-excavation program. DOE, Dhaka. Discussions about EIA guidelines, GEF biodiversity conservation projects, national parks and fish parks, and water quality monitoring program. BWDB, Monitoring, Planning and Program Divisions, Dhaka. Discussion about policy for construction of fish friendly structures, such as fishpasses. LGED, Dhaka. Discussion about canal re-excavation projects, rubber dam projects, fishpass projects. WARPO, Dhaka. Discussion about national water model and real-time flood monitoring. BWDB, Hydrology Division, Dhaka. Discussion about acquisition and use of data for surface water hydrology, river morphology, and groundwater. BWDB Kishoreganj. Discussion about the impacts and sustainability of Bardal Khal re-excavation project, and other re-canal excavation projects in the pipeline. DFO Bagerhat. Discussion about need to conserve floodplain *chotomach*, and impacts of *golda* and *bagda* farming, and impacts of *bagda* seed collection. TFO Nazirpur, near Pirojpur. Discussion about *golda* fry collection and need for sanctuary in Malikhali-Delveri Beel. DOF DD Khulna. Discussion about impacts of waterlogging and salination in the area, Farakka barrage, and *bagda* farming. FRI Brackishwater Station Paikgachha, TFO and local NGO. Discussion about impact of *bagda* farming on rice cultivation, *bagda* seed collection impacts, FRI project pipeline and Sunderban. Project Director and project staff, Oxbow Lakes Fisheries Project, Jessore. Discussion about impact of carp stocking on indigenous *chotomach* species and disease transmission, and tenure system for baors. Station Director and staff, FRI Riverine Station, Chandpur. Discussion about research program and Meghna-Danagoda and Chandpur FCDI projects. Superintending Engineer and staff, Char Bagadi pumphouse and navigation locks, Chandpur FCDI project. Discussion about movement of fish through navigation locks and hizal tree plantations inside project area. Superintending Engineer, BWDB office Lakshmipur. Discussed various environmental aspects of Polder 59 FCDI project near Ramgati. DFO Lakshmipur. Discussed potential for gold seed collection, fishpasses and fish sanctuaries in the area. DFO Feni. Discussed feasibility of a fishpass at the Muhuri FCDI project barrage across Feni River. Director and staff, DOF Marine Fisheries Division, Chittagong. Discussed marine fish stock abundance, mangrove deforestation, water pollution and fish sanctuaries. Director and staff, Institute of Marine Sciences, University of Chittagong. Discussed marine fisheries and environment research. TFO and staff, Teknaf. Discussed fish catch on coral reef of St Martin's Island and shrimp seed collection in Naf River. Deputy Director, FRI Marine Fisheries Station, Cox's Bazar. Discussed Environmentally friendly shrimp culture project and shrimp disease control using *nem* tree leaf extract. DOF Marine Fisheries Officer, Cox's Bazar. Discussion about monitoring of oceanographic parameters, mangrove deforestation impacts, shrimp farming impacts, oil pollution, *bagda* seed collection, coral reef fishing on St Martin's Island and use of poisons for fishing.

Summary of Concerns

Prawn farmers: Most of the farms are not serviced by supply and drainage canals and dependent on monsoon rain water. There is no link canal with river and culture area. Use of snail meat as feed has sharply depressed the natural population of snails, and consequently the price increase of snails is hampering prawn production. Poor pond management practices result in low yields. Farmers do not have technical knowledge about pond construction, pond preparation, pond management, stocking and feed management. After harvesting the crop, farmers do not have any employment opportunities for about four months, and remain idle. Farmers sell their products to depot owners and middleman at low price because they borrow money from them for stocking.

Shrimp farmers: Scarcity of *Bagda* fry and high prices. Scarcity of low priced protein feeds. Large-area land utilisation but comparatively low productivity. Farmers do not have adequate technical knowledge for better production of shrimp crops. Production has collapsed due to outbreak of white spot disease during the last two years. Semi-intensive farms of Khulna and Chittagong were badly affected by disease outbreaks and are presently practicing culture of Thai *pangas*. In some areas of Khulna region, farmers are allowed to take lease of land for only one or two years, and as a result farmers cannot construct permanent embankments, canals and regulators. In Polder 5 (Khulna region), due to constructional defect of the sluice gate, one way flow of water through the sluice gate, and conflict over the primary water supply canal, farmers are deprived of water intake into culture ponds resulting in low production. About 15 sluice gates of Third Fisheries are defective and remain closed due to silting up. Security is :

major problem. In many areas there are no police stations. At many farms there is no electricity. Farms of remote areas do not get ice. As a result quality of the product deteriorates during transportation to depots or processing plants. Instruments, chemicals and fertilisers are not available near farm sites. Skilled manpower is not readily available. In the Cox's Bazar area, the farmers do not have any employment opportunity for about six months after harvesting the crop. Polluted water is used by the semi-intensive farms located at the bank of Bankkhali River (Cox's Bazar), resulting in problems in culturing shrimp. An incentive or prize should be awarded to good farmers. Instructional booklets should be published on different aspects of shrimp culture. A separate brackishwater division of the DOF should be set up to deal with shrimp culture and coastal environments. A Fishery Bank should be established. More cyclone shelters should be constructed. In Paikgacha area, some Bagda farmers cut BWDB embankments and introduce saline water for farming practice without any permission from the concerned department.

Shrimp fry collectors: The shrimp fry collectors in Khulna region who use push nets destroy other planktonic organisms in contrast to the fry collectors who use boats. The latter do not destroy other organisms, but rather release them back to the water). The fry collectors sell their fry to middle at a cheap rate. Many fry collectors do not have their own nets. They borrow nets from middlemen and are compelled to sell their collected fry to the middlemen at a very cheap rate. The farmers do not have the facility to store and to keep the fry alive for a considerable to keep the fry alive for longer time periods. Fry are stored in a pot without any feed or aeration system. Echinoderms, sand dollar, starfish and other intertidal organisms of the intertidal zone have been destroyed due to collection of shrimp fry activity.

Fishery Officers, Research Officers and other personnel: In Golda farming, the farmers use large quantities of snail meat and as a result natural snail populations have declined, and snails are illegally imported without quarantine. Golda farmers use their prepare loose feed using rice bran and fish dust which sometimes pollutes the pond water. Presently there is no relevant policy and legislation for shrimp culture in the country. Conflicts between shrimp culture and agriculture should not damage social harmony. Shrimp farmers, shrimp fry collectors and fishermen should be provided with training in their respective fields. Kenduar beel and other beels should be protected from shrimp culture and paddy production. Shrimp hatcheries should be established both by the GOB and private sector. For shrimp farming, water supply and drainage systems should be developed. Electricity should be provided to shrimp farms. Shrimp culture areas for Golda and Bagda should be identified on the basis of site selection criteria, and land size should be determined and allocated to an actual farmer. Depots should be established with the permission of the concerned GOB office, and hygiene and sanitation should be inspected periodically. Sufficient numbers of insulated vans should be provided for rapid transport and marketing of fishery products. Laboratories should be established in each district head quarter to expand analysis facilities. Some NGOs sell medicine and chemical under different trade names to illiterate shrimp farmers to solve their problems. GOB should investigate the matter so that poor farmers are not cheated. Due to brackishwater shrimp culture, paddy production is reduced, trees are destroyed, drinking water is scarce, and grazing fields for livestock are limited. To conserve the habitat and biodiversity, a 0.5 km wide zone around St Martin's Island should be declared a sanctuary. The depth of the Bankkhali River has decreased by 50% since 1984 due to siltation. At Kasturi Ghat of the river, there previously were abundant stocks of oysters, sea anemone, crabs and other animals, but the habitat has since been destroyed due to pollution, siltation, proliferation of trawlers, and human disturbance. Previously, fishes (*bhetki*, mullet, grouper) were abundant, but the fish resources have now declined due to these causes. Hundreds of fishermen catch coral fish during rough weather with hand lines, and as a result the coral fish around St Martin's Island have declined. Fishermen catch fishes in rock pools situated between Cox's Bazar and Teknaff using rotenone. During collection of monodon fry, the average catch composition is one monodon fry for 38 other shrimp species, 56 zooplankton and 12 finfish larvae. The composition varies from place to place. Around 20% undesired species are released back to water and about 20% by-catch are thrown to beach. Fry mortality is 30%-50% during holding at collection sites and transport to culture sites.

Fishermen and local residents of Dakatia Beel: Paddy does not grow when the water level is high in the beel. Out of 3 sluice gates, only one is in operation and two were closed due to deposition of heavy silt at the bottom of the gate. The Shalu River should be excavated to reduce water logging in the beel. Local fishermen and paddy cultivators are facing difficulties to raise their desired crop and would like to cut the embankment so that tidal water flushes the beel. The embankments of the Bhanad Bhayane and Khukshia beels of Jessore district were cut in different areas just a few days before the field visit to Dakatia Beel by the local farmers to allow tidal water to enter.

Fishermen of baors: Do not want to establish a fish sanctuary as it would interfere with their fishing method. Disturbed by miscreants during harvesting. Farmers pump out water from baor for cultivation of boro paddy and mustered plants. Some baors are partly covered with water hyacinth. Some sluice gates are defective and not in operation.

FCDI Projects: Before the establishment of Muhuri FCDI project of Feni, the fishermen used to catch more fish and shrimp than the present day. At the present time, more shrimp and fish are available on the freshwater side than the brackishwater side of the barrage. Migration of shrimp and fish have been negatively affected due to establishment of the barrage. Before the establishment of Chandpur FCDI project, lots of shrimp and fish were available, but now stocks have declined. A massive infestation of water hyacinth blocks the gate area.

River Fishermen: In the past large numbers of fishes were present but presently the catch has declined. Fish stock reduction in the river is due to the following causes: a) overfishing and no new recruitment, b) use of pesticide in the agricultural fields, c) discharge of waste by the industries, d) depth of water reduced due to siltation, and e) increased turbidity in the river water.

St Martin's Island: There is scarcity of ice and cold storage. There is scarcity of drinking water during the fishing season. There is no fish landing centre and all fish processing and marketing activities are made directly on the sandy beach in unsanitary conditions. During drying of fish insecticides are applied to combat infestation with mites and flies. There is a security problem during catching of fish in the sea and during the return journey to the island with fish. On the east coast, starfish, sea anemones, sand dollars and other animals have become extinct due to human activities on the shore. Turtles used to come at night to lay eggs in the north-east part of the island but now they do not come due to human disturbance. Now they lay their eggs at the southern part of the island.

Summary of Response to Concerns and Actions to be Taken

- Prawn farmers would benefit from link canals from rivers to culture area, low cost protein feeds, technical assistance, training, employment during the low season and soft-term credit facility.
- Shrimp farmers would benefit from better availability of fry for stocking, low priced protein feeds, better management of the ponds, control of diseases, long term lease of GOB land, efficient and functional sluice gates and regulators for water supply, security measures, electricity, supply of ice in remote areas, instruments, chemicals, fertilisers, skilled manpower, control of water pollution, incentive to good farmers, publication of instructional booklets, establishment of a brackishwater division in the DOF, a fishery bank, cyclone shelters and employment opportunities during the low season.
- Proper policy and legislation should be adopted for shrimp culture. Shrimp culture area should be identified. Selling of unknown medicine to the farmers should be controlled and depots should be registered.
- A sanctuary should be established around St Martin's Island to halt the decline of coral fish stocks. Illegal fishing of the rock pools between Cox's Bazar and Teknaf needs to be controlled.
- Beels should be protected for shrimp and paddy cultivation.
- Shrimp fry collectors would benefit from low priced country boat, nets, storing facility with feed and accretion system and direct supply of fries to culturists.
- The crab fishery should be provided with logistic support for development.

Specific actions that should be taken are: In prawn farming areas where there are no facilities for water exchange, link canals should be excavated. Research should be conducted to develop low cost protein feeds for prawns and shrimp. Farmers should be periodically trained in basic and modern culture methods. DFOs and TFOs should be trained in culture methods and in the handling of analytical instruments both in the laboratory and in the field. Farmers should be provided with booklets in Bangla covering different aspects of culture and technical assistance according to their needs by fisheries officers and NGOs. For the steady supply of shrimp fry, hatcheries should be established in Cox's Bazar and Khulna. Sanctuaries should be established in different regions of coastal areas and off the coast to protect shrimp broodstock. To implement control measures for shrimp and fish diseases, a survey should be undertaken to determine the types of diseases present, and mitigation measures should be undertaken in consultation with disease experts. Inoperative sluice gates should be repaired, and all sluice gates should be capable of providing intake and discharge. The

actions should be done in consultation with the engineers concerned. The GOB should provide security, electricity, instruments, chemicals, skilled labour, incentives to productive farmers, a fishery bank and cyclone shelters in the coastal area. The GOB should establish a separate Marine Directorate Office for marine fisheries. All industries discharging solid and liquid waste to the environment should be required to carry out primary treatment at the minimum. Pesticides should be controlled through policy and proper legislation. Shrimp fry collectors should be provided with logistic support and training so that they do not destroy the by-catch. Insulated vans should be provided to transport shrimp and fish from ponds to processing plants. Laboratories should be established for soil and water analysis at divisional headquarters. Proper policy should be adopted for shrimp culture. Depots (where shrimp and prawns are purchased and stored) should be registered and inspected for hygiene and quality of shrimp and prawns. Afforestation programmes should be undertaken for mangrove vegetation along the coast as soon as possible. The number of fishermen and fisherwomen catching fish from rocks pools and coral areas along the coast should be controlled. Logistic support should be provided to the crab fishery. Programmes should be undertaken to clear water hyacinth from haors, baors, beels, barrow pits, FCDI projects and other infested waters. Some small rivers and canals should be re-excavated. Security at sea should be strengthened. A fish landing centre should be established at St Martin's Island. Steps should be taken to protect turtles laying eggs on St Martin's Island. Policy and legislation should be promulgated to protect coral reefs and seaweed beds off St Martin's Island. Research activities should be distributed among the universities of the country rather than FRI because little substantial research activities are undertaken at Chandpur, Paikgaacha and Cox's Bazar FRI stations. MOFL and DOF should have advisory panels of knowledgeable fisheries experts to provide suggestions, evaluate research activities and monitor different fishery programmes.

2.9 Environmental Management Plan

Proposed Mitigation Measures

- **Beel and Baor Hydrology:** The potential for beel and baor draining due to channel flow capacity increasing after canal re-excavation will be reduced through the following measures: Bed elevations in the canal, the adjacent river and the beel/baor will be carefully measured during the feasibility and design study. The new re-excavation bed level of the canal will be set at an appropriate level to prevent beel/baor dewatering. A water regulation structure will be installed at the beel/baor outlet to the canal. The regulator will be closed during the late monsoon drainage period in order to conserve the water level in the beel or baor at the highest possible level at the start of the dry season. It will be opened at the start of the premonsoon period to allow river water and/or fish to enter the beel or baor.
- **FCDI Project Hydrology:** The possible threat to rice cultivation due to entry of water inside FCDI projects through a fishpass will be reduced through the following measures: Study of river hydrology, FCDI project hydrology and potential fish traffic through structure, and adjustment of pool number and pool, baffle and slot dimensions to minimise discharge volume through fishpass. The fishpass will be equipped with gates at either end which will be closed whenever a threat to agriculture materialises. The operator of the fishpass will remain responsive to the concerns of the farming community, and respond positively if farmers feel their crops are threatened by closing the fishpass gates, and reopening the gates once the perceived threat has passed.
- **Water Course Eutrophication:** The potential for eutrophication of natural water courses from pen and cage culture and from prawn farms due to overfeeding and metabolic waste excretion will be reduced through the following measures: Specify the use of pelleted feeds rather than loose feeds, as the former result in less loss. Develop better methods for estimating feed application rates throughout the grow-out period in order to eliminate overfeeding. Specify more frequent water exchange and flushing in prawn pond to discharge metabolic wastes in more diluted form. Protect stocks of chotomach (especially bottom feeders) in the vicinity of cages and allow them to consume uneaten food which drops out of cages. Specify controlled growth of submerged macrophytes inside and/or along the outside margins of pens to absorb dissolved metabolic wastes such as nitrogen.
- **Groundwater Extraction:** The danger of depletion of freshwater groundwater supply and intrusion of saline water due to use of tubewells as water supply to prawn farms situated near coastal areas will be reduced through the following measures: A comprehensive groundwater survey will be carried out in all areas where tubewells are used (or may potentially be used) for prawn farm water sourcing to determine the size

of the aquifer and the recharge rate. Depending on the results of the survey, permits will be issued for allowable volume quotas of groundwater that may be withdrawn by prawn farms and by other users. The aggregate quota volume for an area will not exceed the groundwater recharge rate.

- **Submerged Macrophytes:** The danger of decrease in submerged macrophyte abundance in beels and baors due to stocking of grass carp and common carp (leading to decline in chotomach abundance and catch) will be controlled through the following measures: The stocking of grass carp (which are unable to breed in Bangladesh waters) will be limited to specific areas where excessive macrophyte growth needs to be reduced to normal levels. The stocking density will be adjusted to moderate level (ie 50 large fingerlings per ha), and the adult fish will be caught and removed once the macrophyte density has normalised. No common carp will be stocked by the project. This species has in any case been successfully introduced and occurs in self-sustaining populations in many areas of Bangladesh.
- **Competition for Plankton:** No measure is proposed to mitigate the expected decrease in abundance of indigenous plankton-eating fish in beels, baors and floodplains due to competition from stocked non-indigenous planktivorous carp (silver, bighead). The objective of the stocking is specifically to channel available plankton nutrients into these fast growing non-indigenous fish species, as they are considered capable of producing a larger quantity of harvestable food fish than indigenous planktivorous fish species. A reduction in stocking density would dampening the impact on indigenous species, but this would partly defeat the project purpose. It is suggested that consideration be given to stop the stocking of silver and bighead carp altogether, and that only native species (*ruí, catla, mrigel*) be stocked. Other native carp species such as *kalibaush, bata, boga, ghora, angrót, nandina*, and others should also be considered for stocking.
- **Genetic Diversity:** The following mitigation measures will be used to reduce the loss of genetic diversity in wild major carp stocks (*ruí, catla, mrigel*) on floodplains due to massive stocking with hatchery reared stock of limited genetic diversity: Hatcheries will be specifically licensed to produce fingerlings for floodplain stocking, and fingerlings will only be purchased from these hatcheries. Only first generation broodstock sourced from wild stocks will be used to produce fingerlings used in stocking programs. Inbred and selectively bred lines used in pond culture will not be used. Broodstock used for floodplain stocking will be renewed each year, and old broodstock will be destroyed. Broodstock at a particular hatchery will be sourced from local wild stocks and not be transferred from elsewhere in the country.
- **Disease Transmission:** The potential for disease transmission and pandemics resulting from project activities will be mitigated through the following actions: All fingerlings will be inspected for disease prior to stocking. If diseased fingerlings are detected, the entire consignment will be destroyed. If no diseased fingerlings are detected, the entire consignment will be treated with an antibiotic as a precautionary measure prior to release into natural water bodies. All broodstock imported from outside Bangladesh will be quarantined and inspected for disease. Diseased fish will be destroyed by incineration. All grow-out facilities will be regularly inspected for disease. If disease is detected, all stocks at the facility will be destroyed by incineration, and the facility will be sanitised. It will become illegal to dispose of diseased animals from hatcheries, aquaculture ponds, floating cages or pens by dumping into natural water bodies. The offence will be punishable by fines and imprisonment. A code of procedures will be prepared to reduce the incidence and risk of escapage from aquaculture facilities.
- **Snail Stock Depletion.** The problem of overharvesting of snail populations used for prawn feed, and transmission of diseases from illegally imported snails from India, will be mitigated through the following measures: The harvesting of snail populations occurring in borrow pits, ponds, canals, beels, baors, and other water bodies will be regulated through licensing of collectors, and allocation of specific areas to individual collectors. The culture of snails in purpose built facilities (ie snail nurseries) will be promoted, taking into account the particular reproductive and nutritional needs of snails. The illegal import of snails from India will be controlled.
- **Disenfranchisement:** Instances of possible displacement of some fishermen from the areas designated as fish sanctuaries (including access channels of fishpasses) and the areas used for pen culture will be mitigated as follows: The nature of claims for fishing rights and tenure will be assessed at each fish sanctuary and pen culture location, and ranked according to validity. Compensation will be paid to fishermen or investors with valid leaseholding claims. Other jalmohal will be allocated to fishermen with valid traditional fishing rights to fish sanctuaries or pen culture locations. Where the project intervention is

accompanied by community-based fishery development, disenfranchised genuine fishermen will be included in large-group fishing rights allocations.

- **Navigation:** The expected interference with navigation routes in areas used for pen culture will be mitigated through the following measures: Pen fences will be provided with flexible brush gates that allow shallow draft boats to pass across the fence but prevent fish from escaping. The gate design will be standardised, and constructed from robust materials. Wherever feasible, alternate navigation routes will be designated.

Participation Programme for Interested Parties

Provision will be made for interested parties to participate in the EMP at local and national levels. At local level, interest groups (ie Environmental Advisory Group, or EAG) will be formed which will act in an advisory capacity to the project in executing the EMP. At national level, interested environmental groups will be formed into a national EAG. The views and recommendation of the national EAG will be recorded and taken into account during implementation and periodic review of the project and the EMP.

Accountability

The project personnel that are responsible for implementation of the EMP will be fully accountable to the project director in the implementation of project activities and use of project funds. The implementation and effectiveness of the EMP will be reviewed annually by an Environmental Steering Committee (ESC), a body established jointly by the MOFL, DOE and other concerned ministries.

Contingency Disaster Management Plan and Residual Risks

The potential for disasters arising from project activities is in the following areas:

- **Disease pandemics of wild fish stocks or cultured fish stocks:** This could occur in spite of best efforts to control disease outbreaks in hatcheries, in grow-out facilities and in natural water bodies. It could result in massive mortality of stocks and large economic losses.
- **Civil engineering structure failures:** This includes breaching of beel and baor embankments, washing out of regulators or fishpasses, and jamming of gates of regulators or fishpasses in the open position during floods. Failures could occur during the construction phase or during the operational phase. Such disasters could allow massive flooding to take place within an agricultural area, destroying crops and livestock, and leading to possible loss of human life.
- **Construction site accidents:** The greatest danger from construction accidents is associated with RCC construction methods used for regulators and fishpasses. Manual excavation and earth moving for canal re-excavation are only minimally hazardous.
- **Cyclone or flood damage:** This refers mainly to damage to cages and pens over a wide area. This could result in the release of possibly diseased fish into the environment and massive economic loss from equipment damage and stock escape.
- **Social discord:** Clashes may arise during civil engineering works construction (due to competition over construction materials), due to misunderstanding of project objectives and potentials for impacts, due to fishpass operation (ie protests from rice farmers inside an FCDI project), and during de-leasing and transfer of jamohal ownership (due to the previous leaseholder resisting loss of control over jalmohals). The project activities may directly or indirectly exacerbate existing conflicts within a community, or the project may simply be used as an innocent and unsuspecting scapegoat by one or another groups locked in conflict over unrelated issues.

Disaster Prevention

Several steps can be taken to reduce the eventuality of occurrence of disasters:

- **Civil engineering structure failures:** Supervision of construction activities and adherence to maintenance guidelines is essential for avoiding structure failures. Structures must be checked regularly for cracks and signs of fatigue. In the event of sudden failure, sand bags will be used to 'plug' breaches and gates, until such time as hydrological conditions allow repair of the structure.

- Construction site accidents: Work-site safety programmes will be the responsibility of contractors.
- Social discord: Pre-construction consultation will take place with affected communities to incorporate their concerns and views into project design. This will include the alignment of embankments and location of fishpasses, regulators and fish sanctuaries. Project staff will hold meetings in villages to inform local people about project objectives, activities, and potentials for impacts, and seek their views and recommendations for mitigating impacts.

Disaster Control Plan

The impacts of disasters which cannot be predicted or prevented from occurring can be lessened through the following actions:

- Disease pandemics of wild fish stocks or cultured fish stocks: The most serious consequence of massive mortality due to disease is disruption of food supply to the consumers. A contingency plan would include importation of cheap food fish (ie frozen small pelagics from Peru and Chile) to meet immediate dietary needs of the population, and rapid re-establishment of domestic production through re-crediting of producers.
- Cyclone or flood damage: This disaster would be less threatening to the security of the national food supply than a disease pandemic, and be more localised in impact. A rapid re-establishment of aquaculture infrastructure and facilities would be implemented through special re-crediting of hatcheries and fish farmers.

Residual Risks and Plans for Possible Mitigation

The major residual risk that is not adequately mitigated through the EMP is the containment of a disease pandemic. It would be extremely difficult to prevent the movement of infected aquaculture stock (ie hatchlings, fingerlings or broodstock) from one part of the country to another. Furthermore, it would appear almost impossible to prevent the transport of infected wild caught fish from landing points to market points throughout the country, and to neighbouring countries. Disease may also be transmitted by aquatic birds and other vector organisms, or simply carried in the downstream direction by water flow. The magnitude of the potential disease risk might be somewhat increased in Bangladesh compared to neighbouring countries due to the intensification in aquaculture production that the proposed project aims to implement. One approach to lessening the risk in aquaculture stock is to develop genetically enhanced strains of pond fish with greater tolerance of stress and greater disease resistance. Disease risk will however likely still remain high despite such remedial efforts if new highly virulent strains or pathogens are involved. The only realistic approach in such an eventuality is to allow the disease to 'run its course'.

EMP Implementation

The EMP will be implemented as an integral part of the project development. Implementation will be carried out by an EMP Implementation Group (EIG). This group will be a formal body within the project structure, and be composed of seconded full-time and part-time staff from the following agencies and organisations: DOF, DOE, BWDB, LGED, BIWTA. Staff from selected environmental NGOs will also be seconded to the EIG. Implementation of the EMP will require that the DOF take on new staff with the following areas of expertise: Hydrology (surface water and groundwater), Water chemistry, Civil engineering (design of water management structures and fishpasses), Limnology (macrophytes and plankton), Fish genetics, Fish disease, Malacology (gastropods). No special staff development needs will be required for other agencies in order to carry out the EMP.

Training Plan

Implementation of the EMP would require training to be carried in the following disciplines:

- Water regulator operators: Standard training offered to BWDB and LGED water regulator operators will be required. Some 25 operators will need to be trained. Training would take place at BWDB training facilities, as well as on-the-job training.
- Fishpass operator: Training in operation of fishpass gates and sampling cages will be required. Up to 10 fishpass operators would be trained (depending on the number of structures built). Training would be carried out at the existing vertical slot fishpass at Kashimpur (Manu River FCDI Project near Moulvi Bazar).

- Aquaculture feed control: Training in proper feed preparation and application methods will be required. Some 200 extension workers will be trained. Training would be carried out at the FRI station in Mymensingh and/or at the Vocation School for Aquaculture proposed under this project.
- Hatchery operation for floodplain stocking: Training in hatchery methods appropriate for production of fingerlings for floodplain stocking will be required. About 200 hatchery staff will be trained. Training would be carried out at a selected GOB hatchery and at several privately owned hatcheries.
- Fish and shrimp disease inspection and quarantine: Training in hatchery hygiene and fingerling inspection for disease will be required. Approximately 50 hatchery and DOF staff will be trained. Training will take place at the FRI station in Mymensingh.
- Snail culture methods: Training in methods for snail culture are required. Forty potential snail culturists will be trained. No training facility currently exists for snail culture in Bangladesh. It is proposed that one DOF and one NGO staff be trained in snail culture methods at an overseas facility (to be identified), and that these individuals then lead training courses in Bangladesh at the FRI Paikgachha station.

The total cost for the EMP Training Plan is \$108,500.

Technical Assistance Needs

No special needs for externally-sourced technical assistance is previewed. The EMP budget would contain a contingency fund of US\$50,000 to cover the eventuality of a need developing for external assistance.

EMP Cost

The total cost of the EMP is \$2,368,500.

2.10 Environmental Monitoring Plan

The Environmental Monitoring Plan (EMONP) will provide information on the progress and results of the mitigation measures implemented under the EMP. It would also allow early detection of impact conditions not predicted during the EIA that might require additional mitigation measures. Monitoring activities will be divided into two phases: 1) the baseline pre-project period, and 2) the operational with-project period. In most cases, the same parameters (using the same methodologies) will be monitored during both periods. Monitoring will address the 11 potential impacts of the proposed project. The following environmental parameters will be monitored:

- Beel and Baor Hydrology: Canal discharge; beel, canal and river water levels; beel/baor surface area; water extraction by people for various purposes; fish abundance and biodiversity; fish production.
- FCDI Project Hydrology: Riverside and countryside water levels; rainfall inside FCDI project; water discharge through fishpass; water body surface areas and water levels inside FCDI project; rice cropping patterns and areas; crop damage due to flooding.
- Water Course Eutrophication: Water quality (O₂, BOD₅, NH₃, suspended solids) in grow-out area and in surrounding/receiving waters; stocking density; feed application rates; stock growth rate; stock mortality.
- Groundwater Extraction: Groundwater extraction volumes; groundwater recharge rate; pond water management practices and growth in water demand; groundwater quality (salinity, pH, arsenic).
- Submerged Macrophytes: Submerged macrophyte density and species composition; macrobenthos abundance and biodiversity; water quality in macrophyte stands (turbidity, pH, O₂); chotomach abundance and biodiversity; carp stocking rate; carp growth rate.
- Competition for Plankton: Plankton abundance and biodiversity; water quality (turbidity, pH, O₂); abundance and biodiversity of indigenous planktivorous fish; stocking rate of silver and bighead carp; plankton consumption and growth rate of silver and bighead carp.
- Genetic Diversity: Stock abundance and genetic fingerprinting of wild native carp populations (protein electrophoresis); genetic fingerprinting of hatchery stock.
- Disease Transmission: Disease type and incidence in hatcheries, grow-out facilities and wild populations; disease incidence in wild stocks in the vicinity of escape events; disease incidence in imported broodstock.

- Snail Stock Depletion: Wild snail population abundance, food consumption and growth rate; water quality of natural snail habitat (water temperature, O₂, pH, Ca); macrophyte and periphyton abundance of natural snail habitat; abundance of competitor snail species and other macrobenthos in natural snail habitat; harvesting rate of snails; snail fecundity and recruitment; disease incidence in snails.
- Disenfranchisement: Abundance and biodiversity of fish (pre-project); catch rates, species composition and income of fisheries in fish sanctuaries and pen areas (pre-project period); poaching in fish sanctuaries (with-project period).
- Navigation: Boat traffic patterns.

The EMONP of the proposed project will require a significant technical effort on the part of DOF. It is proposed that a permanent monitoring unit be established within the DOF for this purpose (ie Project Monitoring Unit, PMU). To meet the needs of the EMONP it is proposed that the PMU consist of the following specialists: Chief Monitoring Officer, Hydrologist, Water chemist, Limnologist, Fish geneticist, Fish disease specialist (microbiologist), Malacologist, Fish stock assessment specialist, and Socioeconomist (with experience in navigation). No particular staffing needs are required in other agencies as most of the monitoring activities will be carried out by the DOF. It is proposed that the specialists in the PMU liaise closely with counterpart specialists in relevant agencies (BWDB, DOE, BIWTA).

The breakdown of costs for the EMONP over five years is \$1,072,000.

The findings of the MONP will be reported to the project leadership and the DOF, in the form of a quarterly Environmental Status Report (ESR). The ESR will present monitoring data in analysed and summarised format, and make any recommendation to changes in the EMP or project activities which seem warranted by the EMONP results.

3. TERMS OF REFERENCE FOR ENVIRONMENTAL SUBPROJECTS

3.1 Fish Biodiversity Conservation Subproject

The objective of the proposed subproject is to reverse the trend of fish biodiversity loss. The subproject would have the following components:

1. National Fish Biodiversity Survey Programme Component. This component would train two ichthyologists to MSc level. It would establish a national fish biodiversity repository collection and national aquarium. It would also establish a long term research programme to study the life history of Bangladesh fish species. It would implement a continuing national fish biodiversity monitoring system.
2. Impact of Embankments on Fish Biodiversity Component. This component would study and assess the impacts of FCDI projects and road embankments on floodplain fish biodiversity. It would use the results of the study to draw up a set of guidelines for relevant government agencies (BWDB, LGED, DORH) on best practices and mitigation measures (fishpasses, culverts) to reduce the impact of embankments and associated water management and road transport infrastructure on fish biodiversity.
3. Impact of Stocking and Pond Escapage on Fish Biodiversity Component. This component would carry out a study and assessment of impacts of stocking and pond escapage of non-indigenous and indigenous carp and other species on fish biodiversity in floodplains, haors, beels, baors and other water bodies. The results of the study would be used to modify stocking programs, and regulate the use of pond culture species in order to eliminate adverse impacts.
4. Impact of Shrimp and Prawn Seed Collection on Fish Biodiversity Component. This component would conduct field studies of the impacts of collection of wild shrimp and prawns seed on fish and crustacean stocks in brackishwater, marine and freshwater environments. It would also monitor the quantity of seed captured, and the areas of capture. The results of the studies and monitoring would be used to assess the overall impact and sustainability of this practice. Measures for mitigation of negative impacts would be implemented as appropriate.

5. Stocking of Endangered Fish Species Component. This component would carry out induced breeding of threatened indigenous species (*nandina*, *angrot*, *mohasol*, *sarputi*, *silond* and *pangas*), involving both FRI and private hatcheries. The fingerlings would be stocked in selected protected sanctuary areas in order to re-establish populations in the wild. Active protection measures as well as a public awareness campaign would be implemented to allow stocked populations sufficient opportunity to build up to self-sustaining levels.

The cost summary of the individual components of the Fish Biodiversity subproject is as follows:

National Survey	\$1,500,000
Impact of Embankments	\$250,000
Impact of Stocking and Pond Escapage	\$260,000
Shrimp and Prawn Seed Collection	\$390,000
Stocking of Endangered Fish	\$400,000
TOTAL =	\$2,800,000

3.2 Fisheries Environments Improvement Subproject

The objective of the proposed subproject is to implement environmental improvement measures which are designed primarily to benefit and enhance the fisheries resources carrying capacity of key aquatic habitat types. The subproject would have the following components:

1. Wetland and Mangrove Tree Plantation Component. This component would plant a minimum of 1 million seedlings of the flood tolerant tree species *hizal* (*Barringtonia acutangula* Linn) and mangroves. The principal planting locations would be the shorelines of beels, baors and canals, and the shoreline terraces along coastal polders. Seedlings would be planted in parallel rows of 5 or 6 trees, to form a continuous band along the perimeters of water bodies and polders.
2. Control of Agrochemicals Impacts Component. This component would carry out comprehensive studies of the patterns of use of agrochemicals (fertilisers and pesticides), their modes of flushing into freshwater, brackishwater and marine aquatic habitats, their rate of uptake by sediments and aquatic organisms, and the level of residues in fish tissue. The degree of risk to fish stocks and to human health will be assessed. The use of pesticides to prevent insect infestation of dry fish will also be studied and the health hazard to humans assessed. Guidelines will be prepared for the Ministry of Agriculture and for farmers on the hazards of agrochemicals to fish resources and acceptable practices for utilising agrochemicals so as to protect fishery resources. A study will be made of the types of agrochemical produced in Bangladesh, and the types of agrochemical being imported (legally and illegally). Recommendations will be prepared to assist the GOB in eliminating the manufacture, import and use of agrochemical deemed to be hazardous to fishery resources and general environmental quality, and specifically to human health.
3. Beel and Baor Embankment Component. This component will construct low embankments equipped with water retention regulators around 30 beels and baors in order to increase their dry-season water storage capacity. The *hizal* tree plantation component will be integrated with this component (ie seedlings will be planted on the embankments wherever possible). Hydrological studies will be undertaken, along with fisheries and non-fisheries water use patterns for individual water bodies. Water user committees will be established to regulate the quantities of water that will be used for fisheries and non-fisheries purposes during the dry season and mediate disputes.
4. Artificial River Duars Pilot Schemes Component. This component will construct several types of structures (flow deflectors, bottom sills) which are designed to create downstream duars (= scour holes) in river channels at five pilot locations. Duars are known to be critical overwintering habitat for many commercially important species, and key spawning habitats for major carp (*rui*, *catla*, *mrigel*). The construction of artificial duars for fishery enhancement purposes has not been previously attempted in Bangladesh. The newly created artificial duars will be placed under protected sanctuary management with the participation of local fisheries associations, and will be monitored for several years to assess their utility for stock enhancement and protection.

5. Low Cost Industrial Effluent Treatment Component. This component will prepare the design of low cost industrial effluent treatment systems for tanning, textile, jute, chemicals & pesticides, pulp and paper, seafood processing and fertiliser industries. Treatment systems will be designed for 10 plants. The component will study the plant process system and effluent streams, assist plant managers to reduce the volume of effluent generated, design appropriate treatment systems, and facilitate construction and operation of the treatment systems.
6. Water Hyacinth Control Component. This component will study the infestation and growth patterns of water hyacinth. A national survey of all major beels, baors, rivers, canals and other water bodies will be undertaken to assess the degree of infestation and allow planning of clearing and control activities. Studies of infestation of small systems (khals, borrow pits, tanks, ponds) will also be carried out. It will review available control and utilisation strategies and methods. It will develop an appropriate strategy and approach and identify optimal methods for controlling the negative impacts of water hyacinth on aquatic habitat quality and fish production. It will disseminate the selected approach and methods through demonstration and public awareness programs. Clearing and control activities are expected to be carried out in at least 10,000 ha of water bodies.

The cost summary of the individual components of the environmental improvement subproject is as follows:

Wetland and Mangrove Tree Plantation	\$1,000,000
Control of Agrochemicals	\$470,000
Beel and Baor Embankment	\$6,300,000
Artificial River Duars	\$940,000
Low Cost Industrial Effluent Treatment	\$2,320,000
Water Hyacinth Control	\$275,000
TOTAL =	\$11,030,000

3.3 Community-Owned Fisheries Pilot Project

The objective of the proposed pilot project is to carry out pilot trials of user-ownership type of fisheries management systems to assess the feasibility of widespread implementation in Bangladesh. The subproject would have the following components:

1. Fisheries Association Establishment Component. This component would assist all genuine professional and subsistence fishermen and fisherwomen (as well as women fish processors) of the communities relevant and/or riparian to a particular waterbody to form a single unified fisheries association. It would assist the fisheries association to register as legal production entities. It would provide basic training in organisational skills (ie bookkeeping, accounts, planning) for members.
2. Acquisition of Water Body and Fishery Resource Ownership Component. This component would assist the fisheries associations to acquire from the Ministry of Land (MOL) legal tenure of their relevant water body and all fishery resources contained within the water body. It would where necessary cancel existing leases (with compensation to leaseholders). It would assist to provide resource loans to the fisheries associations to purchase the water bodies and fishery resources from the GOB. It would ensure the full legality and protection by law of the perpetual continuing ownership of the water bodies by the fisheries associations.
3. Financial Management and Loan Repayment Component. This component would assist the fisheries association to plan their financial accounts in a manner consistent with meeting costs, servicing the resource loan repayments, and paying income shares to members for fishing activities.
4. Fishery Management Plan Component. This component would assist the fisheries associations to draw up short term and long term stock management, harvesting and conservation plans. It would train the fisheries associations to collect and interpret fish catch and biological data in order to assess the state of the stocks. It would provide assistance in using the data to formulate annual harvesting plans. It would also assist in the formulation of conservation plans and measures, such as closed seasons, fish sanctuaries,

minimum size limits, broodstock protection, stocking and introduction of rare and/or desirable species, to ensure the long term vitality and high abundance of the fishery resources.

5. Environmental Management Plan Component. This component would assist the fisheries association to plan and implement investments in environmental enhancement and improvement. This would include measures for retaining water during the dry season and prevent dewatering, planting of wetland trees (ie hizal in freshwater habitats, mangroves in brackishwater habitats), improvement of water quality through protection against agrochemicals and other pollutants, and conservation of other aquatic lifeforms (plants, invertebrates, amphibians, reptiles, birds, mammals) which are crucial to maintaining high biodiversity and ecologically balanced ecosystems.

The cost summary of the individual components of the environmental improvement subproject is as follows:

Fisheries Association Establishment	\$510,000
Water Body Acquisition	\$3,450,000
Financial Management/Loan Repayment	\$3,150,000
Fishery Management Plan	\$228,000
Environmental Management Plan	\$1,208,000
TOTAL =	\$8,546,000

3.4 Fish and Shrimp Disease Control Subproject

The objective of the proposed sub-project is designed to improve GOB capability to prevent and control fish disease and to reverse the trend of production decline. The subproject would have the following components:

1. Survey of Fish and Shrimp Diseases and Control Measures. This component would undertake comprehensive and systematic study of diseases, etiology, epizootiology and control in different fisheries habitats, and prepare a status report on fish and shrimp diseases and control.
2. Extension Training on Disease Prevention and Management. The objective of the training would be to improve the technical capabilities of the GOB personnel and farmers at field level. The main emphasis of the training would be on the following: a) develop working knowledge and skills of the participants, GOB personnel and farmers for diagnosis and management of disease; b) enhance understanding of prevention methods under different environmental condition and needs of the beneficiaries; c) greater responsibility by the GOB agencies; and d) updating the knowledge base.
3. Environmental Hygiene and Wastewater Recycling. This component would recycle wastewater fouled due to feed residue and excreta of the reared species in hatcheries and grow-out facilities to avoid environmental hazards. Due to lack of recycling systems receiving waters are being polluted due to discharge of waste water.
4. Quarantine Measures to Contain Disease Outbreaks. This component would set up quarantine posts with laboratories in Dhaka, Khulna, Chittagong, Barisal, Sylhet and Rajshahi to monitor the hygienic condition of fish and crustaceans and to analyse feed, soil and water.

The cost summary of the individual components of the fish and shrimp disease control subprojects is as follows :

Disease Survey	\$250,000
Extension training	\$300,000
Wastewater recycling	\$750,000
Quarantine measures	\$1020,000
TOTAL =	\$2,320,000

3.5 Water Quality and Quantity Monitoring Program Subproject

FOURTH FISHERIES PROJECT PREPARATION Annex 9: Environmental Assessment

The objective of the proposed subproject is to acquire selected water quantity and quality data from the above institutional sources on a routine basis, and reformat and analyse the data in order to provide regular status reports of fisheries environments in Bangladesh. The subproject would have the following components:

1. Acquisition of Hydrology Data Component. This component would purchase selected data sets and model products in computerised form from BWDB, SWMC and WARPO on a regular basis. The data would be stored in project computers.
2. Acquisition of Water Quality Data Component. This component would purchase selected data sets in computerised form from DOE on a regular basis. The data would be stored in project computers.
3. Project Water Monitoring Data Collection Component. This component would sample and collect water quantity and quality data from project activity locations from two perspectives: 1) ambient water quality for production, and 2) process water discharge impacts.
4. Analysis of Water Data Component. This component would carry out regular analysis of the water quantity and water quality databases from the perspective of fisheries management and development. The component would train a hydrologist to carry out the analysis.
5. Fisheries Environments Data Service Component. This component would produce a regular quarterly report on the status of water quantity and quality in Bangladesh from a fisheries perspective. The report will be widely available through public sale at appropriate cost to all potential users in Bangladesh (private sector, NGOs, GOB agencies, donor agencies, general public). The component would also produce specialised reports to meet particular needs of individual clients.

The cost summary of the individual components of the environmental improvement subproject is as follows:

Hydrology Data Acquisition	\$500
Water Quality Data Acquisition	\$500
Project Water Monitoring	\$35,000
Water Data Analysis	\$80,000
Fisheries Environments Data Service	\$75,000
TOTAL =	\$191,000
Sale of Reports	(\$10,000)
Net Cost	\$181,000

4. REVIEW AND EVALUATION OF ENVIRONMENTAL LEGISLATION AND REGULATIONS

4.1 Fisheries and Environmental Laws and Regulations

- The Protection and Conservation of Fish Act, 1950
- The Government Fisheries (Protection) Ordinance, 1959
- The Private Fisheries Protection Act, 1889
- The Protection and Conservation of Fish Rules, 1985
- The Marine Fisheries Ordinance, 1983
- The Fish and Fish Products (Inspection and Quality Control) Ordinance, 1983
- Bangladesh Fisheries Development Corporation Act, 1973
- The Fisheries Research Institute Ordinance, 1984
- The Bangladesh Environment Conservation Act, 1995
- The Bangladesh Land Holding Limitation Order, 1972
- The Development Act, 1935
- The Canals Act, 1986

- The Irrigation Act, 1876
- The Tanks Improvement Act, 1939
- The Bangladesh Irrigation Water Rate Ordinance, 1983
- The Embankment and Drainage Act, 1952
- The Ground Water Management Ordinance, 1985
- The Bangladesh Water and Power Development Boards Order, 1972
- Statute of the Indo-Bangladesh Joint Rivers Commission, 1972
- The Agricultural Pesticides Ordinance, 1971
- The Territorial Water and Maritime Zones Act, 1974
- The Territorial Waters and Maritime Zones Rules, 1977
- The Forest Act, 1927
- The Private Forests Ordinance, 1959
- Bangladesh Wild Life (Preservation) Order, 1973

4.2 Impact on Sustainability of Fisheries

The fisheries and environmental laws of Bangladesh in most respects reflect conventional approaches to protecting the fisheries resources and the surrounding environment. This approach designates a central authority (ie GOB) as the agent responsible and capable of managing fisheries and ensuring their sustainability. The widespread overexploitation of openwater fisheries through improper fishing practices, and decline in stock abundance due to environmental degradation in Bangladesh are clear symptoms of management failure. At least a part of this failure derives from the nature and intent of fisheries and environmental legislation. Beels are not recognised as water bodies, but treated as areas of land which (inconveniently) happen to have water on them.

4.3 Provision of Access to Fisheries Sectors

The fisheries laws provide access to fisheries resources for fishermen and for private fisheries investors. The latter are particularly favoured in inland fisheries under the *jalmohal* leasing system. The laws clearly identify the requirements for access to public or khas fisheries (payment of lease or license fee) and private fisheries (permission of owner). Moreover it gives subsistence fishermen and fisherwomen the right to angle in any navigable river. The *jalmohal* leasing system however clearly discriminates against genuine fishermen, as the majority are unable to raise sufficient capital to pay the high lease fees specified by GOB. *Jalmohal* leases are routinely won by capital investors.

Although fisheries and environmental laws are theoretically equity neutral, in practice they act to support the activities and intentions of the highest income groups (fisheries capital investors who are colloquially known as *jalmohal* leaseholders). The laws are thus regressive in an economic sense.

From an economic perspective, the exploitation of fisheries and other natural resources of Bangladesh would appear to be in a state of Pareto equilibrium (ie no one can increase their own benefits without having a negative impact on someone else's status). This may not be entirely correct due to the massive economic distortions that are caused by improper GOB ownership of natural resources (*jalmohals* and land) and interference with production and marketing. Nonetheless, the provisions of the fisheries and environmental laws has resulted in a state of virtual lawlessness in the fisheries and environmental sectors.

4.4 Existing Enforcement Capacity

Institutional enforcement of fishery laws rests largely with the DOF. The enforcement capacity of the DOF is minimal, with no cadre of trained and equipped fish guards in existence. The police or the army are rarely active in enforcing fisheries laws or intervening in conflicts. The recently formed Bangladesh Coast Guard (BCG) will include in its mandate enforcement of fisheries laws and protection of fishermen from dacoity. Non-institutional enforcement capacity (in the form of fishguards, *paharadar*) is contracted by *jalmohal* leaseholders. There are numerous such private fish guards throughout Bangladesh.

4.5 Impact on Sustainability of Fisheries

The impact on sustainability of institutional enforcement is almost non-existent. Fisheries and environment laws are routinely flouted throughout the country. Few arrests are made by the police for sale or use of current jal, fishing with poisons or failure to drain polders after shrimp growing leases expire. Non-institutional enforcement reduces fishing mortality from unauthorised fishing effort in private and leased waters. However, the marginal gain in survival is usually eroded when the owner or leaseholder carries out jalmohal dewatering and complete harvesting.

4.6 Provision of Access to Fisheries Sectors

Institutional enforcement generally supports the rights of jalmohal leaseholders to exclude unauthorised fishing. In most cases however, this exclusion is actually enforced by privately-contracted fish guards. This has resulted in some extremely violent confrontations in the past, and will likely continue in the future until the practice is eradicated.

4.7 Recommendations For Improvements And Additional Regulations

The main deficit of fisheries and environmental laws is that they do not specify, allocate or protect any roles, rights or responsibilities for genuine fishermen and fisherwomen in the management of fisheries, or in the management of fisheries environments. They also do not recognise the legal status of water bodies such as beel and baors, or specifically protect them from encroachment. It is recommended that a Community-based Fisheries Management Law be promulgated. This law should allocate access or ownership of fisheries resources, as well as fisheries environments as appropriate, to genuine fishing communities, and define management responsibilities. It should also specifically prevent and outlaw access or ownership by individuals or by capital investors (ie previous jalmohal leaseholders and moneylenders), but should at the same time guarantee subsistence fishing rights to individuals using low productivity gears in marginal fishing areas. It is also recommended that a Wetland Conservation Law be promulgated. This law should protect beels and baors. A new regulations should be promulgated by GOB which specify a complete ban on the use of pesticides to treat or preserve fish, especially dry fish.

5. LINKAGES TO OTHER ENVIRONMENTAL PROJECTS

The proposed project should establish cooperative linkages with the following projects:

- Coastal Wetland Biodiversity Management Project (UNDP)
- Biodiversity Conservation In The Sunderbans Project (ADB)
- Small Scale Water Resources Development Sector Project (ADB, IFAD, GON)
- Sunderban World Heritage Site Project (UNESCO)
- Institutional Support To Department Of Environment (CIDA)
- Northeast Regional Water Management Project (CIDA)

I. ENVIRONMENTAL IMPACT
ASSESSMENT OF PROPOSED PROJECT

A. PROJECT SETTING

A.1 Background

The proposed Fourth Fisheries Project is a follow-up project to the Third Fisheries Project (which was co-financed by the World Bank, UNDP and ODA). Third Fisheries focused on floodplain stocking and shrimp farming. It was only partly successful in meeting its objectives and failed to utilise about 70% of its previewed budget. The result was to leave unrealised a significant part of the fisheries sector development potential of Bangladesh.

The present GOB has committed itself to renewed effort to further develop the fisheries sector, and is therefore seeking to formulate an improved sector-wide fisheries development project.

A.2 Rationale and Objectives of the Proposed Project

The natural endowments of hydrology, climate and physiography of Bangladesh have given it a significant development potential in freshwater capture fisheries, freshwater and brackishwater pond culture, and marine fisheries. The fisheries sector has already realised a portion of this potential, but further development would yield worthwhile gains in income and nutrition. Targeted interventions are needed in better management, conservation and enhancement of floodplain and river capture fisheries, further extension of intensified freshwater carp and prawn pond culture, and improvement in infrastructure, production, processing and marketing of brackishwater shrimp farming. Successful project implementation would improve fisheries environments, conserve fish biodiversity and protect floodplain broodstock, provide secure access for genuine fishermen, regulate fishing effort to biologically sustainable levels, give more pond owners access to improved production technology, improve environmental conditions for shrimp and rice rotation and increase yields, and ensure that Bangladesh meets product hygiene and quality requirements for export markets. In socioeconomic terms these results would reduce risk to producers and consumers, increase income and nutrition, and judicate social conflict.

The project goal is to directly improve the physical, biological and socioeconomic environments and conditions pertaining to the fisheries sector, and indirectly benefit related sectors and communities. The principal project objective is to advance toward this goal through focused infrastructure, environmental, technical, social and economic interventions in the various fisheries subsectors. Specific project objectives are as follows:

1. Rehabilitate and enhance openwater floodplain fisheries through aquatic environment improvement, protection of broodstock, stocking of threatened species, security of tenure for genuine fishermen, and regulation of fishing effort.
2. Further extend high yielding carp and prawn freshwater pond culture methods to small land owners.
3. Improve infrastructure, extensive culture methods, and seed supply for brackishwater shrimp farmers, while reducing negative externalities to rotation paddy growers.
4. Redefine and strengthen the capacity of government fisheries institutions and NGOs to provide support services to the private sector.

A.3 Methodology for Environmental Assessment and Review Process

The methodology adopted for environmental assessment of the proposed project by the EIA Team consists of an iterative process of information collection and fact finding (with emphasis on beneficiary group sources) to identify environmental issues and possible solutions, analysis of potential impacts and identifications of mitigation measures, reporting of preliminary results to beneficiary and interested groups, and modification of project design.

Specific actions to acquire information were as follows:

- Carry out field visits together with the project component preparers in order to discuss and influence project design.
- Meet with target beneficiary groups to record their opinions, concerns and aspirations with regard to project objectives and its environmental impacts.
- Meet with other local interested parties to record their opinions on environmental impacts.
- Meet with government and NGO staff at local, district, divisional and national levels to record their opinions about environmental impacts.
- Collect and analyse fisheries and environmental data and reports from local field sources.
- Collect and analyse fisheries and environmental data and reports from national sources.
- Review government and project reports, and other literature sources at national level.

The EIA Team worked closely with the project component preparers to assess and comment on all aspects of project design during the formulation phase.

The environmental assessment will be reviewed by the DOF and the DOE, as well as by the WB.

A.4 EIA Team

The EIA Team consisted of the following individuals:

- Garry Bernacsek, International Environmental Specialist, GLOBAL AQUATIC CORPORATION Pty Ltd, Sydney, Australia.
- Yusuf Sharif Ahmed Khan, National Environmental Specialist, Institute of Marine Sciences, University of Chittagong, Chittagong.

A.5 EIA Budget and Level of Effort

The technical assistance budget for the EIA was \$ xxxxxx, while the operational budget (EIA share out of total project preparation budget) for fieldwork, meetings and materials was \$ xxxxxx.

Person months allocated for the EIA were as follows:

International Environmental Specialist	2 p/m
National Environmental Specialist	4 p/m
Total =	6 p/m

The EIA was carried out during the period 12 October 1997 to 28 February 1998, corresponding to the late monsoon and winter dry seasons.

A.6 Limitations

Implementation of the EIA was constrained by inadequate allocation of personpower, budget and time. It was not possible to visit more than a small number of the proposed project sites (and most project sites had not even been identified during the work period of the international EIA consultant), nor to assemble and analyse adequate first hand baseline data. This resulted in heavy reliance on generic and existing databases. Logistic and timetable constraints interfered with the public consultation and participation process.

A.7 Relationship to Project Feasibility Study

The EIA is strongly integrated into the project feasibility study in all aspects. The various project preparers displayed significant concern with environmental issues and strong willingness to adjust project components to achieve environmental acceptability.

A.8 Scope and Format of Report

The report describes the policy, legal and administrative framework that the project would be nested into. The project is fully described, as are the physical, biological and socio-economic environments in which it will operate and will impact. As the project does not aspire to address all possible development issues and potentials in the fisheries sector, the EIA is highly focused on actual project initiatives, rather than being a sector wide or generic environmental study. The EIA places special emphasis on the proposed environmental management plan and environmental monitoring plan.

In addition to the formal EIA, the report also assesses the state of environmental legislation and enforcement related to fisheries and recommends improvements. A series of environmental subprojects are proposed which are intended to act synergistically with the main proposed project components, by directly addressing specific environmental issues and concerns. Recommendations are also made for linkages between the proposed project and other environmental projects in Bangladesh which would serve to strengthen the impacts of the activities of both projects.

The format of this report follows closely the format for an EIA as recommended by the FPCO. It has been modified as necessary to incorporate the EIA requirements of the WB.

A.9 Acknowledgments

The EIA Team wishes to thank Nasir Uddin, Project Director, for the continuous support given to the team to provide facilities and transport to carry out its mission. Special thanks are due to Rakhil Chandra Kangsa Banik, Head of Bangladesh Fisheries Resources Survey System, who helped set up meetings, organise transport in Dhaka and participated in discussions, and to Badrul

Hassan, the DOF logistics officer. Thanks are due to the Divisional Directors, District Fisheries Officers and Thana Fisheries Officers who extended all possible cooperation. The EIA Team also thanks our fellow consultants and preparers who worked closely with us. Finally, the EIA Team thanks WB staff and personnel, particularly Benson Ateng, Ron Zwieng and Imtiazuddin Ahmed for their guidance and support.

B. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

B.1 Fisheries and Environmental Policy Framework

The MOFL currently lacks a fisheries policy *per se*. A draft fisheries development policy has been prepared but has yet to be adopted by the GOB (an English translation of the Bangla text was not available to the international consultant, but a summary will be translated from Bangla by the national consultant for use in the final report). The current draft has been successively modified and redrafted over the last seven years (without adoption). GOB fisheries agencies (DOF, FRI, BFDC) operate within their terms of reference, and have a general focus on increasing production, promoting exports and raising revenue for government. Policy focus (such as it is) tends to be interest and opportunity driven, rather than government mandated.

The Environmental Policy of the GOB was adopted in 1992, and has the following general objectives:

- To maintain natural ecological balance and ensuring sustainable development of the country through the development and conservation of the environment.
- To protect the country from natural disasters.
- To identify and control of all types of activities that pollute and degrade the environment.
- To ensure environmentally sound development in all sectors.
- To ensure sustainable and environmentally sound use of all natural resources.
- To actively associate, as far as possible, with all international initiatives related to environment.

Specific policy measures relevant to fisheries and fisheries environments include:

- Water Development, Flood Control and Irrigation: Ensure the mitigatory measures of adverse environmental impact of completed water resources development and flood control project; keep the rivers, canals, ponds, lakes, haors, baors and all other water bodies and water resources free from pollution; conduct environmental impact assessment before undertaking projects for water resources development and management.
- Land: Formulate a balanced and environmentally sound national land use policy and plan; prevent spread of salinity and alkalinity on land.

- Forest, Wildlife and Biodiversity: Include tree plantation programmes in all relevant development schemes; conserve wildlife and biodiversity, strengthen related research and help in-semination and exchange of knowledge in the concerned area; conserve and develop wetlands and protect migratory birds.
- Fisheries and Livestock: Ensure appropriate environment for conservation and development of fisheries and livestock; prevent activities which diminish the wetlands/natural habitats of fish and encourage rehabilitative measures in the area; ensure that development activities in fisheries and livestock do not create any adverse impact on the mangrove forests and other ecosystems; evaluate existing projects on water resources development, flood control and irrigation to determine their adverse impact on fisheries and adopt measures for alternate fish culture upon improvement of environmental conditions.
- Coastal and Marine Environment: Ensure environmentally sound conservation and development of coastal and marine ecosystems and resources; prevent all internal and external activities polluting the coastal and marine areas; strengthen necessary research to preserve and develop coastal and marine environment and resources; limit coastal and marine fish catch within tolerable regenerative/respawning limits.
- Institutional Arrangements: DOE will make final review and approve all environmental impact assessments (EIAs).

B.2 Legal Framework

Environmental impact assessment requirements of GOB are encoded in the Environment Law. Detailed EIA guidelines have been produced by the Department of Environment (DOE) for four industrial sectors (cement, fertiliser, textile, pulp and paper), but not for fisheries development projects. However, detailed guidelines were prepared by the Flood Plan Coordination Organisation (FPCO) of the Ministry of Water Resources (MOWR) for water management and related projects (including a number of fisheries projects) under the Flood Action Plan (FAP). The FPCO EIA guidelines have been reviewed and approved by the DOE. After discussion with DOE, it was agreed to use FPCO guidelines for environmental impact assessment as representative of GOB EIA requirements.

The general environmental assessment guidelines of World Bank are contained in Operational Directive 4.01: Environmental Assessment (including Annexes A to F), dated October 1991. Additional detailed sectoral guidelines for fisheries development projects are contained in World Bank Technical paper no 140: Environmental Assessment Sourcebook, Vol II: Sectoral Guidelines.

The GOB (= FPCO) and World Bank guidelines have been combined for the EIA of the proposed project and are presented below, in the form of major section headings of a consolidated Table of Contents (with the specifying agency indicated).

Indicative Consolidated Table of Contents for EIA Report
(Based on GOB and WB Requirements)

- List of Tables (GOB)
- List of Figures (GOB)

- Executive Summary (GOB, WB)

- Project Setting (GOB)
- Policy, Legal and Administrative Framework (WB)
- Project Alternatives (= Analysis of Alternatives) (GOB, WB)
- Project Description (GOB, WB)
- Description of the Existing Environment (= Baseline Data)(GOB, WB)
- Environmental Impact Assessment (GOB, WB)
- Cumulative Impacts (Methodology and Results) (GOB)
- Project Scoping and the Consultation Process/Public Response (GOB)
- Environmental Management Plan (= Mitigation Plan) (GOB, WB)
- Environmental Management and Training (WB)
- Environmental Monitoring Plan (WB)

- Glossary and Abbreviations (GOB)

- Bibliography (GOB, WB)

- Appendices (GOB)
 - Figures (GOB)
 - Tables (GOB)
 - Photographs (GOB)

B.3 Administrative Framework

Environment-related projects and programs (outside of production activities) within the fisheries sector come under the mandate of several GOB agencies:

- DOF has a modest environmental program for fish sanctuaries.
- MOL owns (on behalf of the GOB) all natural inland waters (beels, boars, rivers, khals) and leases them out to users.
- DOE monitors water quality in rivers and other water bodies.
- DOFr is responsible for management of afforestation of mangroves and wetland forests, and administers national parks and game reserves.
- BWDB construct, owns and operates large scale water management structures for flood control, drainage and irrigation, including polders where shrimp culture is practiced, and the sole fishpass in Bangladesh at Kashimpur (Manu River FCDI Project).
- BWDB collects regular hydrology data from rivers.
- SWMC and WARPO use BWDB hydrology data to model and predict flood levels.
- LGED constructs, owns and operates small scale water management structures for flood control, drainage and irrigation.
- The Electricity Board has constructed the only large dam in Bangladesh at Kaptai and manages the Kaptai Reservoir.

The individual mandates of agencies sometimes overlap and conflict (for example MOL and DOF jurisdiction over fisheries management) resulting in government-induced inefficiency, inequity and conflict within the fisheries sector.

C. PROJECT ALTERNATIVES

C.1 Future Without Project

A reasonable scenario of the future without project interventions is as follows (based on forward projection of existing trends within the fisheries sector):

- Continuous decline and possible extinction of native carp stocks in most parts of the country;
- Overfishing of fish overwintering areas and spawning areas resulting in heavy mortality of broodstock and national extinction of some fish species;
- Continued siltation of rivers and access canals, resulting in reduced migration of fish;
- Continued construction of FCDI projects without fishpass facilities resulting in further reduction of fish migration and massive fish loss inside the project areas;
- Slow growth in productivity of pond culture;
- Decline in vitality of fingerlings for pond stocking sourced from hatcheries;
- Overharvesting of shrimp seed from wild sources, resulting in decline in shrimp stocks and catches, and declines in stocks of fish and other species present in seed by-catch;
- Increased social conflict over use of private farm lands inside coastal polders for shrimp grow-out, due to lack of control over activities of shrimp farmers;
- Increased insecurity of supply of larvae for shrimp and prawn farming, resulting in erratic production, and imports of possibly diseased larvae from other countries;
- Slow growth in productivity of prawn farming, and increased incidence of disease and mortality due to poor management practices;
- Increasing rejection of exported shrimp by importing countries due to poor quality and inadequate hygiene standards at shrimp depots and at processing plants;
- Increasingly ineffectual performance of fisheries institutions;
- Continuing decline in fish biodiversity and local and national extinction of fish species;
- Continued degradation of fisheries environments from deforestation, agrochemicals, dewatering, loop cutting of rivers, industrial effluents and water hyacinth infestation;
- Increasing conflict between jalmohal leaseholders/capital investors and genuine fishermen over access and tenure of openwater fisheries resources;
- Increasing incidence of disease pandemics in fish and crustacean stocks, resulting in large economic and nutritional losses.

The damage track of each subscenario will vary, but the cumulative effect of all subscenarios is more likely than not to be quite significant.

C.2 Alternatives

An alternative approach to management and conservation of indigenous fish stocks and fisheries environments is to focus entirely on openwater stocking with indigenous and non-indigenous species (while ignoring natural reproduction and recruitment), and to meet any shortages in supply which may be develop through importation of cheap frozen food fish (such as small pelagics from Chile and Peru). At the same time, increased consumption of other sources of protein (pulses, poultry) could be promoted.

C.3 Selection of Alternative

The approximate cost of the alternative proposed above would be as follows:

- Cost of stocking (4 million ha @ \$50/ha) \$200,000,000
- Cost of imports (500,000 t @ \$500/t) \$250,000,000

TOTAL COST OF PROJECT ALTERNATIVE = \$450,000,000

Not included in this estimate are the social costs of displaced fishermen and fishing input suppliers, subsistence losses in terms of nutrition, and costs of creating alternative employment for large numbers of people (1.2 million). This would substantially raise the true cost of the alternative.

The cost of the proposed project is \$70,000,000, which is only 16% of the nominal cost of the alternative. Given the substantial collateral benefits to environmental improvement that the it would bring, the cost-effectiveness of the proposed project is judged to be much higher than the alternative.

The analysis suggests that the alternative is not viable and should be rejected in favour of the proposed project.

D. PROJECT DESCRIPTION

D.1 Project Overview

General

The project is a capital loan project type which will be financed by the IDA. Additional sources of finance for technical assistance will be sought from other donor agencies. GOB contribution to the project will be in kind and in fiscal capital development funds.

Type

The project is a fisheries development and conservation project. It contains components which will improve the environment, increase production and increase product value. A large portion will be in the form of credit and extension. Some infrastructure construction will also take place, for fishpasses, canal re-excavation, prawn pond water supply and drainage, and prawn and shrimp hatcheries.

Project Components

The proposed project will consist of the following components:

Activities in Inland Openwater Capture Fisheries

(to be completed)

Floodplain Stocking Component

Fish Sanctuaries Component

Canal Re-excavation Component

Fishpass Construction Component

Activities in Freshwater Finfish Aquaculture

Intensive Pond Culture Demonstration and Credit Component

This component will raise yields in existing semi-intensive (ie management driven rather than input driven) ponds to the 3,500-4,000 kg/ha level. This will be accomplished using two principal inputs: 1) the application of inorganic fertilisers to increase the phytoplankton food source, and 2) the application of high quality pelleted feeds. Demonstration (*sic* in-pond trials) will be carried out in 50,000 ponds over a five year period. Demonstrations will focus on 150-200 thanas (50 per thana per year) and approximately 5,000 ha of ponds (average pond size of 1,600 m²). The cost of

demonstration will be US\$8 million. A credit component will allow widespread implementation of the intensive input system, and provide \$20 million to pondowners.

Intensive Cage Culture Demonstration and Credit Component

This component will introduce floating cage culture technologies to inland fishing communities for rivers, beels, baors and ponds. The expected average yield will be 200 kg/m³, from cages ranging in size from 1 to 3 m³. This will be accomplished using high quality pelleted feeds, and assumes a feed conversion ratio (FCR) of 2:1. High value fish will be cultured, including catfish, tilapia and common carp. Demonstration will be carried out in 1,000 cages (with total volume of 3,000 m³) over a five year period. A credit component will allow widespread implementation of the cage culture system.

Semi-Intensive Pen Culture Demonstration and Credit Component

This component will introduce semi-intensive pen culture techniques to inland fishing communities for borrow pits (roadside and FCDI), canals, dead river channels and other suitable locations. The expected yields will be as high as 4,000-5,000 kg/ha, from an average pen size of 2,000 m². This will be accomplished using supplemental high quality pelleted feeds (rather than fertiliser inputs). Demonstration will be carried out in 250 pens (total of 50 ha) over a five year period. A credit component will allow widespread implementation of the cage culture system.

Broodstock and Hatchery Component

This component will introduce pure lines of culturable species already in-country, in part through importation on new blood lines. The component will also carry out hatchery registration.

Contract Research Component

This component will finance aquaculture research on a contract basis. It will allow specific research supportive to proposed project components to be conducted through private organisations, university or GOB agencies.

Activities in Crustacean and Brackishwater Aquaculture

Sustainable Shrimp Seed Collection Component

This component will mitigate negative impacts of shrimp seed collection pressure on natural stocks of fish and shrimp. The objectives of this component are to secure a sufficient and sustainable recruitment of species of fish and crustacean from the coastal and freshwater areas of Bangladesh. It would: 1) introduce non-destructive catching procedures for Penaeus monodon larvae, and 2) develop transportations systems which increase the survival and quality of the caught shrimp larvae. The component would ban the use of push nets, while simultaneously a credit scheme for 5,000 poor head of household women will be provided to allow them to become shrimp larvae collectors through the purchase of wooden boats and nets. Training would be provided to shrimp larvae collectors in proper handling of larvae and to return by-catch to the river through financial assistance to NGOs. Training would be provided to shrimp seed traders in proper handling of seed during transportation. Low cost equipment for transportation and storage of larvae will be introduced.

Integrated Coastal Zone Planning Component

This component is designed to mitigate social conflicts due to land use issues arising from extensive shrimp farming and ease pressure on land resources including mangroves. The objective is to install a land use planning and management system in the coastal areas of Bangladesh which uses a holistic approach. This would aim to allocate land for different activities (including shrimp farming) in each District of the coastal zone. It would develop a management information system for land use, as well as a legislative framework for land use issues. It would also empower government at local level to enforce land use regulations. A preparatory team under the DOE as executive agency will formulate an Integrated Coastal Zone Land Use Project, based on participatory principles which include all affected interest groups in the private sector, NGOs and local and national authorities.

Private Hatcheries for Shrimp and Prawns Component

This component aims to develop a viable privately owned crustacean hatchery industry. The long-term objective of the component is to establish hatcheries for *P. monodon* and *M. rosenbergii* in the private sector with sufficient capacity to meet the total demand for larvae in Bangladesh. It would offer technical assistance to hatchery and nursery operators throughout Bangladesh and encourage processing plant owners to invest in hatchery and nursery operations in order to secure a steady and predictable supply of marketable shrimp and prawns. It would also introduce a quality assessment system for hatchery produced larvae. It is anticipated that the direct project output would be the supply of 30% of total demand for shrimp and prawn larvae by privately owned and operated hatcheries. Cost-effective larvae production would be facilitated by the provision of in-hatchery training and trouble-shooting. A Codex for quality assurance of post-larvae will be developed and hatcheries will be certified.

Improved Freshwater Prawn Culture Component

This component will provide assistance to smallholder pond operators producing freshwater prawns. The objective is to introduce a sustainable system for production of *M. rosenbergii* in rotation with rice among smallholder farmers in rural areas of Bangladesh. It would develop and demonstrate a number of techniques including monoculture of prawns and polyculture of prawns with different finfish species. It would train farmers in appropriate prawn farming techniques with special emphasis on women pond operators and make credit available through NGOs. Training would also be given to NGO extension workers, fry suppliers and marketable prawn collectors (*forias*) in prawn farming techniques. It will demonstrate how prawn farmer groups could construct, operate and maintain water supply and drainage system installations themselves, and with the only external input requirements being supervision assistance and access to loans with low interest rates. The expected component output would be an increase in production of prawns (and by-product fish) through the combination of better management, improved water supply (where applicable) and an increase in prawn pond farming area. Men and women prawn farmers will be trained in management of different types of prawn farming systems. NGO extension workers, fry suppliers and marketable prawn collectors will be trained and equipped with manuals made available by the project. Field trials in different pond types will establish procedures for the most cost effective management systems. Two water supply and drainage systems will be constructed through the efforts of farmer groups. Men and women prawn farmers with less than

0.2 ha of land will be assisted through additional income generating activities, including construction, operation and maintenance of water supply and drainage systems.

Improved Shrimp Processing Practices Component

This component will train middle management personnel in the shrimp and prawn processing industry in good manufacturing practices and HACCP.

Activities in Institutional Development

Vocational School for Aquaculture Component

This component would establish a vocational school for aquaculture. The objective is to make available to the private sector aquaculture specialists with comprehensive technical knowledge in commercial aquaculture procedures. It would train young men and women to a relatively high level in aquaculture management, techniques and system dynamics. A curriculum would be developed, an appropriate location for the school selected, and the number of teachers and their qualifications determined.

Institutional Restructuring

Activities are not presently defined, but will be pending a review and evaluation process. Likely items include the following:

- Fisheries Management Information System Component
- Environmental Management System Component
- Seafood Products Quality Control Improvement Component
- Evaluation and Restructuring of Fisheries Development Agencies Component
- Evaluation and Restructuring of Fisheries Research Agencies Component
- Human Resources Development Component

Activities in Environmental Management

The proposed project would have four discreet subprojects and one pilot project dealing with environmental issues and problems. These are fully described below (Section II. Terms of Reference for Environmental Subprojects). The main components of the subprojects and pilot project are as follows:

Fish Biodiversity Conservation Subproject

This subproject has the following components:

- National Fish Biodiversity Survey Programme Component
- Impact of Embankments on Fish Biodiversity Component
- Impact of Stocking and Pond Escapage on Fish Biodiversity Component
- Impact of Shrimp and Prawn Seed Collection on Fish Biodiversity Component
- Stocking of Endangered Fish Species Component.

Fisheries Environments Improvement Subproject

This subproject has the following components:

- Wetland and Mangrove Tree Plantation Component
- Control of Agrochemicals Impacts Component
- Beel and Baor Embankment Component
- Artificial River Duars Pilot Schemes Component
- Low Cost Industrial Effluent Treatment Component
- Water Hyacinth Control Component.

Community-Owned Fisheries Pilot Project

This pilot project has the following components:

- Fisheries Association Establishment Component
- Acquisition of Water Body and Fishery Resource Ownership Component
- Financial Management and Loan Repayment Component
- Fishery Management Plan Component
- Environmental Management Plan Component

Fish and Shrimp Disease Control Subproject

This subproject has the following components:

- Survey of Fish and Shrimp Disease and Control Measures Component
- Extension Training on Disease Prevention and Management
- Environmental Hygiene and Wastewater Recycling Component
- Quarantine Measures to Contain Disease Outbreaks Component

Water Quality and Quantity Monitoring Program Subproject

This subproject has the following components:

- Acquisition of Hydrology Data Component
- Acquisition of Water Quality Data Component
- Project Water Monitoring Data Collection Component
- Analysis of Water Data Component
- Fisheries Environments Data Service Component

Location

Project interventions and construction will take place in the following divisions and districts:
(to be completed)

District	Initiative
	Prawn pond water supply and drainage
Khulna, Cox's Bazar	Shrimp hatcheries
Khulna, Cox's Bazar	Prawn hatcheries
	Fishpass construction
	Canal re-excavation
Entire country	Carp pond culture extension
	Fish sanctuaries

D.2 Pre-Implementation Phase

Status of Project During EIA Study

The project was in the design stage during the EIA study.

Design Activities

Project design was carried out by a team of 16 consultants. This involved extensive field visits throughout Bangladesh (although this was constrained by time for the international consultants). Possible project intervention sites were identified and preliminary designs for fishpasses, hatcheries and other structures were prepared. Detailed design would be carried out during project implementation.

D.3 Implementation Phase

Likely Construction Activities

The project is likely to construct up to 5 fishpasses, 3 hatcheries, 30 water regulators, and re-excavate some 50 km of canals and drains.

Possible Hazards

Premonsoon and monsoon flood damage presents a hazard for construction of fishpass projects which are not fully completed during a single winter dry season construction period. Cyclone damage presents a hazard for brackishwater shrimp construction.

Probable Schedule of Works and Logistics

The window of opportunity for construction of fishpasses is short (December to May) and site preparation and construction should ideally be completed during one season. Experience during construction of the Kashimpur fishpass indicates that this should be possible at most sites.

Similar considerations also affect regulator construction and canal re-excavation for shrimp farming.

D.4 Operation and Maintenance Phase

O & M Schedule

Periodic inspection and maintenance will be required for all structures.

Likely Hazards

Possible hazards to structures include flood damage, cyclone damage and earthquake and/or subsidence damage.

D.5 Overall Project Schedule and Logistics

The project will have a 5 year lifespan. It is anticipated that Year 1 of the project will be occupied with preparation of the inception report, baseline monitoring and detailed design work. Years 2 to 5 would be occupied by construction, normal operation and impact monitoring.

E. DESCRIPTION OF THE EXISTING ENVIRONMENT

E.1 Natural Physical Environment

Climate

Bangladesh has a subtropical climate governed by two major weather regimes:

- Wet southwest monsoon from May to end of September (originates over Indian Ocean),
- Dry northeast wind from November to mid-March.

The seasons consist of a dry cool winter season, a hot spring season, a warm wet monsoon summer, and a hot moist autumn season.

Maximum air temperatures range from 35°C to 43 °C and occur in April and May. Minimum temperatures range from 5 °C to 12 °C and occur in December and January.

Mean annual precipitation ranges from 1,200 mm in the west to almost 6,000 mm in the northeast. The catchment of the Surma River (a tributary of the Meghna) in India includes the wettest place on earth with annual rainfall of over 13,000 mm. About 85% of the annual rainfall occurs from June to September.

Tropical cyclones originating over the Indian Ocean occur during the premonsoon and postmonsoon periods. Cyclones are accompanied by storm surge tidal waves. Tornados, hailstorms and flash floods are produced by nor'westers during the transition from the winter to monsoon season, especially in the northeast.

Water Resources

Three major rivers traverse Bangladesh: the Padma (= Ganges), the Jamuna (= Brahmaputra) and the Meghna. They drain a catchment of 1.72 million km² in India, Nepal, Bhutan, China and Bangladesh. About 8% of the catchment lies within Bangladesh.

About 90% of the flow of the three main rivers originates outside of Bangladesh. The combined discharge of the Jamuna and Padma varies from a minimum of 10,000 cumecs in January to a peak of 80,000 to 140,000 cumecs in late August and early September. The Farakka Barrage (situated upstream of the point of entry of the Ganges into Bangladesh) diverts some flow to India, resulting in increased shortage of water during the dry season in southwestern Bangladesh. Smaller coastal rivers occur in the southeast (Feni, Karnaphuli, Shankha and Matamuhuri) and provide an additional xx mcm of annual discharge.

The annual hydrological cycle begins with low water minimal discharge during the cool dry winter season. Rainfall in the catchment in March and April causes premonsoon flood surges and temporary bank overflow to occur in some rivers (ie the Koshiyara and the Surma in the Upper Meghna basin). The onset of the full monsoon rainfall in May and June causes all rivers to rise and overflow their banks. Peak discharges are attained in August and September. Sustained flooding in some areas can last throughout the monsoon - typically until October and November. The level of inundation of the floodplain varies according to location. Postmonsoon drainage of the floodplain occurs in November and December.

Groundwater resources are(to be completed)

Land Resources

The Bangladesh landscape is characterised by 20 physiographic units, which can be grouped into three land forms:

- Hilly areas (12%)
- Terrace areas (8%)
- Floodplain areas (80%)

Most of Bangladesh consists of floodplain and deltaic deposits of the Jamuna, Padma and Meghna Rivers. Average land elevation above sea level is only a few meters. Highlands occur in the southwest where mountains rise to almost 3,300 m. About 25% to 30% of the country is flooded each year from May to September.

The total land area of Bangladesh is 14.8 million ha. Some 9.5 million ha (64.2%) is used for agriculture. Six million ha are subject to flooding, ranging from 30 cm to over 2 m. Flood period, depth and duration determine the type and period of crops. Land types based on flood depths and rice varieties are as follows:

Land Type	Depth of Flooding (cm)	Area (million ha)	Suitable rice variety for monsoon season
F ₀	0-30	3.5	HYV
F ₁	30-90	3.2	Local varieties
F ₂	90-180	1.6	Deepwater rice
F ₃	> 180	1.1	Deepwater rice
F ₄	> 180	0.1	None

E.2 Natural Biological Environment

(to be completed)

Freshwater Environment

Swamps and Permanent Seasonal Water Bodies

Natural Fishes

Aquatic Flora and Fauna

Biodiversity

Ecologically Sensitive Areas

Tidal-Marine Environment

Delta, Estuary and Marine Environment

The entire coastline of Bangladesh is intercepted by an intricate network of interconnecting waterways (estuarine ecosystem), some of which varying in width from few meters to several kilometres. These generally run in a north to south direction. Some of the world's largest rivers (Ganges, Brahmaputra, Meghna, and also the smaller Karnafully) discharge through estuaries into the Bay of Bengal.

Although intensive studies on the estuaries have not yet been carried out, several authors have highlighted some interesting aspects of some of our estuarine system (Mahmood and Ahmed, 1976; Salam, 1976; Quader, 1976; Khair, 1976; Mohi, 1977; Das, 1977; Amin and Mahmood, 1979; Das and Das, 1980; Mahmood and Khan, 1980; Hakim et al., 1981; Paul, 1981; Islam, 1982; Haque, 1983; Hossain, 1983; Mohmood, 1984; and Mahmood et al., 1985). The most notable feature in hydrology of estuaries is the presence of a yearly prolonged low salinity regime, mostly during monsoon and post-monsoon seasons.

The semidiurnal type of tide is a characteristic feature of Bangladesh coastal waters, with a range of approximately 3 meters during the time of spring tides. The mean level of tide is not constant throughout the year as it undergoes changes that vary with attitude and hydrographic (Patullo, 1963). The Bay of Bengal has possibly the largest such variation known on earth. This seasonally changing, large fluctuation of mean tide level has an important impact on the overall geomorphology of the coastal area. The average level in March is 94 cm below the average level in September which is the month with the highest tides (Smith, 1982).

Descriptions of two important estuaries are given below.

Karnafully estuary: This is the most important river of Chittagong division. It is surrounded by a region of dense population, high industrialisation and large agricultural land. Chittagong is commercially important and also the main port city of Bangladesh, with a permanent population of about 3 million. The city does not have waste treatment facilities and untreated wastes are discharged into the river. Most of the industries of Chittagong (tanneries, textile mills, oil refineries, chemical complex, fertiliser factories, paper and rayon mills, cement factories, steel mills, soap and detergent factories) are located near the banks of the Karnafully river and discharge their untreated effluents directly or indirectly into the estuary. The combination of large population, high industrialisation, heavy shipping activities and shallow depth gives the estuary substantial pollution problems. Such problems, however, have not been well documented.

Meghna estuary: The international rivers Ganges and Brahmaputra enter Bangladesh from the west and north, respectively, join together inside the country, and flow downstream as the Meghna River to discharge into the Bay of Bengal. This is the main freshwater input into the Bay of Bengal. The estuary is very important from a geohistorically and is one of the most active areas of sedimentation in the world. All river going vessels (passenger, cargo, oil tankers, mechanised and non-mechanised boats) run through the estuary from Chittagong port to upstream districts and to Dhaka.

Natural Hazards

than 50% slope as suitable for forestry practices. This land is known as USF and at present comprise of only barren hills as a result of unrestricted extraction of wood through grant of permits over a long period of time. So far, 65,000 ha of USF have been transferred to DOFr for plantation establishment. The remaining land is now administered by three district councils on behalf of MOL. In addition, an unknown area of hilly khas land exists in greater Chittagong and Sylhet districts.

- **Private Forest:** Private forest is the aggregation of all land with tree cover in villages in the country and is not a forest in the actual sense of the term. This includes: 1) 724,000 ha of village forests comprising 477,000 ha of village homestead tree cover, 147,000 ha of bamboo and 102,000 ha of other trees, and 2) about 49,000 ha of land comprising derelict and abandoned tea gardens, and areas in tea estates unsuitable for tea plantation (Mahtab et al, 1991).

The forests under the management of DOFr can be classified into:

- Hill forests, covering an area of 465,000 ha, including 120,000 ha of plantations;
- Mangrove forests consisting of 587,000 ha of natural mangroves (Sunderbans) and 101,000 ha of artificially raised mangrove plantations in the coastal bays and offshore islands,
- Plain land forests covering about 12,000 ha in Gazipur, Tangail, Sherpur, Mymensingh, Rajshahi, Rangpur and Dinajpur districts.

Wildlife

At least 18 species of wildlife have become extinct in Bangladesh during the present century. All of them still exist in neighbouring countries, except the pinheaded Duck (*Rhodonessa carrvophyllacea*) Which is totally extinct. All these extinctions took place during the period of colonial rule. At least 40 more species are endangered, and unless drastic measures are taken they will become extinct in the next few decades. These include tiger and other cats, elephants, hoolock gibbon, monkeys, deer, gangetic, dolphin, whitewinged wood duck and a number of other birds, gharial, estuarine crocodile and monitor lizards. Another 27 or more species are threatened and these could become endangered within the first half of the next century.

Including the endangered and threatened species referred to above, there exist about 123 species of mammals (belonging to 33 families), 567 birds, 154 reptiles (belonging to 20 families), and about 23 amphibians. This is a conservative estimate, as there are a few more species whose presence in Bangladesh awaits confirmation. Exact figures of the past are unknown as no authentic record of the animals of this part of the world exists. But there is little doubt that a rich wild life fauna existed in the distant past.

Hunting, shooting and trapping are harmful practices, especially for the larger species, but these are not the most important causative factors for environmental degradation and population decline.

Biodiversity

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Biodiversity

The land mass may be divided into several divisions whose vegetation and crops are somewhat different from each other representing different ecosystems. These are as follows:

- Hilly areas with evergreen and semi-evergreen forest occur in the Chittagong Hill Tracts, Sylhet, Moulvibazar and Habigonj districts in the East and Netrokona and Sherpur districts in the North.
- The mangrove forest of the Sunderban in Khulna, Satkhira and Patuakhali districts in the south-west is the world's largest natural mangrove forest. Small areas of mangrove also occur in Chakoria and Teknaff of Cox's Bazar district in the south-east.
- Deciduous forest of mixed species occur in the high land (9-18m above mean sea level) of Madhupur Tracts extending over Tangail, Mymensingh, Gazipur and Narsingdi districts.
- The uplands of the Brained Tract (20-23m above mean sea level) in the western part are greatly denuded of tree cover at present and show signs of desertification. They form a distinct ecosystem different from other parts of the country.
- A small area in the north west in Panchagar, Tetulia shows an undulating terrain with acid soil and is different from the other plains.
- Coastal islands and a coral reef at St Martin's Island.
- Chars or small islands in the river beds of the major rivers form a distinct ecosystem.
- Recently accreted plodder land in the southern parts of Bangladesh is ecologically different from the older formed land mass.

At least 5,000 species of flowering plants occur in Bangladesh, many of them are of economic importance. The main crops are rice, wheat, jute, sugarcane, tea, cotton, mullets, pulses, potato, oil seeds, yam and numerous species of vegetables. Among fruits, jack fruit, mango, banana, coconut, cashew nut, pineapple, guava, lychee, melon, watermelon, borassus palm, lime, papaya and blackberry are common.

The hilly forests are example of tropical rain forest with a tall canopy of trees and an undergrowth of bamboos, empatorium and other species. Many plants are of medicinal value. Dipterocarps are the dominant species in these forest. The inland deciduous forests contain mainly jackfruit and other species. Plantation of teak, rubber, mahogany, eucalyptus, tropical pine, oil palm and other valuable indigenous exotic species of timber and firewood now form a major part of the managed forests of Bangladesh. Among timber trees teak, mahogany, koroi, gamari, chapalish, jackfruit, kathali chapa and mango are important. The mangrove forests provide sundari, goran, gewal, golpata and firewood from miscellaneous species of trees. Golpata, sungrass and bamboo are economic plants used for mainly thatched houses of rural areas. Bamboo is also used for industrial purposes. There are several rattan species and many medicinal plants growing in forests.

Invertebrates are very diverse in Bangladesh. From a partial survey many species of soil nematodes were recorded. Several leeches and earth worms represent the annelids. Several species of slugs and snails occur. Spider, centipedes, millipedes and innumerable insects represent terrestrial arthropods. Many of them are important pests of various crops and vectors of diseases.

However, many of them are useful. In Bangladesh several races of silkworm (Bombyx mori) occur.

Eri silk moths also occur but they have not been exploited commercially. The lac insect (Kerya lacca) occur in Rajshahi-Chapai Nawabganj and is cultured. Honey is harvested commercially. At least three bee species occur in Bangladesh (Apis indica, A. dorsata and A. florea). Insects also play a very important role in pollination. Termites, borers, leaf miners, leaf hoppers and plant hoppers, mosquitoes, sand flies, flies, ticks and mites play important roles in agriculture, health and animal husbandry sectors. But comprehensive inventories of the invertebrate animals of Bangladesh has never been prepared.

Among the amphibians, toads, frogs and tree frogs have been recorded. Frogs and toads play important roles in natural control of agriculture pests. Bull frogs were once exported but this is now banned. Lizards, geckoes and the Bengal monitor are important land reptiles. There are many turtles, but the only truly terrestrial tortoise occurring in Bangladesh is the Burmese Brown Tortoise (Geochelone emys). One species of skink (Anjani, Mabniya carinata) occurs in Bangladesh. Many snakes occur in Bangladesh including two species of python (Python molurus molurus and P. reticulatus) and two species of blind snakes (Typhina spp). Other well known snakes are darash or the ratsnake (Ptyas mucorsus), dudhraj or Copper head trinket snake (Elaphe radiata), kalnagini (Chrysopela ornata), common vine snake (Aphaetulla nasutus), common wolf snake or gharginni (Lycodon spp.), king cobra (Ophiopagus hanna), cobra (Naja spp.), Banded krait (Bungurus fasciatus), common krait (B. caerutus), Dussel's viper (Vipera russelli) and others.

Of the 579 species of birds recorded from Bangladesh there occurs one species each of a grebe, a pelican and one little cormorant. Other species include herons, egrets, bitterns, storks, ibis, spoonbill, ducks, geese, falcon, eagles, buzzards, kites, harriers, osprey, vultures, fowls, pheasant, crane, moor hen, jacana, snipes, sandpipers, gulls, pigeon, doves, parrots, cuckoos, owls, night swift, house swift, king fisher, hornbill and wood peckers, Among the passerine birds there are larks, swallow, bulbuls, shrikes, fly catchers, crows and drongo. Many of these birds are migratory while others are residents in the country.

Among mammals there are shrews, fruit bats, pipestrelles (chamchika), pangolin. Among primates there is a tree strew (Ipaia nicobarica), slow loris (Nycticebus coucang). Rhesus monkey (Macaca mulatta), crab eating macaque (M. irus), lengurs (Presbytis spp.), Hook gibbon (Hylobates hoolock). There are squirrels, rats mouse, porcupines, Indian hare (Lepus cuniculus ruficandatus) and the Assam Rabbit or the Hispid hare (Capnolagus hispius). Among carnivores the most famous species in the Royal Bengal tiger (Panthera tigris). Other carnivores include leopards, civets and other cats, fox, jackal, the Asiatic wild dog or dhole (Cuon alpinus), bears and mongoose. Domestic horse and ass occur among ungulates. One horned Rhinoceros used to exist but is now extinct. Among the even toed ungulates wild boar, domestic pig, barking deer, spotted deer, Sambur, sebu (Bos indicus) and domestic European ox (Bos taurus), and the Asiatic Buffalo (Bubalus bubalis) are common, gaur (Bas gaurus) and goyal (Bos frontalis) are rare. Domestic

goats and sheep are found but the wild serow (*Capricornis sumatraensis*) is an endangered species.

The need for conservative has arisen due to overexploitation of certain resources. Energy demands are putting great pressure on forest resources. This pressure can be alleviated by making available alternatives for fuel wood. Conditions should be made conducive for saving animal waste for preparing organic manure rather than burning them as fuel. Plans must be made to allocate land for fodder crops. Resource allocation shall have to be revised and reallocated to make development sustainable. It would be important to integrate agricultural crop production with animal husbandry, poultry management and fish culture. Recognition of this integration at the highest policy making level would lead to the reorganisation and renovation of the management of the above sectors (Mahtab et al. 1991).

Ecologically Sensitive Areas

E.3 Socio-Economic Environment

Economic Development

Agriculture

Livestock

Settlement

Industries

Infrastructure

Social Development and Quality of Life

Political, Jurisdictional and Institutional Considerations

Demographic and Social Context

Public Health (Water Supply, Sanitation, Drainage, Noise and Vibration)

Aesthetics

Cultural Heritage Context

Historical, Cultural and Archaeological Sites

F. ENVIRONMENTAL IMPACT ASSESSMENT

F.1 Predicted Impacts

Impacts in Inland Openwater Capture Fisheries

Floodplain Stocking Component

This component has a potential for negative impact on native *chotomach* species due to competition from stocked non-indigenous species. The degree of impact could depend on stocking density, and possibly the quality of ancillary management efforts. Heavy stocking of grass carp and common carp can greatly reduce the abundance of submerged macrophytes in beels and baors which provide essential habitat shelter and food sources for a large number of small fish species. A reduction in abundance of those *chotomach* species dependant on submerged macrophyte habitats would be expected. The tendency of common carp to roil the water by stirring up fine sediment and clay while feeding reduces water quality and could further affect production of some of the more sensitive *chotomach* species. Stocking of silver carp and bighead carp can negatively impact the production of plankton feeding *chotomach* such as *chapila*, *ketchki* and some cyprinids through competition for food. The production trade-off is likely to be less drastic compared to grass and common carp stocking.

There exists a potential for a negative impact on the genetic diversity of wild stocks of indigenous carp species (*rui*, *catla*, *mrigel*) due to stocking of large numbers of fingerlings of these species derived from relatively few hatchery resident broodstock. The wild stocks of native carp are currently much reduced in abundance due to overfishing and environmental degradation. Hatchery-produced fingerlings would likely greatly outnumber wild fingerlings wherever large scale stocking of floodplains is carried out, and very quickly dilute wild genetic diversity with less diverse hatchery gene pools. Natural selection could likely eliminate unfit genotypes of hatchery origin fairly quickly and act to dampen the drain on diversity somewhat. Nonetheless a net loss of genetic diversity is to be expected. This would increase the long-term risk of survival of wild carp stocks. The potential negative impact of genetic diversity loss cannot be readily quantified.

There exists a potential for a negative impact on wild fish stocks by transmission of disease from hatchery stocks. Entry of new disease into Bangladesh through importation of broodstock could result in new pandemics. Also, reinfection of stocks in areas that have recovered from previous epidemics could also take place through stocking of hatchery reared fingerlings. High rates of mortality can arise as a result of disease epidemics in beels and baors.

Positive impacts from floodplain stocking are the increase in abundance of depressed native carp populations (*rui*, *catla*, *mrigel*).

Fish Sanctuaries Component

No negative environmental impacts are expected from the establishment of fish sanctuaries. Positive impacts are the increased protection of fish biodiversity and maintenance of stock abundance. Some social impacts may occur due to displacement of some fishermen from sanctuary areas.

Canal Re-excavation Component

There exists a potential for a negative impact on the stored volume of water in beels and baors during the dry season due to improved drainage capacity of the canal. This could result in reduced area/volume of dry season refuge habitat for fish, increase environmental stress on fish populations (likely leading to outbreaks of disease and significant fish mortality) and increase the probability that dewatering would be used to do a complete fish harvest. Loss of reproductive success and recruitment during the monsoon due to total harvest of broodstock during the previous dry season could depress monsoon production.

The positive impacts from canal re-excavation are: 1) re-establishment of active fish migration routes between rivers/khals and beels/baors, and 2) replenishment of beel/baor fish biodiversity and stock abundance.

Fishpass Construction Component

There exists a minor potential for a negative impact on boro and aus rice production during the premonsoon and early monsoon periods due to entry of water through the fishpass into the FCDI project area. The magnitude of this potential impact is very variable and difficult to predict, and in the majority of cases the impact will be nil.

The positive impacts of fishpass construction are the re-establishment of fish and prawn migration routes across flood control embankments, leading to increased fish biodiversity and stock abundance inside the FCDI project.

Because the access canals/khals on either side of the fishpass need to be declared as sanctuaries, the potential positive and social impacts associated with sanctuaries noted above are also applicable to fishpasses.

Impacts in Freshwater Finfish Aquaculture

Intensive Pond Culture Demonstration and Credit Component

There exists a potential for negative impacts on wild fish stocks in adjacent rivers and floodplains due to escape of fish from ponds. The impact can be in the form of disease transmission and/or in the form of establishment of undesirable non-indigenous species in openwater habitats. Many non-indigenous species now occur in natural water bodies in Bangladesh (tilapia, Thai *puti*, Thai *pangas*, African *magur*, silver carp and common carp). Some non-indigenous species have established self-sustaining populations (ie tilapia and common carp). It would be undesirable if certain other non-indigenous species (Thai *puti* and African *magur*) were able to establish self-

sustaining populations in the wild. Impacts of non-indigenous species on native species and aquatic habitat have already been noted above under the floodplain stocking component. In most cases the number of individual fish escaping ponds will be relatively small, and their impact on natural populations and habitat would not be as great as under the floodplain stocking component. However, once established in the wild, an undesirable species is almost impossible to eradicate.

Intensive Cage Culture Demonstration and Credit Component

There exist potentials for negative impacts which are similar to those noted above for the intensive pond culture component. The risk to native fish stocks and aquatic habitat due to escape from cages into surrounding rivers, beels or baors is considered to be greater than for ponds. Additional potential for negative impact could arise in the form of eutrophication due to the use of un-pelleted feed or due to overfeeding. The greater fish biomass carrying capacity of cages compared to a similar volume of uncaged surface water will result in greater release of metabolic waste products such as ammonia, urea and CO₂. Eutrophication impacts might be reduced naturally by rapid re-assimilation of lost feed and molecular wastes by the surrounding trophic chain if adequate stocks of chotomach are allowed to congregate around cages, and stands of submerged macrophytes take root around cages.

Semi-Intensive Pen Culture Demonstration and Credit Component

There exist potentials for negative impacts which are similar to those noted above for the intensive cage culture component. The risk to native fish stocks and aquatic habitat due to escape from pens into seasonally connected rivers, beels or baors is considered to be marginally greater than for ponds, but less than for cages. The potential for negative impact due to eutrophication from the use of un-pelleted feed or due to overfeeding is significant. However, the isolated nature of borrow pits and dead rivers will result in containment of impacts to the grow-out area for three types of water bodies. Eutrophication impacts might be reduced naturally by rapid re-assimilation of lost feed and dissolved wastes by the surrounding trophic chain if adequate stocks of chotomach are allowed to co-habit with stocked fish, and stands of submerged macrophytes allowed to take root. There are also potentials for interference with navigation routes in canals, and disenfranchisement of fishermen and fisherwomen who previously fished in the water bodies.

Broodstock and Hatchery Component

There exists a potential for negative impacts on wild fish stocks as well as pond stock due to disease transmission, especially new diseases brought in by imported broodstock.

Contract Research Component

There exists a moderate potential for negative impacts on wild fish stocks through disease transmission or competition with non-indigenous species resulting from escape or deliberate dumping of fish into the natural environment.

Impacts in Crustacean and Brackishwater Aquaculture

Sustainable Shrimp Seed Collection Component

No negative environmental impacts are expected from this component. An expected positive impact is the reduction in mortality of shrimp and fish larvae, and an increase in stock abundance.

Integrated Coastal Zone Planning Component

No negative environmental impacts are expected from this component. An expected positive impact is the limitation of shrimp farming to designated areas which do not threaten existing mangrove stands or agriculture.

Private Hatcheries for Shrimp and Prawns Component

There exists a potential for a negative impact on farm and wild shrimp and prawn stocks by transmission of disease from hatchery stocks. The most serious disease currently affecting farm shrimp stocks is the white spot virus. The cause of the latest outbreak of this disease in Bangladesh is due to large-scale importation of shrimp seed from Thai hatcheries in 1995. Hatcheries - whether domestic or foreign - clearly have a significant potential to propagate and transmit crustacean diseases.

Improved Freshwater Prawn Culture Component

There exists a potential for negative impacts on water quantity and quality from increased water supply and drainage of prawn ponds. The pumping of groundwater through tubewells for pond water supply in areas where insufficient surface water exists could result in depletion of freshwater and intrusion of saline water into the groundwater aquifer. The discharge of metabolic waste products during pond drainage could have a negative effect on receiving waters. The general tendency to overfeed prawns with snail meat and loose dry feeds exacerbates the problem of poor quality of drainage water. In many areas the baseline quality of receiving waters is already low due to human sewage, industrial effluents and agricultural chemicals pollution. Additional nutrient loading from prawn farms will result in further water quality deterioration and additional stress to living organisms.

There also exists a potential for negative impacts on wild snail populations which are used for food for prawns. The largest fraction of prawn feed is made up of snail meat. Expansion of prawn farming has increased the harvesting rate of snails from natural sources. This has resulted in depletion of some snail populations, and supplies are now augmented with imports from India. Further expansion of prawn farming could result in the collapse of local snail stocks and increased reliance on imports from India. Importation carries with it the risk of disease transmission, including vectors possibly harmful to humans.

Improved Shrimp Processing Practices Component

No negative environmental impacts are expected from this component.

Impacts in Institutional Development

Evaluation and Restructuring of Fisheries Development Agencies Component

No negative environmental impacts are expected from this component.

Evaluation and Restructuring of Fisheries Research Agencies Component

No negative environmental impacts are expected from this component.

Human Resources Development Component

No negative environmental impacts are expected from this component.

Vocational School for Aquaculture Component

No negative environmental impacts are expected from this component.

Fisheries Management Information System Component

No negative environmental impacts are expected from this component. Positive impacts expected are improved fisheries management resulting in greater stock abundance and increased biodiversity.

Environmental Management System Component

No negative environmental impacts are expected from this component. Positive impacts that are expected include improvements and enhancement of aquatic environments and lessening of environmental degradation, leading to greater stock abundance and biodiversity.

Seafood Products Quality Control Improvement Component

No negative environmental impacts are expected from this component.

Impacts in Environmental Management

Fish Biodiversity Conservation Subproject

No negative environmental impacts are expected from this component. Positive benefits include re-establishment of self-sustaining populations of endangered species (including *nandina*, *angrot*, *mohasol*, *sarputi*, *pangas*, and *silond*) and increases in catches of these species.

Fisheries Environments Improvement Subproject

No negative environmental impacts are expected from this component. Expected positive impacts of this component are habitat improvement through tree plantation, greater dry season water levels in beels and baors, creation of artificial duars in rivers, and reduction of negative impacts of agrochemicals and industrial pollution. Habitat improvements will lead to increased stock abundance and increased fish biodiversity.

Community-Owned Fisheries Pilot Project

No negative environmental impacts are expected from this component. Expected positive impacts are better conservation of floodplain fish resources and a reduction in destructive fishing practices.

Fish and Shrimp Disease Control Subproject

No negative environmental impacts are expected from this component. Positive impacts that are expected are decreased risk of disease transmission from hatcheries, between ponds, and to natural waters and fish stocks, as well as less loss of production due to disease.

Water Quality and Quantity Monitoring Program Subproject

No negative environmental impacts are expected from this component.

F.2 Level and Quantification of Impacts for Various Environments

Impacts Associated with Natural Physical Environment

The following impacts on the natural physical environment could be expected from project activities:

1. Beel and Baor Hydrology: Increased drainage and/or dewatering of beels and baors due to improved channel flow capacity from canal re-excavation, leading to reduced dry season refuge habitat and increased mortality of overwintering fish stocks.
2. FCDI Project Hydrology: Marginal increase of water level inside FCDI projects due to entry of water into area through fishpass during premonsoon and early monsoon floods, possibly threatening some rice crops planted around margin of internal beels and lowlying areas.
3. Water Course Eutrophication: Variable degree of eutrophication of natural water courses from pen and cage culture and from prawn farms due to overfeeding and metabolic waste products excretion.
4. Groundwater Extraction: Depletion of freshwater groundwater supply and intrusion of saline water due to use of tubewells as water supply to prawn farms situated near coastal areas.

Impacts Associated with Natural Biological Environment

The following impacts on the natural biological environment could be expected from project activities:

5. Submerged Macrophytes: Decrease in submerged macrophyte abundance in beels and baors due to stocking of grass carp and common carp, leading to decline in chotomach abundance and catch.
6. Competition for Plankton: Decrease in abundance of indigenous plankton-eating fish in beels, baors and floodplains due to competition from stocked non-indigenous planktivorous carp (silver, bighead).
7. Genetic Diversity: Loss of genetic diversity in wild major carp stocks (rui, catla, mrigel) on floodplains due to dilution from stocking with hatchery reared stock of limited genetic diversity.
8. Disease Transmission: Fish and crustacean disease transmission resulting in pandemics of new diseases or re-infection with existing diseases of wild and cultured fish and crustacean stocks: a) from hatcheries during stocking of floodplains or aquaculture grow-out facilities with disease animals, b) from hatcheries due to importation of new broodstock which is diseased, and c) from escapee or deliberate dumping of diseased animals from hatcheries, aquaculture ponds, floating cages or pens.

9. Snail Stock Depletion. Overharvesting of snail populations used for prawn feed, and transmission of diseases from illegally imported snails from India.

Impacts Associated with Socio-Economic Environment

The following impacts on the socio-economic environment are expected from project activities:

10. Disenfranchisement: Displacement of some fishermen from the areas designated as fish sanctuaries (including access channels of fishpasses) and the areas used for pen culture.
11. Navigation: Interference with navigation routes in areas used for pen culture.

Impacts Affecting the Boundary Regions

Possible impact of the propose project outside of the project boundary area are as follows:

- Downstream water course eutrophication beyond project boundary from pen and cage culture and from prawn farming.
- Loss of genetic diversity in migratory fish stocks beyond project boundary due to out-migration and mingling on remote spawning grounds of hatchery-sourced major carp (*rui*, *catla*, *mrigel*) used in floodplain stocking.
- Disease outbreaks beyond project boundary.
- Out-migration of undesirable introductions beyond project boundary.
- Pressure on Indian snail stocks due to importation to Bangladesh for prawn feed.

Information Deficiencies and Requirements

Comprehensive assessment and quantification of the 11 principal potential project impacts that have been identified is not readily possible. Reliable quantification is hampered by lack of information in the following areas:

- Beel and Baor Hydrology: Design details on canal re-excavation and hydrology of canals and affected beels and baors have not yet been prepared. This information is required before a quantified assessment can be made of the potential risk of stress to beel and baor dry season water volumes, and the risk to fish stocks.
 - FCDI Project Hydrology: Analysis of river and FCDI hydrology (without fishpass) and establishment of fishpass design parameters of each FCDI project selected for fishpass construction have not yet been carried out. These analyses are required before it would be possible to estimate the volumes of water entering an FCDI project through a fishpass. A separate analysis of cropping patterns and topography inside the FCDI project is required before the potential impact of incoming water on rice crops could be determined.
 - Water Course Eutrophication: Information on the total number of culture units, their locations, quantity of waste discharged, and receiving water hydrology and quality are required before the potential impact of eutrophication can be assessed.
-

- Groundwater Extraction: Information on the total number of prawn ponds, their locations, quantity of groundwater extracted, the groundwater recharge rates, and the proximity of saline water are required before the potential impact of groundwater extraction can be assessed.
 - Submerged Macrophytes: Information on proposed stocking densities of grass carp and common carp is required, as well as stocking locations, existing submerged macrophyte densities, and stock abundance of affected chotomach species.
 - Competition for Plankton: Information on proposed stocking densities of silver carp and bighead carp is required, as well as stocking locations, average plankton densities, and stock abundance of affected planktivorous native species.
 - Genetic Diversity: Information on the proposed stocking densities of hatchery-reared *ru*, *catla* and *mrigel*, and abundance of wild stock in the stocking area is required. Genetic diversity for both hatchery-reared and wild stocks would need to be determined (in terms of genetic trait quality and quantity).
 - Disease Transmission: Adequate data on the existing incidence of disease at various sources is not available and would need to be assembled. Data on disease incidence and risk from potential external sources of broodstock is also not available. A survey and assessment would also need to be undertaken of existing practices in Bangladesh hatcheries which might increase the risk of disease propagation. Information on the activities of fish and prawn farmers, and data on the incidence of escapage due to various causes (inadequately constructed facilities, cyclone damage, flooding) would need to be assembled.
 - Snail Stock Depletion. Data on snail stock assessment, growth rates and survival rates, as well as the harvesting rate are needed in order to assess the status of the snail collection activity. Information on the quantity of snails illegally imported from India, and the disease status of the imports is also needed.
 - Disenfranchisement: The number of fishermen displacement at each proposed fish sanctuary needs to be determined, as well as their catch rates and earnings.
 - Navigation: The locality of each pen needs to be specified, and information on boat traffic in the area needs to be collected.
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G. CUMULATIVE IMPACTS

G.1 Cumulative Impact Assessment Methodology

Cumulative impacts are effects that result from the addition of two or more impacts. Cumulative impacts may derive from:

- actions from the past, present and future,
- multiple human activities,
- natural events.

The actions may be repeated or occur in combinations.

For the present EIA, cumulative impacts refers to impacts that might result from various combinations of project impacts acting in association with extra-project activities and events.

A large but fragmented, incomplete and partly unreliable database exists for past and present activities taking place within the project area. This database was scrutinised for relevant items. Field visits were conducted to various proposed project locations and additional data was collected, as well as clarification of existing databases. Information on snail stocks in India was not readily available.

Planning pipelines for future project activities such as FCDI works under the BWDB and LGED were also examined.

G.2 Potential Non-Project Impacts Combined with Project Impacts

Regional Impacts

Several cumulative effects are possible from the externalities of the proposed project.

Improved drainage through canal excavation could put stress on dry season beel and baor water volumes, that would be intensified by further water extraction by farmers for boro rice irrigation. This could increase the likelihood that dewatering for complete fish harvesting would be carried out because of the low cost of pumping out the small amount of water remaining.

The water entering into an FCDI project through a fishpass might be sufficient to cause increased crop damage if accompanied by simultaneous sustained heavy rainfall inside the project area.

Groundwater extraction for aquaculture would be additive to existing groundwater extraction for crop irrigation and other water supply uses such as for domestic and industrial applications. The effect would be to more rapidly deplete groundwater aquifers, resulting in possible lowering of water tables, aquifer exhaustion and/or saline water intrusion.

A complex of factors negatively impact native chotomach and planktivorous fish stocks, including FCDI development, deforestation, agrochemicals, industrial pollution, sedimentation, disease, overfishing and dewatering. This has already led to heavy pressure on many populations resulting in local stock depletion. Intensified openwater fisheries stocking could lead to further pressure on these fish stocks and accelerate stock collapse.

Both natural and culture fish and crustacean stocks have suffered severe disease outbreaks during the last decade (ie EUS, white spot). This has resulted in major economic and nutritional losses in the past. The transmission of new diseases or mutated strains of existing diseases would lead to further economic and nutritional losses in the future.

Worldwide Climate Change

There is an increasing trend in rainfall in some parts of Bangladesh and the surrounding catchment region over the last 30 years. This is leading to intensified and more prolonged flooding. The cumulative impact of increased flooding with project impacts is mainly in the greater impact on rice cultivation inside FCDI projects due to greater head differences across fishpasses (leading to increased discharge through the structure).

Upper Riparian Activities

Increasing deforestation in the catchments (especially in India and Nepal) of the main rivers of Bangladesh will further intensify fish an systemic flooding and sedimentation. An increase in water pollution from human sewage and industrial development can also be expected. Cumulative impacts in combination with project externalities will be on hydrology (as per the previous paragraph), and on water quality (derived from aquaculture discharges).

Lower Riparian Pollution Transport

Water course eutrophication from aquaculture would be additive to eutrophication and pollution from other sources. Aquaculture discharge water could contain high biological oxygen demand from uneaten food, nitrogen and ammonia from metabolic wastes, and toxic or otherwise harmful chemicals from biocides, lime and other pond preparation and treatment measures. The cumulative effect could be to render water courses unfit for aquatic life for some distance downstream.

G.3 Cumulative Impacts Relevant to Other Regions

Large-picture cumulative impacts of the proposed project in association with the major environmental issues of Bangladesh is related to population growth. The proposed project will lead to greater food fish production. This will in turn result in better nutrition, improved foreign exchange earnings and greater population growth in areas outside the project. The large and dense population of Bangladesh has already had severe environmental impacts including massive deforestation to clear land for rice production, massive solid and liquid waste disposal into the environment, and fishery resource depletion for food. Increase in urban population (Dhaka, Khulna, Chittagong) - bolstered by in-migration of increasing number of rural landless people - will lead to greater demand and more intensive mining of fish resources in the mainly rural project area to provide food for the relatively wealthier urban population. Thus the principal desirable impact of the project (increased food fish production and better nutrition) could feed back negatively to the environment in the form of increased fishery resource exploitation pressure.

In a related vein, an increasing population that relies heavily for food on the intensified fish production that the project aims to achieve would be put at greater risk if production was disrupted by natural disasters such as the cyclones and floods that Bangladesh is particularly prone to, or by outbreaks of new and highly virulent diseases. Steadily greater deterioration of water quality from sewage and pollution could also lead to sudden reproductive or recruitment failures in some fish stocks followed by population extinction. Increased risk would appear to be inherent to some degree in intensification of fish production. Intensification of production is more sustainable if adequate precautions are taken to minimise risk.

H. PROJECT SCOPING AND THE CONSULTATION PROCESS

H.1 Public Consultation

Public Meetings with Local Residents

The EIA Team held the following discussion meetings with local residents:

(to be completed)

- 3rd Fisheries carp fingerling supplier, private carp hatchery, Dhaka. Discussed with hatchery owner problems of seed production.
- Daria Kandi village, near Kishoreganj. Discussed with 2 fishermen the impact of re-excavation of Gonokhali canal.
- Balukber village, near Kishoreganj. Discussed with 10 local residents (mostly farmers) the impact of re-excavation of Bardal Khal.
- Karimganj village, near Kishoreganj. Discussed with 15 local residents (fishermen, boatmen, traders) the potential for a fish sanctuary in the Dhanu River at Beel Boyar Duar.
- Faltita village, near Bagerhat. Discussed with 10 *golda* farmers, and DFO and TFO *golda* farming impacts and *bagda* seed collection.
- Faltita village, near Bagerhat. Discussed with 40 *golda* farmers and other local residents, and DFO and TFO *golda* farming impacts and potential for snail culturing (for *golda* feed).
- Khulna. Discussed with 40 *bagda* farmers, shrimp processors, DD, DFO and TFO
- Beel Dakatia. Discussed with one local resident (ex-BWDB regulator operator) problem of waterlogging, siltation, FCDI, fish shelters, and wetland trees.
- Paikgachha. Discussed with two *bagda* seed collector in Shibs River various methods of seed collection and utilisation.
- Paikgachha. Discussed with a *behundijal* fishermen in Shibs River impact of *bagda* seed collection on fish stock abundance.

- Paikgachha. Discussed with 15 *bagda* farmers and rice farmers impact of *bagda* farming on rice production.
- Kaliganj near Satkhira. Discussed with 20 rice farmers and *bagda* farmers impacts of *bagda* farming on rice cultivation, and water supply problems from BWDB infrastructure.
- Shyamnagar, Polder 5, near Satkhira. Discussed with 5 shrimp farmers impact of *bagda* farming on rice production.
- Buri Goalini, near Satkhira. Discussed with shrimp farmer problem of shrimp disease in 3rd Fisheries semi-intensive ponds.
- Buri Goalini, near Satkhira. Discussed with 5 shrimp farmers and tana administrator problem of 3rd Fisheries/BWDB regulator failure.
- Nasti Baor, near Jessore. Discussed with 5 fishermen impact of stocking on indigenous species, need for fish sanctuary, and possibility for wetland tree plantations.
- Shachta Baor, near Jessore. Discussed with project staff control of aquatic macrophytes to improve habitat.
- Char Bagadi pumphouse, Chandpur FCDI project. Discussion with 12 fishermen and other local residents movement of golda fry in and out of FCDI project.
- Seafood Corporation Ltd, Chandpur. Discussed with processing plant manager and staff local supply of golda.
- Feni River barrage, Muhuri FCDI project. Discussion with 20 fishermen and other local persons the impact of the barrage on the movement fish and fish catches.
- St Martin's Island. Discussed with 10 fishermen about fish catches and coral reef.
- Large shrimp farm owner, Cox's Bazar. Discussed impact of disease on intensive shrimp production.
- Meghna Shrimp Farm, Cox's Bazar. Discussed with farm manager and two foreign buyers
- Coastal channel, Cox's Bazar. Discussed with 4 bagnet fishermen the impact of shrimp farm development on fish catches.

- Niribili Shrimp Culture Farm, Cox's Bazar. Discussed with farm manager shrimp seed collection, mangrove die-off, and shrimp disease.
- Cox's Bazar. Meeting with 10 shrimp hatchery owners, shrimp farmers and shrimp processors to discuss problems of disease, seed collection and mangrove deforestation.
- BFDC Fish Landing and Market Hall, Cox's Bazar. Discussion with trader on fish catch and potential for eco-tourism development (possibilities for billfish charters).

Meetings with Special Interest Groups, Donors and NGOs

The EIA Team held the following discussion meetings with organisations:

(to be completed)

- Bangladesh Frozen Foods Exporters Association, Dhaka. Discussion about *bagda* disease problem and impact of *bagda* farming on rice production.
- Caritas, Dhaka. Discussion about *bagda* seed collection impacts and impact of *bagda* farming on rice production.
- Prism Bangladesh, Dhaka. Discussion about impact of GOB taxation on fish producers.
- Center for National Research for Sustainability, Dhaka. Discussion about re-excavation of canals.
- Surface Water Modelling Centre, Dhaka. Discussion about hydrology data and modelling.
- BWDB, Planning Scheme 1, Dhaka. Discussion about FCDI projects requiring fishpasses and khal re-excavation program.
- DOE, Dhaka. Discussions about EIA guidelines, GEF biodiversity conservation projects, national parks and fish parks, and water quality monitoring program.
- BWDB, Monitoring, Planning and Program Divisions, Dhaka. Discussion about policy for construction of fish friendly structures, such as fishpasses.
- LGED, Dhaka. Discussion about canal re-excavation projects, rubber dam projects, fishpass projects.
- WARPO, Dhaka. Discussion about national water model and real-time flood monitoring.

- BWDB, Hydrology Division, Dhaka. Discussion about acquisition and use of data for surface water hydrology, river morphology, and groundwater.
- BWDB Kishoreganj. Discussion about the impacts and sustainability of Bardal Khal re-excavation project, and other re-canal excavation projects in the pipeline.
- DFO Bagerhat. Discussion about need to conserve floodplain *chotomach*, and impacts of *golda* and *bagda* farming, and impacts of *bagda* seed collection.
- TFO Nazirpur, near Pirojpur. Discussion about *golda* fry collection and need for sanctuary in Malikhali-Delveri Beel.
- DOF DD Khulna. Discussion about impacts of waterlogging and salination in the area, Farakka barrage, and *bagda* farming.
- FRI Brackishwater Station Paikgachha, TFO and local NGO. Discussion about impact of *bagda* farming on rice cultivation, *bagda* seed collection impacts, FRI project pipeline and Sunderban.
- Project Director and project staff, Oxbow Lakes Fisheries Project, Jessore. Discussion about impact of carp stocking on indigenous *chotomach* species and disease transmission, and tenure system for baors.
- Station Director and staff, FRI Riverine Station, Chandpur. Discussion about research program and Meghna-Danagoda and Chandpur FCDI projects.
- Superintending Engineer and staff, Char Bagadi pumphouse and navigation locks, Chandpur FCDI project. Discussion about movement of fish through navigation locks and hizal tree plantations inside project area.
- Superintending Engineer, BWDB office Lakshmipur. Discussed various environmental aspects of Polder 59 FCDI project near Ramgati.
- DFO Lakshmipur. Discussed potential for gold seed collection, fishpasses and fish sanctuaries in the area.
- DFO Feni. Discussed feasibility of a fishpass at the Muhuri FCDI project barrage across Feni River.
- Director and staff, DOF Marine Fisheries Division, Chittagong. Discussed marine fish stock abundance, mangrove deforestation, water pollution and fish sanctuaries.

- Director and staff, Institute of Marine Sciences, University of Chittagong. Discussed marine fisheries and environment research.
- TFO and staff, Teknaf. Discussed fish catch on coral reef of St Martin's Island and shrimp seed collection in Naf River.
- Deputy Director, FRI Marine Fisheries Station, Cox's Bazar. Discussed Environmentally friendly shrimp culture project and shrimp disease control using *nem* tree leaf extract.
- DOF Marine Fisheries Officer, Cox's Bazar. Discussion about monitoring of oceanographic parameters, mangrove deforestation impacts, shrimp farming impacts, oil pollution, bagda seed collection, coral reef fishing on St Martin's Island and use of poisons for fishing.

Media Releases

(To be completed)

H.2 Integration of the Concerns of Interested Parties into Assessment

Summary of Concerns by Category

Meetings were held with local residents and agency staff. The following are the main environmental concerns (grouped by categories) expressed during the meetings:

Prawn farmers

- Most of the farms are not serviced by supply and drainage canals and dependent on monsoon rain water. There is no link canal with river and culture area.
- Use of snail meat as feed has sharply depressed the natural population of snails, and consequently the price increase of snails is hampering prawn production.
- Poor pond management practices result in low yields.
- Farmers do not have technical knowledge about pond construction, pond preparation, pond management, stocking and feed management.
- After harvesting the crop, farmers do not have any employment opportunities for about four months, and remain idle.
- Farmers sell their products to depot owners and middleman at low price because they borrow money from them for stocking.

Shrimp farmers

- Scarcity of Bagda fry and high prices.
- Scarcity of low priced protein feeds.
- Large-area land utilisation but comparatively low productivity.
- Farmers do not have adequate technical knowledge for better production of shrimp crops.
- Production has collapsed due to outbreak of white spot disease during the last two years. Semi-intensive farms of Khulna and Chittagong were badly affected by disease outbreaks and are presently practicing culture of Thai *pangas*.
- In some areas of Khulna region, farmers are allowed to take lease of land for only one or two years, and as a result farmers cannot construct permanent embankments, canals and regulators.
- In Polder 5 (Khulna region), due to constructional defect of the sluice gate, one way flow of water through the sluice gate, and conflict over the primary water supply canal, farmers are deprived of water intake into culture ponds resulting in low production
- About 15 sluice gates of Third Fisheries are defective and remain closed due to silting up.
- Security is a major problem. In many areas there are no police stations.
- At many farms there is no electricity.
- Farms of remote areas do not get ice. As a result quality of the product deteriorates during transportation to depots or processing plants.
- Instruments, chemicals and fertilisers are not available near farm sites.
- Skilled manpower is not readily available.
- In the Cox's Bazar area, the farmers do not have any employment opportunity for about six months after harvesting the crop.
- Polluted water is used by the semi-intensive farms located at the bank of Bankkhali River (Cox's Bazar), resulting in problems in culturing shrimp.
- An incentive or prize should be awarded to good farmers.
- Instructional booklets should be published on different aspects of shrimp culture.
- A separate brackishwater division of the DOF should be set up to deal with shrimp culture and coastal environments.
- A Fishery Bank should be established.
- More cyclone shelters should be constructed.
- In Paikgacha area, some Bagda farmers cut BWDB embankments and introduce saline water for farming practice without any permission from the concerned department.

Shrimp fry collectors

- The shrimp fry collectors in Khulna region who use push nets destroy other planktonic organisms in contrast to the fry collectors who use boats. The latter do not destroy other organisms, but rather release them back to the water).
- The fry collectors sell their fry to middle at a cheap rate.

- Many fry collectors do not have their own nets. They borrow nets from middlemen and are compelled to sell their collected fry to the middlemen at a very cheap rate.
- The farmers do not have the facility to store and to keep the fry alive for a considerable to keep the fry alive for longer time periods. Fry are stored in a pot without any feed or aeration system.
- Echinoderms, sand dollar, starfish and other intertidal organisms of the intertidal zone have been destroyed due to collection of shrimp fry activity.

Fishery Officers, Research Officers and other personnel

- In Golda farming, the farmers use large quantities of snail meat and as a result natural snail populations have declined, and snails are illegally imported without quarantine.
- Golda farmers use their prepare loose feed using rice bran and fish dust which sometimes pollutes the pond water.
- Presently there is no relevant policy and legislation for shrimp culture in the country.
- Conflicts between shrimp culture and agriculture should not damage social harmony.
- Shrimp farmers, shrimp fry collectors and fishermen should be provided with training in their respective fields.
- Kenduar beel and other beels should be protected from shrimp culture and paddy production.
- Shrimp hatcheries should be established both by the GOB and private sector.
- For shrimp farming, water supply and drainage systems should be developed.
- Electricity should be provided to shrimp farms.
- Shrimp culture areas for Golda and Bagda should be identified on the basis of site selection criteria, and land size should be determined and allocated to an actual farmer.
- Depots should be established with the permission of the concerned GOB office, and hygiene and sanitation should be inspected periodically.
- Sufficient numbers of insulated vans should be provided for rapid transport and marketing of fishery products.
- Laboratories should be established in each district head quarter to expand analysis facilities.
- Some NGOs sell medicine and chemical under different trade names to illiterate shrimp farmers to solve their problems. GOB should investigate the matter so that poor farmers are not cheated.
- Due to brackishwater shrimp culture, paddy production is reduced, trees are destroyed, drinking water is scarce, and grazing fields for livestock are limited.
- To conserve the habitat and biodiversity, a 0.5 km wide zone around St Martin's Island should be declared a sanctuary.
- The depth of the Bankkhali River has decreased by 50% since 1984 due to siltation. At Kasturi Ghat of the river, there previously were abundant stocks of oysters, sea anemone, crabs and other animals, but the habitat has since been destroyed due to pollution, siltation, proliferation of trawlers, and human disturbance. Previously, fishes

(*bhetki*, mullet, grouper) were abundant, but the fish resources have now declined due to these causes.

- Hundreds of fishermen catch coral fish during rough weather with hand lines, and as a result the coral fish around St Martin's Island have declined.
- Fishermen catch fishes in rock pools situated between Cox's Bazar and Teknaff using rotenone
- During collection of monodon fry, the average catch composition is one monodon fry for 38 other shrimp species, 56 zooplankton and 12 finfish larvae. The composition varies from place to place. Around 20% undesired species are released back to water and about 20% by-catch are thrown to beach. Fry mortality is 30%-50% during holding at collection sites and transport to culture sites.

Fishermen and local residents of Dakatia Beel

- Paddy does not grow when the water level is high in the beel.
- Out of 3 sluice gates, only one is in operation and two were closed due to deposition of heavy silt at the bottom of the gate.
- The Shalu River should be excavated to reduce water logging in the beel. Local fishermen and paddy cultivators are facing difficulties to raise their desired crop and would like to cut the embankment so that tidal water flushes the beel.
- The embankments of the Bhanad Bhayane and Khukshia beels of Jessore district were cut in different areas just a few days before the field visit to Dakatia Beel by the local farmers to allow tidal water to enter.

Fishermen of baors

- Do not want to establish a fish sanctuary as it would interfere with their fishing method.
- Disturbed by miscreants during harvesting.
- Farmers pump out water from baor for cultivation of boro paddy and mustered plants.
- Some baors are partly covered with water hyacinth.
- Some sluice gates are defective and not in operation.

FCDI Projects

- Before the establishment of Muhuri FCDI project of Feni, the fishermen used to catch more fish and shrimp than the present day. At the present time, more shrimp and fish are available on the freshwater side than the brackishwater side of the barrage. Migration of shrimp and fish have been negatively affected due to establishment of the barrage.
- Before the establishment of Chandpur FCDI project, lots of shrimp and fish were available, but now stocks have declined. A massive infestation of water hyacinth blocks the gate area.

River Fishermen

- In the past large numbers of fishes were present but presently the catch has declined.
- Fish stock reduction in the river is due to the following causes: a) overfishing and no new recruitment, b) use of pesticide in the agricultural fields, c) discharge of waste by the industries, d) depth of water reduced due to siltation, and e) increased turbidity in the river water.

St Martin's Island

- There is scarcity of ice and cold storage.
- There is scarcity of drinking water during the fishing season.
- There is no fish landing centre and all fish processing and marketing activities are made directly on the sandy beach in unsanitary conditions.
- During drying of fish insecticides are applied to combat infestation with mites and flies.
- There is a security problem during catching of fish in the sea and during the return journey to the island with fish.
- On the east coast, starfish, sea anemones, sand dollars and other animals have become extinct due to human activities on the shore.
- Turtles used to come at night to lay eggs in the north-east part of the island but now they do not come due to human disturbance. Now they lay their eggs at the southern part of the island.

Summary of Response to Concerns

The following measures would alleviate many of the concerns expressed during the consultations:

- Prawn farmers would benefit from link canals from rivers to culture area, low cost protein feeds, technical assistance, training, employment during the low season and soft-term credit facility.
- Shrimp farmers would benefit from better availability of fry for stocking, low priced protein feeds, better management of the ponds, control of diseases, long term lease of GOB land, efficient and functional sluice gates and regulators for water supply, security measures, electricity, supply of ice in remote areas, instruments, chemicals, fertilisers, skilled manpower, control of water pollution, incentive to good farmers, publication of instructional booklets, establishment of a brackishwater division in the DOF, a fishery bank, cyclone shelters and employment opportunities during the low season.
- Proper policy and legislation should be adopted for shrimp culture. Shrimp culture area should be identified. Selling of unknown medicine to the farmers should be controlled and depots should be registered.

- A sanctuary should be established around St Martin's Island to halt the decline of coral fish stocks. Illegal fishing of the rock pools between Cox's Bazar and Teknaf needs to be controlled.
- Beels should be protected for shrimp and paddy cultivation.
- Shrimp fry collectors would benefit from low priced country boat, nets, storing facility with feed and accretion system and direct supply of fries to culturists.
- The crab fishery should be provided with logistic support for development.

Actions to be Taken

The following are priority actions suggested by the consultations which would lead to increases in production:

- In prawn farming areas where there are no facilities for water exchange, link canals should be excavated.
- Research should be conducted to develop low cost protein feeds for prawns and shrimp.
- Farmers should be periodically trained in basic and modern culture methods.
- DFOs and TFOs should be trained in culture methods and in the handling of analytical instruments both in the laboratory and in the field.
- Farmers should be provided with booklets in Bangla covering different aspects of culture and technical assistance according to their needs by fisheries officers and NGOs.
- For the steady supply of shrimp fry, hatcheries should be established in Cox's Bazar and Khulna. Sanctuaries should be established in different regions of coastal areas and off the coast to protect shrimp broodstock.
- To implement control measures for shrimp and fish diseases, a survey should be undertaken to determine the types of diseases present, and mitigation measures should be undertaken in consultation with disease experts.
- Inoperative sluice gates should be repaired, and all sluice gates should be capable of providing intake and discharge. The actions should be done in consultation with the engineers concerned.
- The GOB should provide security, electricity, instruments, chemicals, skilled labour, incentives to productive farmers, a fishery bank and cyclone shelters in the coastal area.
- The GOB should establish a separate Marine Directorate Office for marine fisheries.
- All industries discharging solid and liquid waste to the environment should be required to carry out primary treatment at the minimum.
- Pesticides should be controlled through policy and proper legislation.
- Shrimp fry collectors should be provided with logistic support and training so that they do not destroy the by-catch.
- Insulated vans should be provided to transport shrimp and fish from ponds to processing plants.

- Laboratories should be established for soil and water analysis at divisional headquarters.
- Proper policy should be adopted for shrimp culture.
- Depots (where shrimp and prawns are purchased and stored) should be registered and inspected for hygiene and quality of shrimp and prawns.
- Afforestation programmes should be undertaken for mangrove vegetation along the coast as soon as possible.
- The number of fishermen and fisherwomen catching fish from rocks pools and coral areas along the coast should be controlled.
- Logistic support should be provided to the crab fishery.
- Programmes should be undertaken to clear water hyacinth from haors, baors, beels, barrow pits, FCDI projects and other infested waters.
- Some small rivers and canals should be re-excavated.
- Security at sea should be strengthened.
- A fish landing centre should be established at St Martin's Island.
- Steps should be taken to protect turtles laying eggs on St Martin's Island.
- Policy and legislation should be promulgated to protect coral reefs and seaweed beds off St Martin's Island.
- Research activities should be distributed among the universities of the country rather than FRI because little substantial research activities are undertaken at Chandpur, Paikgaacha and Cox's Bazar FRI stations.
- MOFL and DOF should have advisory panels of knowledgeable fisheries experts to provide suggestions, evaluate research activities and monitor different fishery programmes.

I. ENVIRONMENTAL MANAGEMENT PLAN

I.1 Environmental Protection Plan

Anticipated Negative Environmental Impacts

Eleven potential impacts are predicted from the proposed project.

- Beel and Baor Hydrology: Increased drainage and/or dewatering of beels and baors due to improved channel flow capacity from canal re-excavation, leading to reduced dry season refuge habitat and increased mortality of overwintering fish stocks.
- FCDI Project Hydrology: Marginal increase of water level inside FCDI projects due to entry of water into area through fishpass during premonsoon and early monsoon floods, possibly threatening some rice crops planted around margin of internal beels and lowlying areas.
- Water Course Eutrophication: Variable degree of eutrophication of natural water courses from pen and cage culture and from prawn farms due to overfeeding and metabolic waste excretion.
- Groundwater Extraction: Depletion of freshwater groundwater supply and intrusion of saline water due to use of tubewells as water supply to prawn farms situated near coastal areas.
- Submerged Macrophytes: Decrease in submerged macrophyte abundance in beels and baors due to stocking of grass carp and common carp, leading to decline in chotomach abundance and catch.
- Competition for Plankton: Decrease in abundance of indigenous plankton-eating fish in beels, baors and floodplains due to competition from stocked non-indigenous planktivorous carp (silver, bighead).
- Genetic Diversity: Loss of genetic diversity in wild major carp stocks (rui, catla, mrigel) on floodplains due to massive stocking with hatchery reared stock of limited genetic diversity.
- Disease Transmission: Fish and crustacean disease transmission resulting in pandemics of new diseases or re-infection with existing diseases of wild and cultured fish and crustacean stocks: a) from hatcheries during stocking of floodplains or aquaculture grow-out facilities

with diseased animals, b) from hatcheries due to importation of new broodstock which is diseased, and c) from escape or deliberate dumping of diseased animals from hatcheries, aquaculture ponds, floating cages or pens.

- Snail Stock Depletion. Overharvesting of snail populations used for prawn feed, and transmission of diseases from imported snails from India.
- Disenfranchisement: Displacement of some fishermen from the areas designated as fish sanctuaries (including access channels of fishpasses) and from areas used for pen culture.
- Navigation: Interference with navigation routes in areas used for pen culture.

Proposed Mitigation Measures

Mitigation of the anticipated negative environmental impacts of the project is described below.

Beel and Baor Hydrology: The potential for beel and baor draining due to channel flow capacity increasing after canal re-excavation will be reduced through the following measures:

- Bed elevations in the canal, the adjacent river and the beel/baor will be carefully measured during the feasibility and design study.
- The new re-excavation bed level of the canal will be set at an appropriate level to prevent beel/baor dewatering.
- A water regulation structure will be installed at the beel/baor outlet to the canal. The regulator will be closed during the late monsoon drainage period in order to conserve the water level in the beel or baor at the highest possible level at the start of the dry season. It will be opened at the start of the premonsoon period to allow river water and/or fish to enter the beel or baor.

This mitigation measure will require monitoring of water levels in the river and beel/baor, and operation of the regulator according to guidelines which will be established by the project.

FCDI Project Hydrology: The possible threat to rice cultivation due to entry of water inside FCDI projects through a fishpass will be reduced through the following measures:

- Study of river hydrology, FCDI project hydrology and potential fish traffic through structure, and adjustment of pool number and pool, baffle and slot dimensions to minimise discharge volume through fishpass.
- The fishpass will be equipped with gates at either end which will be closed whenever a threat to agriculture materialises. The operator of the fishpass will remain responsive to the concerns of the farming community, and respond positively if farmers feel their crops are threatened by closing the fishpass gates, and reopening the gates once the perceived threat has passed.

This mitigation measure will require monitoring of water levels in the river and FCDI project, and operation of the fishpass gates according to guidelines which will be established by the project.

Water Course Eutrophication: The potential for eutrophication of natural water courses from pen and cage culture and from prawn farms due to overfeeding and metabolic waste excretion will be reduced through the following measures:

- Specify the use of pelleted feeds rather than loose feeds, as the former result in less loss.
- Develop better methods for estimating feed application rates throughout the grow-out period in order to eliminate overfeeding.
- Specify more frequent water exchange and flushing in prawn pond to discharge metabolic wastes in more diluted form.
- Protect stocks of chotomach (especially bottom feeders) in the vicinity of cages and allow them to consume uneaten food which drops out of cages.
- Specify controlled growth of submerged macrophytes inside and/or along the outside margins of pens to absorb dissolved metabolic wastes such as nitrogen.

Better feed application is in the farmer's best interest as it lowers cost. Greater use of water may entail higher costs, while use of chotomach and macrophytes to control feed loss and metabolites entails foregoing a possible benefit in the form of sale or consumption of chotomach, and some labour to remove macrophytes when their growth becomes excessive.

Groundwater Extraction: The danger of depletion of freshwater groundwater supply and intrusion of saline water due to use of tubewells as water supply to prawn farms situated near coastal areas will be reduced through the following measures:

- A comprehensive groundwater survey will be carried out in all areas where tubewells are used (or may potentially be used) for prawn farm water sourcing to determine the size of the aquifer and the recharge rate.
- Depending on the results of the survey, permits will be issued for allowable volume quotas of groundwater that may be withdrawn by prawn farms and by other users. The aggregate quota volume for an area will not exceed the groundwater recharge rate.

Submerged Macrophytes: The danger of decrease in submerged macrophyte abundance in beels and baors due to stocking of grass carp and common carp (leading to decline in chotomach abundance and catch) will be controlled through the following measures:

- The stocking of grass carp (which are unable to breed in Bangladesh waters) will be limited to specific areas where excessive macrophyte growth needs to be reduced to normal levels. The stocking density will be adjusted to moderate level (ie 50 large fingerlings per ha), and the adult fish will be caught and removed once the macrophyte density has normalised.

- No common carp will be stocked by the project. This species has in any case been successfully introduced and occurs in self-sustaining populations in many areas of Bangladesh.

Competition for Plankton: No measure is proposed to mitigate the expected decrease in abundance of indigenous plankton-eating fish in beels, baors and floodplains due to competition from stocked non-indigenous planktivorous carp (silver, bighead). The objective of the stocking is specifically to channel available plankton nutrients into these fast growing non-indigenous fish species, as they are considered capable of producing a larger quantity of harvestable food fish than indigenous planktivorous fish species. A reduction in stocking density would dampening the impact on indigenous species, but this would partly defeat the project purpose. It is suggested that consideration be given to stop the stocking of silver and bighead carp altogether, and that only native species (*ruoi*, *catla*, *mrigel*) be stocked. Other native carp species such as *kalibaush*, *bata*, *boga*, *ghora*, *angrot*, *nandina*, and others should also be considered for stocking.

Genetic Diversity: The following mitigation measures will be used to reduce the loss of genetic diversity in wild major carp stocks (*ruoi*, *catla*, *mrigel*) on floodplains due to massive stocking with hatchery reared stock of limited genetic diversity:

- Hatcheries will be specifically licensed to produce fingerlings for floodplain stocking, and fingerlings will only be purchased from these hatcheries.
- Only first generation broodstock sourced from wild stocks will be used to produce fingerlings used in stocking programs. Inbred and selectively bred lines used in pond culture will not be used.
- Broodstock used for floodplain stocking will be renewed each year, and old broodstock will be destroyed.
- Broodstock at a particular hatchery will be sourced from local wild stocks and not be transferred from elsewhere in the country.

The objective of the mitigation measures is to ensure that the vigour and natural diversity of wild genotypes is maintained by minimising any direct human interference with, or manipulation of, genetic traits.

Disease Transmission: The potential for disease transmission and pandemics resulting from project activities will be mitigated through the following actions:

- All fingerlings will be inspected for disease prior to stocking. If diseased fingerlings are detected, the entire consignment will be destroyed. If no diseased fingerlings are detected, the entire consignment will be treated with an antibiotic as a precautionary measure prior to release into natural water bodies.
- All broodstock imported from outside Bangladesh will be quarantined and inspected for disease. Diseased fish will be destroyed by incineration.
- All grow-out facilities will be regularly inspected for disease. If disease is detected, all stocks at the facility will be destroyed by incineration, and the facility will be sanitised.

- It will become illegal to dispose of diseased animals from hatcheries, aquaculture ponds, floating cages or pens by dumping into natural water bodies. The offence will be punishable by fines and imprisonment.
- A code of procedures will be prepared to reduce the incidence and risk of escape from aquaculture facilities.

Snail Stock Depletion. The problem of overharvesting of snail populations used for prawn feed, and transmission of diseases from illegally imported snails from India, will be mitigated through the following measures:

- The harvesting of snail populations occurring in borrow pits, ponds, canals, beels, baors, and other water bodies will be regulated through licensing of collectors, and allocation of specific areas to individual collectors.
- The culture of snails in purpose built facilities (ie snail nurseries) will be promoted, taking into account the particular reproductive and nutritional needs of snails.
- The illegal import of snails from India will be controlled.

Disenfranchisement: Instances of possible displacement of some fishermen from the areas designated as fish sanctuaries (including access channels of fishpasses) and the areas used for pen culture will be mitigated as follows:

- The nature of claims for fishing rights and tenure will be assessed at each fish sanctuary and pen culture location, and ranked according to validity.
- Compensation will be paid to fishermen or investors with valid leaseholding claims.
- Other jalmohal will be allocated to fishermen with valid traditional fishing rights to fish sanctuaries or pen culture locations.
- Where the project intervention is accompanied by community-based fishery development, disenfranchised genuine fishermen will be included in large-group fishing rights allocations.

Navigation: The expected interference with navigation routes in areas used for pen culture will be mitigated through the following measures:

- Pen fences will be provided with flexible brush gates that allow shallow draft boats to pass across the fence but prevent fish from escaping. The gate design will be standardised, and constructed from robust materials.
- Wherever feasible, alternate navigation routes will be designated.

Monitoring Plans

Monitoring of the environmental impact of proposed project components, and assessment of the effectiveness and performance of mitigation measures, will be carried out in a comprehensive manner by the project. Details of the environmental monitoring plan (EMONP) are presented below in Section I.J. Environmental Monitoring Plan.

Compensation Plans

Once-only compensation for lease payments already made will be paid to disenfranchised fishermen displaced from fish sanctuaries and from pen culture locations, assuming their claim to compensation is valid.

Environmental Enhancement

A wide range of environmental enhancement measures is proposed as a discrete subproject. Details of the proposed subproject are presented below in Section II.B Fisheries Environments Improvement Subproject.

Participation Programme for Interested Parties

Provision will be made for interested parties to participate in the EMP at local and national levels.

At local level, interest groups (ie Environmental Advisory Group, or EAG) will be formed which will act in an advisory capacity to the project in executing the EMP. Local EAGs will be provided with frequently updated status reports on environmental impacts and implementation of the EMP in their area. The views and recommendation of the local EAG will be recorded and taken into account during implementation and periodic review of the project and the EMP.

At national level, interested environmental groups will be formed into a national EAG. This body would be provided with frequently updated status reports on environmental impacts and implementation of the EMP throughout the country (including local advisory group recommendations). The views and recommendation of the national EAG will be recorded and taken into account during implementation and periodic review of the project and the EMP.

Both local and national EAGs will be provided with modest resources and facilities to carry out activities.

Accountability

The project personnel that are responsible for implementation of the EMP will be fully accountable to the project director in the implementation of project activities and use of project funds.

The implementation and effectiveness of the EMP will be reviewed annually by an Environmental Steering Committee (ESC), a body established jointly by the MOFL, DOE and other concerned ministries. The ESC will be provided with all project reports pertaining to the EMP and environmental issues, as well as recommendations of the local and national EAGs. The ESC will review and analyse the reports, and forward recommendations for improvement of project activities to the project leadership.

I.2 Contingency Disaster Management Plan and Residual Risks

Disaster Assessment

The potential for disasters arising from project activities is in the following areas:

- Disease pandemics of wild fish stocks or cultured fish stocks: This could occur in spite of best efforts to control disease outbreaks in hatcheries, in grow-out facilities and in natural water bodies. It could result in massive mortality of stocks and large economic losses.
- Civil engineering structure failures: This includes breaching of beel and baor embankments, washing out of regulators or fishpasses, and jamming of gates of regulators or fishpasses in the open position during floods. Failures could occur during the construction phase or during the operational phase. Such disasters could allow massive flooding to take place within an agricultural area, destroying crops and livestock, and leading to possible loss of human life.
- Construction site accidents: The greatest danger from construction accidents is associated with RCC construction methods used for regulators and fishpasses. Manual excavation and earth moving for canal re-excavation are only minimally hazardous.
- Cyclone or flood damage: This refers mainly to damage to cages and pens over a wide area. This could result in the release of possibly diseased fish into the environment and massive economic loss from equipment damage and stock escape.
- Social discord: Clashes may arise during civil engineering works construction (due to competition over construction materials), due to misunderstanding of project objectives and potentials for impacts, due to fishpass operation (ie protests from rice farmers inside an FCDI project), and during de-leasing and transfer of jamohal ownership (due to the previous leaseholder resisting loss of control over jalmohals). The project activities may directly or indirectly exacerbate existing conflicts within a community, or the project may simply be used as an innocent and unsuspecting scapegoat by one or another groups locked in conflict over unrelated issues (a common feature of Bangladesh politics).

Disaster Prevention

Several steps can be taken to reduce the eventuality of occurrence of disasters:

- Civil engineering structure failures: Supervision of construction activities and adherence to maintenance guidelines is essential for avoiding structure failures. Structures must be checked regularly for cracks and signs of fatigue. In the event of sudden failure, sand bags will be used to 'plug' breaches and gates, until such time as hydrological conditions allow repair of the structure.
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- Construction site accidents: Work-site safety programmes will be the responsibility of contractors.
- Social discord: Pre-construction consultation will take place with affected communities to incorporate their concerns and views into project design. This will include the alignment of embankments and location of fishpasses, regulators and fish sanctuaries. Project staff will hold meetings in villages to inform local people about project objectives, activities, and potentials for impacts, and seek their views and recommendations for mitigating impacts. Fishpass operation committees will be formed that include representatives from the farming community to ensure that gates are closed whenever a possibly disastrous threat to crops due to water entry materialises. Compensation will be paid to disenfranchised leaseholders during de-leasing and transfer of jamohal ownership, and police and military enforcement will be used in the event that the previous leaseholder attempt to illegally retain control over jalmohals through force. The project will retain social planners who will study beneficiary communities during the project design and planning phase in order to identify existing conflicts within a community which may be exacerbated by project activities, and appropriate measures will be adopted (including compensation payments) to minimise potential involvement of the project in such conflicts. Project leadership and implementing staff would be required to remain fully aware of community sentiment concerning project activities, and act in an astute manner to forestall the possibility of victimisation through naivety or lack of information about the actions of conflicting interest groups. The project will retain the right of access to the highest level of GOB to assist in the resolution of intransient situations.

Disaster Control Plan

The impacts of disasters which cannot be predicted or prevented from occurring can be lessened through the following actions:

- Disease pandemics of wild fish stocks or cultured fish stocks: The most serious consequence of massive mortality due to disease is disruption of food supply to the consumers. A contingency plan would include importation of cheap food fish (ie frozen small pelagics from Peru and Chile) to meet immediate dietary needs of the population, and rapid re-establishment of domestic production through re-crediting of producers.
- Cyclone or flood damage: This disaster would be less threatening to the security of the national food supply than a disease pandemic, and be more localised in impact. A rapid re-establishment of aquaculture infrastructure and facilities would be implemented through special re-crediting of hatcheries and fish farmers.

Residual Risks and Plans for Possible Mitigation

In the opinion of the EIA Team, the major residual risk that is not adequately mitigated through the EMP is the containment of a disease pandemic. It would be extremely difficult to prevent the movement of infected aquaculture stock (ie hatchlings, fingerlings or broodstock) from one part of

the country to another. Furthermore, it would appear almost impossible to prevent the transport of infected wild caught fish from landing points to market points throughout the country, and to neighbouring countries. Disease may also be transmitted by aquatic birds and other vector organisms, or simply carried in the downstream direction by water flow.

The magnitude of the potential disease risk might be somewhat increased in Bangladesh compared to neighbouring countries due to the intensification in aquaculture production that the proposed project aims to implement. This is due to the increased stress on fish that intensification usually produces - leading to greater possibility of disease outbreak. One approach to lessening the risk in aquaculture stock is to develop genetically enhanced strains of pond fish with greater tolerance of stress and greater disease resistance. Environmental improvement might also lessen stress and increase disease resistance in wild fish stocks.

Disease risk will however likely still remain high despite such remedial efforts if new highly virulent strains or pathogens are involved. The only realistic approach in such an eventuality is to allow the disease to 'run its course'. The spread of the disease should be monitored closely, and fish farmers should be dissuaded from further investment until there are clear indications that the epidemic is on the decline.

I.3 Implementation of Environmental Management Plan

Institutional Arrangements

The EMP will be implemented as an integral part of the project development. Implementation will be carried out by an EMP Implementation Group (EIG). This group will be a formal body within the project structure, and be composed of seconded full-time and part-time staff from the following agencies and organisations: DOF, DOE, BWDB, LGED, BIWTA. Staff from selected environmental NGOs will also be seconded to the EIG.

The responsibilities for various institutions and organisations for carrying out the various components the EMP are indicated in the following table:

EMP Component	Activity	Implementing GOB Institutions
Beel & Baor Hydrology	Design studies	BWDB, LGED
"	Regulator operation	BWDB, LGED
FCDI Hydrology	Design studies	DOF, BWDB
"	Fishpass gate operation	DOF, BWDB
Water Eutrophication	Feed control	DOF
"	Water exchange	BWDB
"	Chotomach protection	DOF
"	Macrophyte control	DOF
Groundwater Extraction	Groundwater survey	BWDB
"	Extraction regulation	BWDB
Submerged Macrophytes	Grass carp stocking	DOF
"	Common carp stocking	DOF
Genetic Diversity	Wild broodstock sourcing	DOF
"	Broodstock renewal	DOF
"	Broodstock localisation	DOF
Disease transmission	Fingerling inspection	DOF
"	Imported broodstock quarantine	DOF, Customs Authority
"	Facilities inspection	DOF
"	Dumping of stock	DOF, local judiciary
"	Escapage code of procedure	DOF
Snail Stock Depletion	Regulation of harvesting	DOF, DOE
"	Snail culture	DOF
"	Banning Indian imports	Customs authority
Disenfranchisement	Assessment of claim	DOF, DC, MOL
"	Compensation payment	DOF
"	Jalmohal allocation	DOF, DC, MOL
"	Community-based fisheries	DOF
Navigation	Brush gates	BIWTA, LGED
"	Alternate routes	BITWA

Institutional Strengthening

Staff Development Needs of DOF

Implementation of the EMP will require that the DOF take on new staff with the following areas of expertise:

- Hydrology (surface water and groundwater)
- Water chemistry
- Civil engineering (design of water management structures and fishpasses)
- Limnology (macrophytes and plankton)
- Fish genetics
- Fish disease
- Malacology (gastropods)

Staff Development Needs of Other Agencies

No special staff development needs will be required for other agencies in order to carry out the EMP.

Procurement of Equipment and Supplies

The EIG would require access to transport in order to carry out its work.

Equipment needed for EMP implementation is as follows:

- Hydrological measurement instruments
- Water chemistry analysis field kits
- Fish disease laboratories
- Navigation brush gates

Organisational Changes

No organisational changes are required for implementation of the EMP.

Training Plan

Implementation of the EMP would require training to be carried in the following disciplines:

- Water regulator operation
- Fishpass operation
- Aquaculture feed control
- Hatchery operation for floodplain stocking
- Fish and shrimp disease inspection and quarantine
- Snail culture methods

The purpose of the training plan is to ensure that a sufficient cadre of well trained and knowledgeable specialists is available to carry out the various component activities of the EMP.

Details of each training component are as follows:

- Water regulator operators: Standard training offered to BWDB and LGED water regulator operators will be required. Some 25 operators will need to be trained. Training would take place at BWDB training facilities, as well as on-the-job training.
- Fishpass operator: Training in operation of fishpass gates and sampling cages will be required. Up to 10 fishpass operators would be trained (depending on the number of structures built). Training would be carried out at the existing vertical slot fishpass at Kashimpur (Manu River FCDI Project near Moulvi Bazar).

- Aquaculture feed control: Training in proper feed preparation and application methods will be required. Some 200 extension workers will be trained. Training would be carried out at the FRI station in Mymensingh and/or at the Vocation School for Aquaculture proposed under this project.
- Hatchery operation for floodplain stocking: Training in hatchery methods appropriate for production of fingerlings for floodplain stocking will be required. About 200 hatchery staff will be trained. Training would be carried out at a selected GOB hatchery and at several privately owned hatcheries.
- Fish and shrimp disease inspection and quarantine: Training in hatchery hygiene and fingerling inspection for disease will be required. Approximately 50 hatchery and DOF staff will be trained. Training will take place at the FRI station in Mymensingh.
- Snail culture methods: Training in methods for snail culture are required. Forty potential snail culturists will be trained. No training facility currently exists for snail culture in Bangladesh. It is proposed that one DOF and one NGO staff be trained in snail culture methods at an overseas facility (to be identified), and that these individuals then lead training courses in Bangladesh at the FRI Paikgachha station.

A breakdown of costs for the EMP Training Plan is provided below:

Water regulator operators		
25 @ \$100 per operator		\$2,500
Fishpass operator		
10 @ \$200 per operator		\$2,000
 Aquaculture feed control		
200 @ \$100 per extension worker		\$20,000
 Hatchery operation for floodplain stocking		
200 @ \$150 per hatchery staff		\$30,000
 Disease inspection and quarantine		
50 @ \$200 per hatchery and DOF staff		\$10,000
 Snail culture methods		
2 @ \$20,000 per DOF/NGO trainers (overseas)		\$40,000
40 @ \$100 per snail culturist		\$4,000

TOTAL COST OF TRAINING PLAN = \$108,500

Technical Assistance Needs

The activities of the EMP will be carried out by the EIG in collaboration with competent GOB institutions. No special needs for externally-sourced technical assistance is previewed. The EMP budget would contain a contingency fund of US50,000 to cover the eventuality of a need developing for external assistance. This is most likely to develop in the area of fish disease control.

Implementation Schedule

The EMP would be implemented over the entire five year lifespan of the proposed project. Annual EMP activities as presented in the following chart:

FOURTH FISHERIES PROJECT PREPARATION Annex 9: Environmental Assessment

COMPONENT/ACTIVITY	Y1	Y2	Y3	Y4	Y5
BEEL & BAOR HYDROLOGY (Canal Re-excavation)	X	X	X	X	X
• Bed elevation design	X	X			
• Regulator operation		X	X	X	X
FCDI HYDROLOGY	X	X	X	X	X
• Design studies	X	X	X		
• Fishpass gate operation			X	X	X
WATER COURSE EUTROPHICATION	X	X	X	X	X
• Feed application improvement	X	X	X	X	X
• Prawn pond flushing		X	X	X	X
• Natural biota protection (chotomach, plants)		X	X	X	X
GROUNDWATER EXTRACTION	X	X	X	X	X
• Groundwater survey	X	X			
• Groundwater withdrawal regulation		X	X	X	X
NATURAL SUBMERGED MACROPHYTES PROTECTION	X	X	X	X	X
• Regulation of grass carp stocking	X	X	X	X	X
GENETIC DIVERSITY	X	X	X	X	X
• Wild broodstock acquisition	X	X	X	X	X
• Disposal of old broodstock	X	X	X	X	X
DISEASE TRANSMISSION	X	X	X	X	X
• Fingerling inspection	X	X	X	X	X
• Imported broodstock quarantine & inspection	X	X	X	X	X
• Grow-out facilities inspection	X	X	X	X	X
• Enforcement of anti-dumping regulation	X	X	X	X	X
• Code of procedures to control escapage	X	X			
SNAIL STOCK DEPLETION	X	X	X	X	X
• Regulation of snail harvesting	X	X	X	X	X
• Snail culture extension	X	X	X	X	X
• Banning of snail imports	X	X	X	X	X
DISENFRANCHISEMENT	X	X			
• Compensation of displaced fishermen	X	X			
• Jalmohal allocation	X	X			
• Community-based fisheries	X	X			
NAVIGATION	X	X	X	X	X
• Installation and operation of brush gates	X	X	X	X	X
PARTICIPATION PROGRAM	X	X	X	X	X
• Local Environmental Advisory Groups	X	X	X	X	X
• National Environmental Advisory Group	X	X	X	X	X
TRAINING	X	X	X	X	X
• Water regulator operators	X	X			
• Fishpass operators				X	X
• Aquaculture feed extensionists	X	X	X		
• Floodplain stocking hatchery staff	X	X			
• Fish disease inspectors	X	X	X		
• Snail culture trainers	X				
• Snail culturists		X	X		

I.4 Cost of EMP and Sources of Funds

Breakdown of costs of the EMP is as follows:

Beel and Baor Hydrology	
• Canal re-excavation design	\$50,000
• Water regulation structures (20 units)	\$400,000
FCDI Project Hydrology	
• Design studies	\$50,000
• Fishpass gate operation	\$10,000
Water Course Eutrophication	
• Feed application	\$80,000
• Water flushing	\$100,000
• Biota protection	\$10,000
Groundwater Extraction	
• Groundwater survey	\$200,000
• Groundwater withdrawal regulation	\$20,000
Genetic Diversity	
• Annual broodstock renewal	\$100,000
Disease Transmission	
• Fingerlings inspection	\$200,000
• Imported broodstock quarantine	\$30,000
• Grow-out facilities inspection	\$60,000
• Code of procedures on escapage	\$10,000
Snail Stock Depletion	
• Snail harvesting regulation	\$20,000
• Promotion of snail culture	\$300,000
Disenfranchisement	
• Compensation payments for leases	\$250,000
• Jalmohal re-allocation	\$100,000
Navigation	
• Brush gates installation	\$100,000
Participation Programme for Interested Parties	
• Local EAGs	\$100,000
• National EAG	\$20,000
Technical assistance	\$50,000
EMP Training Plan	\$108,500

TOTAL COST OF EMP = \$2,368,500

I.5 Linkage with the Project Assessment Process

The EMP is linked to the project assessment process primarily through the environmental monitoring plan (described below in Section I.J Environmental Monitoring Plan). The degree to which potential negative impacts are mitigated by the EMP will be assessed by comparison of with-project impacts to pre-project baseline conditions:

- If the comparison indicates little or no change, the mitigation measures will be assessed as successful.
- If the comparison indicates a large (negative) change, the mitigation measures will be assessed as not successful.

In the event of the second result, the inefficient component(s) of the EMP will be identified and redesigned to improve its performance.

During the course of project implementation, EMP components which are judged to be redundant will be eliminated.

J. ENVIRONMENTAL MONITORING PLAN

J.1 Purpose and Implementation of Environmental Monitoring Plan

The Environmental Monitoring Plan (EMONP) will provide information on the progress and results of the mitigation measures implemented under the EMP. It would also allow early detection of impact conditions not predicted during the EIA that might require additional mitigation measures.

J.2 Environmental Monitoring Activities

Monitoring activities will be divided into two phases: 1) the baseline pre-project period, and 2) the operational with-project period. In most cases, the same parameters (using the same methodologies) will be monitored during both periods. This will ensure consistency, and allow comparison to be made and detection of any changes due to project impacts. Ideally, no change (or a beneficial change) should be detected if the impact mitigation measures of the EMP are successful in their intended effect. A negative change indicates a need for reassessing and modifying the EMP.

Monitoring will address the 11 potential impacts of the proposed project. The following environmental parameters will be monitored:

- Beel and Baor Hydrology: Canal discharge; beel, canal and river water levels; beel/baor surface area; water extraction by people for various purposes; fish abundance and biodiversity; fish production.
- FCDI Project Hydrology: Riverside and countryside water levels; rainfall inside FCDI project; water discharge through fishpass; water body surface areas and water levels inside FCDI project; rice cropping patterns and areas; crop damage due to flooding.
- Water Course Eutrophication: Water quality (O₂, BOD₅, NH₃, suspended solids) in grow-out area and in surrounding/receiving waters; stocking density; feed application rates; stock growth rate; stock mortality.

- Groundwater Extraction: Groundwater extraction volumes; groundwater recharge rate; pond water management practices and growth in water demand; groundwater quality (salinity, pH, arsenic).
- Submerged Macrophytes: Submerged macrophyte density and species composition; macrobenthos abundance and biodiversity; water quality in macrophyte stands (turbidity, pH, O₂); chotomach abundance and biodiversity; carp stocking rate; carp growth rate.
- Competition for Plankton: Plankton abundance and biodiversity; water quality (turbidity, pH, O₂); abundance and biodiversity of indigenous planktivorous fish; stocking rate of silver and bighead carp; plankton consumption and growth rate of silver and bighead carp.
- Genetic Diversity: Stock abundance and genetic fingerprinting of wild native carp populations (protein electrophoresis); genetic fingerprinting of hatchery stock.
- Disease Transmission: Disease type and incidence in hatcheries, grow-out facilities and wild populations; disease incidence in wild stocks in the vicinity of escapage events; disease incidence in imported broodstock.
- Snail Stock Depletion. Wild snail population abundance, food consumption and growth rate; water quality of natural snail habitat (water temperature, O₂, pH, Ca); macrophyte and periphyton abundance of natural snail habitat; abundance of competitor snail species and other macrobenthos in natural snail habitat; harvesting rate of snails; snail fecundity and recruitment; disease incidence in snails.
- Disenfranchisement: Abundance and biodiversity of fish (pre-project); catch rates, species composition and income of fisheries in fish sanctuaries and pen areas (pre-project period); poaching in fish sanctuaries (with-project period).
- Navigation: Boat traffic patterns.

J.3 Institutional Strengthening for Environmental Monitoring

Staff Needs of DOF

The EMONP of the proposed project will require a significant technical effort on the part of DOF. It is proposed that a permanent monitoring unit be established within the DOF for this purpose (ie Project Monitoring Unit, PMU). The PMU would also be responsible for monitoring tasks in other fisheries development projects as well as collaborate with general national monitoring

programmes such as BFRSS and the water quantity and quality programme proposed below (Section II.E Water Quality and Quantity Monitoring Program Subproject).

To meet the needs of the EMONP it is proposed that the PMU consist of the following specialists:

- Chief Monitoring Officer
- Hydrologist
- Water chemist
- Limnologist
- Fish geneticist
- Fish disease specialist (microbiologist)
- Malacologist
- Fish stock assessment specialist
- Socioeconomist (with experience in navigation)

Staff Needs of Other Agencies

No particular staffing needs are required in other agencies as most of the monitoring activities will be carried out by the DOF. It is proposed that the specialists in the PMU liaise closely with counterpart specialists in relevant agencies (BWDB, DOE, BIWTA).

Equipment Needs

The following equipment will be needed to carry out the EMONP:

- Hydrological measurement instruments
- Water analysis kits
- Limnological sampling gear and laboratory supplies
- Protein electrophoresis equipment and laboratory supplies
- Bacteriological laboratory equipment
- Fish sampling gear and measuring equipment
- Small work boats and outboard motors

J.4 Cost of Environmental Monitoring Plan

The breakdown of costs for the EMONP over five years is as follows:

Institutional Strengthening

- Technical specialist salaries (540 p/m @ \$300/month) \$162,000

Operating expenses	
• Field expenses	\$250,000
• Laboratory expenses	\$400,000
Equipment	
• Field equipment	\$50,000
• Laboratory equipment	\$200,000
Reporting	\$10,000
TOTAL COST OF EMONP	\$1,072,000

J.5 Environmental Monitoring Reporting Procedures

The findings of the MONP will be reported to the project leadership and the DOF, in the form of a quarterly Environmental Status Report (ESR). The ESR will present monitoring data in analysed and summarised format, and make any recommendation to changes in the EMP or project activities which seem warranted by the EMONP results.

II. TERMS OF REFERENCE FOR ENVIRONMENTAL SUBPROJECTS

A. FISH BIODIVERSITY CONSERVATION SUBPROJECT

A.1 Background and Subproject Objective

Previous studies and projects (for example, BCAS/MPO study at Chandpur FCDI, FAP-6, FAP-16, FAP-17) have indicated that Bangladesh is losing valuable fish biodiversity at local, regional and national level. The causes of this biodiversity loss are several, including FCDI impacts, water pollution, excessive selective fishing mortality and sedimentation arising from watershed deforestation. In some cases the immediate cause of biodiversity loss is not clear (for example, the disappearance in the northeast region of the once widespread carp *nandina*).

The problem of fish biodiversity loss has not yet been addressed in a focused and comprehensive manner by the GOB.

The objective of the proposed subproject is to reverse the trend of fish biodiversity loss.

A.2 Rationale

Recruitment failure is endangering some fish stock in Bangladesh, The causes leading to recruitment failure and biodiversity loss are several - partly due to environmental degradation and partly due to overexploitation of broodstock. The proposed project will address these causes through an environmental improvement subproject, and by installing fish sanctuaries, canal re-excavation and fishpasses.

The above measures may however not be sufficient to re-establish threatened fish species whose population density has fallen below the critical level necessary to maintain a self-sustaining population. Such species include the *baromach* species *nandina*, *angrot*, *mohasol*, *sarputi*, *silond* and *pangas*. It is necessary therefore to carry out a program of stocking of these threatened species in order to re-establish them in rivers and floodplains.

Moreover, new threats to fish biodiversity are likely to arise in the future. Research into the effects of various types of development projects on fish biodiversity, as well as regular monitoring of the status of the fish biodiversity resources of Bangladesh are needed in order to early-detect potential losses of biodiversity and to implement timely measures to mitigate threats.

Implementing an effective research, monitoring, artificial breeding and stocking program for fish biodiversity would result in the reversal of the current trend of loss of fish biodiversity and allow continued maintenance of a high level of biodiversity.

A.3 Project Components

The subproject would have the following components:

1. National Fish Biodiversity Survey Programme Component. This component would train two ichthyologists to MSc level. It would establish a national fish biodiversity repository collection and national aquarium. It would also establish a long term research programme to study the life history of Bangladesh fish species. It would implement a continuing national fish biodiversity monitoring system.
2. Impact of Embankments on Fish Biodiversity Component. This component would study and assess the impacts of FCDI projects and road embankments on floodplain fish biodiversity. It would use the results of the study to draw up a set of guidelines for relevant government agencies (BWDB, LGED, DORH) on best practices and mitigation measures (fishpasses, culverts) to reduce the impact of embankments and associated water management and road transport infrastructure on fish biodiversity.
3. Impact of Stocking and Pond Escapage on Fish Biodiversity Component. This component would carry out a study and assessment of impacts of stocking and pond escapage of non-indigenous and indigenous carp and other species on fish biodiversity in floodplains, haors, beels, baors and other water bodies. The results of the study would be used to modify stocking programs, and regulate the use of pond culture species in order to eliminate adverse impacts.
4. Impact of Shrimp and Prawn Seed Collection on Fish Biodiversity Component. This component would conduct field studies of the impacts of collection of wild shrimp and prawns seed on fish and crustacean stocks in brackishwater, marine and freshwater environments. It would also monitor the quantity of seed captured, and the areas of capture. The results of the studies and monitoring would be used to assess the overall impact and sustainability of this practice. Measures for mitigation of negative impacts would be implemented as appropriate.
5. Stocking of Endangered Fish Species Component. This component would carry out induced breeding of threatened indigenous species (*nandina*, *angrot*, *mohasol*, *sarputi*, *silond* and *pangas*), involving both FRI and private hatcheries. The fingerlings would be stocked in selected protected sanctuary areas in order to re-establish populations in the wild. Active protection measures as well as a public awareness campaign would be implemented to allow stocked populations sufficient opportunity to build up to self-sustaining levels.

A.4 Expected Outputs

The following general outputs are expected from the subproject:

- Two trained ichthyologists (freshwater fish, marine fish)
- National fish collection
- National aquarium
- Improved biodiversity-friendly design of FCDI and road projects
- Improved biodiversity-friendly stocking and pond culture practices
- Improved shrimp and prawn collection practices
- Re-establishment of threatened fish stocks

A.5 Cost Estimates

Subproject cost breakdown by components over a 5 year period (unless noted) is as follows:

National Fish Biodiversity Survey Programme Component

Training of two ichthyologists (MSc level) (2 years)	100,000
National fish biodiversity repository collection	200,000
National aquarium (construction) (2 years)	1,000,000
National aquarium (operation, 3 years)	150,000
Life history research programme	25,000
National fish biodiversity monitoring system	25,000
Subtotal =	\$1,500,000

Impact of Embankments on Fish Biodiversity Component

Field study of FCDI impacts (3 year study)	100,000
Field study of road embankment impacts (3 year study)	100,000
Preparation of guidelines (1 year)	50,000
Subtotal =	\$250,000

Impact of Stocking and Pond Escapage on Fish Biodiversity Component

Field study of floodplain stocking (2 year study)	70,000
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Field study of baor stocking (2 year study)	70,000
Field study of pond escapage (2 year study)	70,000
Preparation of guidelines (1 year)	<u>50,000</u>
Subtotal =	\$260,000

Impact of Shrimp and Prawn Seed Collection on Fish Biodiversity Component

Field study of seed collection (2 year study)	70,000
Field study of impacted fishery stocks (2 year study)	70,000
Implementation of mitigation measures	<u>250,000</u>
Subtotal =	\$390,000

Stocking of Endangered Fish Species Component

Development of induced breeding methods	100,000
Stocking of fingerlings	150,000
Fish sanctuary protection program	100,000
Public awareness program	<u>50,000</u>
Subtotal =	\$400,000

The cost summary of the individual components of the Fish Biodiversity subproject is as follows:

National Survey	\$1,500,000
Impact of Embankments	\$250,000
Impact of Stocking and Pond Escapage	\$260,000
Shrimp and Prawn Seed Collection	\$390,000
Stocking of Endangered Fish	\$400,000
TOTAL =	\$2,800,000

B. FISHERIES ENVIRONMENTS IMPROVEMENT SUBPROJECT.

B.1 Background and Subproject Objective

Over the last four decades both the terrestrial and the aquatic environments of Bangladesh have suffered substantial disruption and degradation. The aquatic environment has been particularly hard hit because it is vulnerable to direct negativities such as industrial effluent discharge, as well as terrestrial environment-originating indirect externalities such as sedimentation resulting from deforestation and agrochemical runoff resulting from agricultural development. The latter in particular has generated the most extensive direct and indirect impacts due to landclearing for rice cultivation and widespread construction of flood control, drainage, and irrigation schemes.

A number of feasibility studies have been undertaken on aquatic habitat improvement (particularly under FAP) and several projects are being implemented. However there is no project currently being implemented which focuses on the particular requirements of fisheries in aquatic environments.

The objective of the proposed subproject is to implement environmental improvement measures which are designed primarily to benefit and enhance the fisheries resources carrying capacity of key aquatic habitat types.

B.2 Rationale

Part of the decline in openwater capture fisheries is due to widespread degradation of aquatic habitat quality. The causes of this degradation are due to negative externalities of other development sectors (especially agriculture and industry which together result in decreased water quantity and water pollution).

Various measures (including strategic) are being implemented to ameliorate and dampen the magnitude of water-impacting externalities of the agriculture and industrial sectors. These may in future reduce the level of impact, but in themselves will not restore habitats in affected locations. A more direct approach to aquatic habitat rehabilitation is required in order to more rapidly reverse the existing trends and re-establish the fundamentals of habitat quality and health upon which openwater fish productivity is based.

Implementing a multi-dimensioned and innovative aquatic habitat restoration program would in both the short and long term result in higher levels of openwater fish production and reduced risk of stock failure due to environmental degradation. Integration of this subproject into on-going community-based fisheries resource management initiatives (such as the Oxbow Lakes Project II and the Community-based Fisheries Management Programme of the DOF) is necessary to realise the full benefits of the subproject and ensure long term sustainability.

B.3 Project Components

The subproject would have the following components:

1. Wetland and Mangrove Tree Plantation Component. This component would plant a minimum of 1 million seedlings of the flood tolerant tree species *hizal* (*Barringtonia acutangula* Linn) and mangroves. The principal planting locations would be the shorelines of beels, baors and canals, and the shoreline terraces along coastal polders. Seedlings would be planted in parallel rows of 5 or 6 trees, to form a continuous band along the perimeters of water bodies and polders.
2. Control of Agrochemicals Impacts Component. This component would carry out comprehensive studies of the patterns of use of agrochemicals (fertilisers and pesticides), their modes of flushing into freshwater, brackishwater and marine aquatic habitats, their rate of uptake by sediments and aquatic organisms, and the level of residues in fish tissue. The degree of risk to fish stocks and to human health will be assessed. The use of pesticides to prevent insect infestation of dry fish will also be studied and the health hazard to humans assessed. Guidelines will be prepared for the Ministry of Agriculture and for farmers on the hazards of agrochemicals to fish resources and acceptable practices for utilising agrochemicals so as to protect fishery resources. A study will be made of the types of agrochemical produced in Bangladesh, and the types of agrochemical being imported (legally and illegally). Recommendations will be prepared to assist the GOB in eliminating the manufacture, import and use of agrochemical deemed to be hazardous to fishery resources and general environmental quality, and specifically to human health.
3. Beel and Baor Embankment Component. This component will construct low embankments equipped with water retention regulators around 30 beels and baors in order to increase their dry-season water storage capacity. The hizal tree plantation component will be integrated with this component (ie seedlings will be planted on the embankments wherever possible). Hydrological studies will be undertaken, along with fisheries and non-fisheries water use patterns for individual water bodies. Water user committees will be established to regulate the quantities of water that will be used for fisheries and non-fisheries purposes during the dry season and mediate disputes.

4. Artificial River Duars Pilot Schemes Component. This component will construct several types of structures (flow deflectors, bottom sills) which are designed to create downstream duars (= scour holes) in river channels at five pilot locations. Duars are known to be critical overwintering habitat for many commercially important species, and key spawning habitats for major carp (*rui*, *catla*, *mrigel*). The construction of artificial duars for fishery enhancement purposes has not been previously attempted in Bangladesh. The newly created artificial duars will be placed under protected sanctuary management with the participation of local fisheries associations, and will be monitored for several years to assess their utility for stock enhancement and protection.
5. Low Cost Industrial Effluent Treatment Component. This component will prepare the design of low cost industrial effluent treatment systems for tanning, textile, jute, chemicals & pesticides, pulp and paper, seafood processing and fertiliser industries. Treatment systems will be designed for 10 plants. The component will study the plant process system and effluent streams, assist plant managers to reduce the volume of effluent generated, design appropriate treatment systems, and facilitate construction and operation of the treatment systems.
6. Water Hyacinth Control Component. This component will study the infestation and growth patterns of water hyacinth. A national survey of all major beels, baors, rivers, canals and other water bodies will be undertaken to assess the degree of infestation and allow planning of clearing and control activities. Studies of infestation of small systems (khals, borrow pits, tanks, ponds) will also be carried out. It will review available control and utilisation strategies and methods. It will develop an appropriate strategy and approach and identify optimal methods for controlling the negative impacts of water hyacinth on aquatic habitat quality and fish production. It will disseminate the selected approach and methods through demonstration and public awareness programs. Clearing and control activities are expected to be carried out in at least 10,000 ha of water bodies.

B.4 Expected Outputs

The following general outputs are expected from the subproject:

- One million hizal and mangrove trees planted around water bodies and polders
- Improved application of agrochemicals by farmers
- Reduction in use of hazardous pesticides by fish processors/traders
- Curtailment of manufacture and import of hazardous pesticides
- Reduction in damage to fish stocks and human health from hazardous pesticides
- Low embankments and water retention regulators around 30 beels and baors
- Water user committees in 30 beels and baors

- Five artificial river duars
- 10 low cost industrial effluent treatment systems
- 10,000 ha of water bodies cleared of water hyacinth.

B.5 Cost Estimates

Subproject cost breakdown by components over a 5 year period (unless noted) is as follows:

Wetland and Mangrove Tree Plantation Component

Planting of 1 million <i>hizal</i> and mangrove seedlings	1,000,000
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Control of Agrochemicals Impacts Component

Field study of agrochemicals use (2 years)	70,000
Field study of agrochemicals in aquatic habitat (3 years)	105,000
Study of pesticide residues in fish (3 years)	150,000
Field study of pesticide application on dry fish (2 years)	70,000
Preparation of guidelines on agrochemical use (1 year)	50,000
Study of pesticide supply (0.5 year)	<u>25,000</u>
Subtotal =	\$470,000

Beel and Baor Embankment Component

Hydrology studies and design	1,000,000
Construction of beel embankments (150 km) and regulators	5,000,000
Water user committee support	<u>300,000</u>
Subtotal =	\$6,300,000

Artificial River Duars Pilot Schemes Component

Hydrology studies and design	200,000
Construction of flow deflector and bottom sills	500,000
Fish sanctuary protection program (4 years)	80,000
Impact monitoring (4 years)	<u>160,000</u>
Subtotal =	\$940,000

Low Cost Industrial Effluent Treatment Component

Treatment system design	200,000
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Construction of treatment systems	2,000,000
Impact monitoring (3 years)	<u>120,000</u>
Subtotal =	\$2,320,000

Water Hyacinth Control Component

National infestation survey and planning (2 years)	70,000
Small water body infestation study (2 years)	70,000
Development of control methods (1 year)	35,000
Control demonstration and public awareness program	100,000
Subtotal =	\$275,000

The cost summary of the individual components of the environmental improvement subproject is as follows:

Wetland and Mangrove Tree Plantation	\$1,000,000
Control of Agrochemicals	\$470,000
Beel and Baor Embankment	\$6,300,000
Artificial River Duars	\$940,000
Low Cost Industrial Effluent Treatment	\$2,320,000
Water Hyacinth Control	\$275,000
TOTAL =	\$11,030,000

C. COMMUNITY-OWNED FISHERIES PILOT PROJECT.

C.1 Background and Pilot Project Objective

Several projects during the last decade have addressed the problem of management of the openwater fisheries of Bangladesh through user-management approach. These include the New Fisheries Management Policy, the ICLARM/Ford Foundation supported Community-based Management Project and the DANIDA/IFAD financed Oxbow Lakes Project. The projects have been only partly successful in meeting their objectives. Sustainability of initiatives after project termination has been problematic.

The problem of effective openwater fisheries resource management has evidently not been solved by previous projects. A new approach needs to be formulated and tested.

The objective of the proposed pilot project is to carry out pilot trials of user-ownership type of fisheries management systems to assess the feasibility of widespread implementation in Bangladesh.

C.2 Rationale

Overexploitation is a serious threat to sustainability of production in openwater fisheries. The most widely practiced fisheries management systems implemented by GOB to date (ie jalmohal leasing) has contributed directly to overexploitation, as well as economic marginalisation of genuine fishermen. Various trials of community-based type systems have lacked durability due to continuation of government-rent seeking through taxation (official and unofficial) and extortion by previously vested interests.

The fundamental feature common to both jalmohal leasing and community-based systems (as previously implemented in Bangladesh) is ownership of the water body and fishery resources by the state. This creates an irresolvable conflict of interest between the owner of the resource (ie the state in the form of the GOB) and the user of the resource (ie the genuine fishermen) which invariably and probably inevitably defeats attempts to achieve sustainable production and economic equity for fishermen. Lack of resource ownership on the part of the user results in short-term planning horizons and promotes resource mining practices such as annual katha harvesting, current jal use and beel dewatering.

In sharp contrast to the evident stock depletion and unsustainability of openwater fisheries, high levels of production sustainability and resource management are evident in the agriculture sector and in pond aquaculture, and this derives directly from the resource ownership regimes which exist in these production sectors (ie rice farmers own their fields and paddy crops; fish farmers own their own ponds and fish crops). The absence of kinds of conflict which exist when the resource owner and the resource user are two different entities is likely a precondition for sustainable production and income equity in renewable natural resource sectors.

Outright ownership of water bodies and fish stocks by fishermen would remove (or at least minimise) the risk of loss of access to resources and livelihood due to shifts in government policy or manipulation by vested interests. It would also allow long term planning for stock conservation and regulation of harvesting rates to sustainable levels. Moreover, investment in environmental enhancement and stock improvement will also become feasible under conditions of security of long term ownership.

Implementing pilot projects in various types of water bodies to test the utility of ownership-based fisheries management systems would allow careful assessment and evaluation to be made of the benefits and costs of such systems. The feasibility for widespread implementation of such systems could also be assessed with a degree of confidence.

C.3 Project Components

The subproject would have the following components:

1. Fisheries Association Establishment Component. This component would assist all genuine professional and subsistence fishermen and fisherwomen (as well as women fish processors) of the communities relevant and/or riparian to a particular waterbody to form a single unified fisheries association. It would assist the fisheries association to register as legal production entities. It would provide basic training in organisational skills (ie bookkeeping, accounts, planning) for members.
2. Acquisition of Water Body and Fishery Resource Ownership Component. This component would assist the fisheries associations to acquire from the Ministry of Land (MOL) legal tenure of their relevant water body and all fishery resources contained within the water body. It would where necessary cancel existing leases (with compensation to leaseholders). It would assist to provide resource loans to the fisheries associations to purchase the water bodies and fishery resources from the GOB. It would ensure the full legality and protection by law of the perpetual continuing ownership of the water bodies by the fisheries associations.
3. Financial Management and Loan Repayment Component. This component would assist the fisheries association to plan their financial accounts in a manner consistent with

meeting costs, servicing the resource loan repayments, and paying income shares to members for fishing activities.

4. Fishery Management Plan Component. This component would assist the fisheries associations to draw up short term and long term stock management, harvesting and conservation plans. It would train the fisheries associations to collect and interpret fish catch and biological data in order to assess the state of the stocks. It would provide assistance in using the data to formulate annual harvesting plans. It would also assist in the formulation of conservation plans and measures, such as closed seasons, fish sanctuaries, minimum size limits, broodstock protection, stocking and introduction of rare and/or desirable species, to ensure the long term vitality and high abundance of the fishery resources.
5. Environmental Management Plan Component. This component would assist the fisheries association to plan and implement investments in environmental enhancement and improvement. This would include measures for retaining water during the dry season and prevent dewatering, planting of wetland trees (ie hiral in freshwater habitats, mangroves in brackishwater habitats), improvement of water quality through protection against agrochemicals and other pollutants, and conservation of other aquatic lifeforms (plants, invertebrates, amphibians, reptiles, birds, mammals) which are crucial to maintaining high biodiversity and ecologically balanced ecosystems.

C.4 Expected Outputs

The following general outputs are expected from the subproject:

- Thirty waterbody-based functional fisheries associations
- Legal deeds providing for full ownership of 30 waterbodies and fishery resources by fisheries associations
- Resource loans granted to fisheries associations to purchase waterbodies and fishery resources
- Thirty fisheries association financial management plans
- Annual fisheries management plans (a total of 120 for 30 association over 4 years).
- Thirty long term fishery management plans
- Thirty long term environmental management plans.

C.5 Cost Estimates

Subproject cost breakdown by components over a 5 year period (unless noted) is as follows:

Fisheries Association Establishment Component

Associations establishment (2 years)	450,000
Association registration fees (2 years)	30,000
Organisational training (2 years)	<u>30,000</u>
Subtotal =	\$510,000

Acquisition of Water Body and Fishery Resource Ownership Component

Compensation to leaseholders (2 years)	300,000
Purchase of 30 waterbodies/resource loans (2 years)	3,000,000
Legal fees (2 years)	<u>150,000</u>
Subtotal =	\$3,450,000

Financial Management and Loan Repayment Component

Accounting fees	150,000
Debt servicing cost and interest (4 years)	<u>3,000,000</u>
Subtotal =	\$3,150,000

Fishery Management Plan Component

Stock assessment studies (4 years)	24,000
Annual fish harvesting plan preparation (4 years)	24,000
Fish sanctuary protection program (4 years)	60,000
Fingerling stocking (4 years)	<u>120,000</u>
Subtotal =	\$228,000

Environmental Management Plan Component

Planting of 100,000 <i>hizal</i> seedlings (4 years)	100,000
Control of agrochemicals (3 years)	90,000
Construction of beel/baor embankments/regulators (3 years)	1,000,000
Water hyacinth control (3 years)	<u>18,000</u>
Subtotal =	\$1,208,000

The cost summary of the individual components of the environmental improvement subproject is as follows:

Fisheries Association Establishment	\$510,000
Water Body Acquisition	\$3,450,000
Financial Management/Loan Repayment	\$3,150,000

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Fishery Management Plan	\$228,000
Environmental Management Plan	\$1,208,000
TOTAL =	\$8,546,000

D. FISH AND SHRIMP DISEASE CONTROL SUBPROJECT

D.1 Background and Subproject Objective

Fish and shrimp are poikilothermal and aquatic animals which easily get diseased, particularly in closed environment where the dynamics of equilibrium between fish/shrimp and pathogens collapse very easily primarily due to environmental stress.

Fish and shrimp health management is an important component of aquaculture as it influences the production in many ways. Health problems may increase or decrease the production by reducing or causing morbidity and mortality and may even cause total loss by outbreak of epizootics.

The problem of fish and shrimp diseases has yet not been addressed in a systematic and comprehensive manner by the GOB.

The objective of the proposed sub-project is designed to improve GOB capability to prevent and control fish disease and to reverse the trend of production decline.

D.2 Rationale

A number of measures have so far been taken by the fish and shrimp farmers to control diseases but there has been little success.

Moreover, new outbreaks of disease (EUS, white spot) in fish and shrimp are continuing. Early detection is required to take preventive measure and to mitigate the threat.

The outbreak of diseases particularly in fish has also been detected within FCDI projects, indicating the impact of development project on disease outbreak. Research into the effects of development projects on fish diseases, as well as regular monitoring of disease status in various fisheries habitat are needed in order to detect and diagnose diseases, and implement timely measures to mitigate threats.

Implementation of effective research, monitoring of environmental parameters, creation of awareness and extension service through training and media by GOB personnel to farmers would result in the control of fish and shrimp mortality and hence increase the productivity.

D.3 Project Components

The subproject would have the following components:

1. Survey of Fish and Shrimp Diseases and Control Measures. This component would undertake comprehensive and systematic study of diseases, etiology, epizootiology and control in different fisheries habitats, and prepare a status report on fish and shrimp diseases and control.
2. Extension Training on Disease Prevention and Management. The objective of the training would be to improve the technical capabilities of the GOB personnel and farmers at field level. The main emphasis of the training would be on the following: a) develop working knowledge and skills of the participants, GOB personnel and farmers for diagnosis and management of disease; b) enhance understanding of prevention methods under different environmental condition and needs of the beneficiaries; c) greater responsibility by the GOB agencies; and d) updating the knowledge base.
3. Environmental Hygiene and Wastewater Recycling. This component would recycle wastewater fouled due to feed residue and excreta of the reared species in hatcheries and grow-out facilities to avoid environmental hazards. Due to lack of recycling systems receiving waters are being polluted due to discharge of waste water.
4. Quarantine Measures to Contain Disease Outbreaks. This component would set up quarantine posts with laboratories in Dhaka, Khulna, Chittagong, Barisal, Sylhet and Rajshahi to monitor the hygienic condition of fish and crustaceans and to analyse feed, soil and water.

D.4 Expected Outputs

The following general outputs are expected from the subproject:

- National fish and shrimp diseases data base
- Data analysis and report production
- Trained GOB staff and farmers
- Improved management of diseases
- Reduced loss of production due to disease

D.5 Cost Estimates

Subproject cost breakdown by components over a 5 year period (unless noted) is as follows:

Survey of Fish and Shrimp Diseases and Control Component

Field study and design (3 years)	\$150,000
Preparation of guidelines on diseases and control(2 years)	<u>\$100,000</u>
Subtotal =	\$250,000

Extension Training on Disease Prevention and Management Component

Training design	\$50,000
Implementation of training course	\$150,000
Training aids	<u>\$100,000</u>
Subtotal =	\$300,000

Environmental Hygiene and Wastewater Recycling Components

Recycling components	\$500,000
Installation of the components by phase (5 years)	\$200,000
Repairing of the components	<u>\$50,000</u>
Subtotal =	\$750,000

Quarantine Measures to Contain Disease Outbreaks Component

Land acquisition by phase (2 years)	\$200,000
Lab building	\$150,000
Equipment	\$120,000
Chemicals and glassware	\$200,000
Establishment cost	<u>\$350,000</u>
Subtotal =	\$1,020,000

The cost summery of the individual components of the fish and shrimp disease control subprojects is as follows :

Disease Survey	\$250,000
Extension training	\$300,000
Wastewater recycling	\$750,000
Quarantine measures	\$1020,000
TOTAL =	\$2,320,000

E. WATER QUALITY AND QUANTITY MONITORING PROGRAM SUBPROJECT

E.1 Background and Subproject Objective

In recent years, the 26 component projects of the Flood Action Plan have collated, collected and analysed a massive water quantity database covering the whole of Bangladesh. Many of the FAP projects also studied water quality parameters.

Routine monitoring of hydrology is carried out by the BWDB at 317 water level stations. The raw data is analysed by SWMC and WARPO, and used to generate flood status and flood prediction reports. The DOE maintains 53 water quality sampling stations in 30 rivers, where 15 parameters are monitored. Oceanographic data is collected routinely by the DOF at several stations.

Despite the availability of routinely collected comprehensive water quantity and quality data over most of the country, little use of this data is made to monitor the status of fisheries environments of Bangladesh, or to plan fisheries management or development activities.

The objective of the proposed subproject is to acquire selected water quantity and quality data from the above institutional sources on a routine basis, and reformat and analyse the data in order to provide regular status reports of fisheries environments in Bangladesh.

E.2 Rationale

Over the last few decades fisheries environments in Bangladesh have been undergoing major changes in both water quantity and water quality. The general trend is towards deterioration in hydrological flows and lowering of water quality. Causes of these negative changes are deforestation, FCDI and agricultural development, industrialisation and increase in sewage discharge. Various studies have linked declining openwater fish production to one or more of these factors (apart from overfishing impacts).

Given the substantial socio-economic importance of fish production from inland and marine environments, it is important that continuous monitoring of ambient aquatic environmental quality be carried out. This would have two purposes:

1. To identify, predict and control threats to fish stocks arising from environmental deterioration.
2. To enable timely and accurate planning of contingency measures for food security and other fishery-related programs which may arise due to short-term or long-term environmental deterioration or fluctuations.

Although relevant water quantity and quality data is being routinely collected in Bangladesh, the information is not general accessed by fisheries agencies, and therefore not being effectively used for fisheries management and development. Implementing a water quantity and quality monitoring program that would acquire data and prepare regular environmental status reports for distribution within the fisheries sector would provide a valuable analytic and planning data tool to fisheries managers and developers.

E.3 Project Components

The subproject would have the following components:

1. Acquisition of Hydrology Data Component. This component would purchase selected data sets and model products in computerised form from BWDB, SWMC and WARPO on a regular basis. The data would be stored in project computers.
2. Acquisition of Water Quality Data Component. This component would purchase selected data sets in computerised form from DOE on a regular basis. The data would be stored in project computers.
3. Project Water Monitoring Data Collection Component. This component would sample and collect water quantity and quality data from project activity locations from two perspectives: 1) ambient water quality for production, and 2) process water discharge impacts.
4. Analysis of Water Data Component. This component would carry out regular analysis of the water quantity and water quality databases from the perspective of fisheries management and development. The component would train a hydrologist to carry out the analysis.
5. Fisheries Environments Data Service Component. This component would produce a regular quarterly report on the status of water quantity and quality in Bangladesh from a fisheries perspective. The report will be widely available through public sale at appropriate cost to all potential users in Bangladesh (private sector, NGOs, GOB agencies, donor agencies, general public). The component would also produce specialised reports to meet particular needs of individual clients.

Locations of Water Sampling Stations

It is proposed that only key BWDB water level monitoring stations be used for the proposed subproject. This would include the following rivers (mainly channels which carry active discharge, rather than distributaries):

Jamuna
Padma
Meghna
Upper Meghna
Kushiyara
Surma
Manu
Khowai
Kangsha
Old Brahmaputra
Tista
Jamuneswari
Atrai
Feni
Karnaphuli
Shankha
Matamuhuri

Water level in key beels/haors, baors and reservoirs will be monitored. These would include:

Tangua Haor
Hakaluki Haor
Kawadighi Haor
Hail Haor
Dakatia Beel
Baluhar Baor
Nasti Baor
Shachta Baor
Kaptai Reservoir
Foy's Lake

Key DOE water quality monitoring stations would be used for the proposed subproject. These will be selected from the 53 stations in 30 rivers currently being monitored. Additional data for coastal and estuarine water quality will be accessed from DOF sources.

Final selection of water quantity and quality monitoring stations will be done during subproject implementation.

Frequency of Water Sampling and Analysis

BWDB water staff gauge readings are taken several times per day. This exceeds the requirement for the proposed subproject. Only a subsample of the available BWDB database would be brought into the subproject database.

DOE water quality sampling frequency varies by station: monthly, bimonthly and trimonthly. For purpose of the subproject, monthly sampling would be preferable. The DOE is willing to adjust its sampling schedule to suit client needs.

E.4 Expected Outputs

The following general outputs are expected from the subproject:

- National water quantity (hydrology) database
- National water quality database
- Water quantity and quality data from project sites
- One trained DOF staff hydrologist
- Data analysis and report production office

E.5 Cost Estimates

Subproject cost breakdown by components over a 5 year period is as follows:

Acquisition of Hydrology Data Component

Purchase of BWDB and other data (50 stations)	500
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Acquisition of Water Quality Data Component

Purchase of DOE data (40 stations)	500
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Project Water Monitoring Data Collection Component

Hydrology and water analysis equipment	10,000
Field expenses	<u>25,000</u>
Subtotal =	\$35,000

Analysis of Water Data Component

Training of hydrologist	30,000
Computer equipment	25,000
Operating expenses	<u>25,000</u>
Subtotal =	\$80,000

Fisheries Environments Data Service Component

Desktop publishing equipment	50,000
Operating expenses	<u>25,000</u>
Subtotal =	\$75,000

The cost summary of the individual components of the environmental improvement subproject is as follows:

Hydrology Data Acquisition	\$500
Water Quality Data Acquisition	\$500
Project Water Monitoring	\$35,000
Water Data Analysis	\$80,000
Fisheries Environments Data Service	\$75,000
TOTAL =	\$191,000
Sale of Reports	(\$10,000)
Net Cost	\$181,000

**III. REVIEW AND EVALUATION OF
ENVIRONMENTAL LEGISLATION AND
REGULATIONS**

A. EXISTING LAWS AND REGULATIONS

A.1 Provisions of Fisheries and Environmental Laws and Regulations

The main provisions of existing fishing laws and regulations, and also environmental laws which have a bearing on fisheries, are summarised below.

Fisheries Laws

The Protection and Conservation of Fish Act, 1950 (Bengal Act XVIII of 1950)

This act provides for protection and conservation of fish in Bangladesh. It gives the GOB power to:

- Prohibit or regulate: fixed engines; weirs, dams, bunds, embankments; use and method of operation of fishing nets and mesh size; manufacture, import, marketing, carrying, transporting or possessing of fishing gears.
- Prohibit the use of explosives, gun, bow and arrow to destroy fish.
- Prohibit destruction of fish by poisoning of water and pollution.
- Prescribe closed seasons for fishing.
- Prescribe minimum sizes of capture or sale.
- Prohibit fishing in all or specified waters for a specific period.
- Prohibit destruction of fish by drying or dewatering of any fishery.

Breach of rules are punishable by one to six months of imprisonment and fines of up to Tk 1,000. Repeat offenders are punishable by imprisonment from 2 months to one year and fines up to Tk 2,000.

The Government Fisheries (Protection) Ordinance, 1959 (Ordinance No. XXXIV of 1959)

This ordinance gives the GOB power to declare any fishery belonging to, or under the management and control of the GOB, to be a khas managed fishery. It allows GOB to issue licences to fishermen at rates fixed by GOB or authorised agency, and to lay down terms and conditions. Fishing without a licence is a contravention punishable by up to 2 years imprisonment or a fine of up to Tk 5,000, or both. Confiscated fish, gear and boats may be forfeited to the GOB.

The Private Fisheries Protection Act, 1889 (Bengal Act II of 1889)

This act defines private waters as:

- waters which are the exclusive property of any person, or
- in which any person has an exclusive right of fishery, and in which fish are not confined but have means of ingress or egress.

It considers any person guilty of an offence who

- fishes in any private waters, not having a right to fish therein,
- places fixed engines in private waters without permission.

The first offence is punishable with a fine up to Tk 50. Subsequent offence is punishable by up to one month imprisonment or with a fine not exceeding Tk 200, or both. Contravening fixed engines will be forfeited, and removed by the district Magistrate.

Entry upon private land or private waters with intent of contravening the act is punishable by a fine no exceeding Tk 50.

The act protects the right of persons to fish by angling with a rod and line or with a line only in any portion of a navigable river.

The Protection and Conservation of Fish Rules, 1985

This regulation prohibits the erection and use of fixed engines in rivers, canals, khals and beels. Contravention will result in seizure and forfeit the engine and of the fish caught. It prohibits construction of permanent or temporary bunds, weirs, dams and embankments in, on or across or over rivers, canals, khals or beels for any purpose other than irrigation, flood control or drainage.

It also prohibits use of explosives, gun, bow and arrow for fishing, the use of poisons or destruction of fish by pollution.

Specific rules governing closed seasons and size limits are decreed for certain species:

- Catching of fry of *shol*, *gazar* and *taki* or parent fish guarding fry is prohibited from 1 April to 31 August in rivers, canals, khals beels or other sheet of water connected to any river, canal, khal or beel. (Destruction of these species during the closed season is permitted for the purpose of carp culture).
- Catching of *rui*, *catla*, *mrigel*, *kalibaush* and *gonia* of any size is prohibited from 1 April to 30 June in rivers, khals and water bodies specified in the accompanying First Schedule (lists portions of the Kushiyara, Kalni, Surma, and associated tributaries and khals in the northeast region). Catching for pisciculture while in possession of a licence costing Tk 100 is permitted.

Except for pisciculture purpose, it is illegal to catch, carry, transport, offer, expose or possess fish of the species and sizes listed in the accompanying Second Schedule during indicated time periods. These are:

- Carps (*catla*, *ru*, *mrigel*, *kalibaush*, *gonia*) below 23 cm in length, between July and December each year.
- *Hilsha* below 23 cm in length (ie *jatka*), between November and April each year.
- *Pangas* below 23 cm in length (ie *jatka*), between November and April each year.
- *Silon* below 30 cm in length, between February and June each year.
- *Boal* below 30 cm in length, between February and June each year.
- *Air* below 30 cm in length, between February and June each year.

Forfeited fish will be disposed of by auction as the auction money deposited with the GOB.

This act also empowers the GOB to prohibit the catching, carrying, transporting, offering, exposing or possessing of dead or alive frogs.

The Marine Fisheries Ordinance, 1983
(Ordinance No. XXXV of 1983)

This ordinance makes comprehensive provisions for management, conservation and development of marine fisheries. Provisions deal with:

- Non-mechanised local fishing vessels and local fishing with limited horsepower.
- Fishing zones.
- Responsible for management lies with the Director of Fisheries.
- Types, classes and numbers of fishing vessels.
- Issuing of licences valid for particular species, gears, fishing methods and fishing locations.
- Duty to provide information on catches.
- Interference with navigational aids or shipping routes by fishing vessels.
- Registration of local fishing vessels.
- Certificate of inspection of fishing vessels.
- Prohibition on foreign fishing vessels fishing in Bangladesh waters without a licence.
- Prohibition on use of explosives, poisons and noxious substances for fishing.
- Prohibition on nets with small mesh sizes.
- Declaration of marine reserves to protect aquatic flora and fauna.
- Prohibition on fishing, dredging and constructions in a marine reserve.
- Authorisation of fisheries officers to stop and examine fishing vessels.
- Obstruction of authorised officer.
- Wilful damage of fishing vessel.
- Destruction of fish, fishing gear, or other proscribed fishing appliances to avoid seizure or detection.

- Failure to mark vessels.
- Liability of skipper for offences committed by persons on board vessel.
- Compounding of offences.
- Forfeiture of seized vessels.
- Fish found on board a fishing vessel committing an offence presumed to be caught illegally.

The Fish and Fish Products (Inspection and Quality Control) Ordinance, 1983
(Ordinance No. XX of 1983)

This ordinance confers power to GOB to establish wide-ranging rules in the following areas:

- Prescribing fish product grades, quality and standards.
- Regulation of catching, handling and marketing.
- Processing, storing, grading, packaging, marking, transporting and inspection of products.
- Quality and specifications of containers, and marking and inspection of containers.
- Registration of fish processing and packing plants.
- Licensing of persons dealing freezing, processing and preservation of fish.
- Determine the requirements of equipment, construction and sanitary operation of plants.
- Prescribe the fees for registration of plants, issuing of licences and inspection of laboratory analysis of samples.
- Prohibition of sale or offering for sale of fish products.
- Prescribe the sampling procedure for fish products.
- Prohibit or restrict marketing or offering fish without obtaining quality control certificates.
- Manner of disposal of fish products which do not conform with standards or are unfit for human consumption.

It also empowers GOB to inspect premises to ensure compliance with the provisions of the Ordinance.

It is illegal to export products intended for human consumption which are decomposed, unwholesome or contaminated with pathogenic organisms.

It is illegal for a person suffering from leprosy, tuberculosis or other contagious disease to catch, handle, carry, or process fish or work in a plant.

Penalties for contravention of the ordinance range from imprisonment up to three months, six months, or fines up to Tk 5,000, Tk 10,000 or both.

Bangladesh Fisheries Development Corporation Act, 1973
(Act No. XXII of 1973)

This act establishes the BFDC, and empowers it to take measures to develop fisheries and fishing industry. It can establish units to catch fish (ie acquire, hold or dispose of fishing boats, fish carriers, road and river transports and all equipment and accessories). It can also establish processing units, encourage establishment of fishermen cooperatives, undertake fishery resources surveys and investigations, establish training and research institutions, and acquire, hold and dispose of other properties required. General direction and management of BFDC is invested in a Board which is required to act on commercial considerations.

The Fisheries Research Institute Ordinance, 1984
(Ordinance No. XLV of 1984)

This Ordinance establishes the FRI and defines its functions as:

- To carry out and coordinate fisheries research;
- To assist in developing more efficient and economic methods of fish production, management, processing and marketing;
- To carry out other necessary acts.

Environmental Law

The Bangladesh Environment Conservation Act, 1995
(Act No. 1 of 1995)

This act establishes the Department of Environment, headed by a Director General. It confers on the GOB power to do the following activities relevant to fisheries:

- Declaration of ecologically critical areas.
- Control of direct or indirect damage to eco-systems.
- Receive requests from any person affected by or likely to be affected by pollution or degradation of the environment for remedying the damage or apprehended damage.
- Control discharge of excessive environmental pollutants.
- Power of entry and to take samples.
- Grant environmental clearance to allow establishment of an industrial unit or project.
- Formulation of environmental guidelines.
- Appeals, penalties, offences by companies.
- Delegation of power and rule making power.

This act repeals the previous Environmental Pollution Control Ordinance, 1977 (Act XIII of 1977).

Land and Water Laws

The Bangladesh Land Holding Limitation Order, 1972
P.O. No. 98 of 1972

This order provides for a reduction of the maximum quantity of land that may be held by a family or a body. Land is defined so as to include land covered with water at any time of year. No body is allowed to retain any land in excess of 100 standard bighas (= 13 ha). GOB may relax this limitation for: 1) a cooperative society of farmers where the members thereof surrender their ownership in the lands unconditionally to the society and cultivate the land themselves, or 2) an industrial concern where such realisation is considered necessary in the public interest.

The Development Act, 1935

(Bengal Act XVI of 1935)

This act provides for collection of a levy from the benefited local public by the GOB for canal and river re-excavation works.

The Canals Act, 1986

(Bengal Act V of 1986)

This act provides for collection of tolls on canals and construction and improvement of navigation channel, including land expropriation and acquisition.

The Irrigation Act, 1876

Bengal Act III of 1876)

This act empowers GOB to construction irrigation works for agriculture. It prohibits interference with water supply flow, corrupting or fouling water of canals, cutting of flood-embankments, unauthorised opening, shutting or obstructing of sluices in embankments, or construction of dams or other obstructions for diverting or opposing the current of a river where flood-embankments are located.

The Tanks Improvement Act, 1939

(Bengal Act No. XV of 1939)

This acts allows for seizure and improvement of derelict tanks (= artificial reservoirs). It allows persons to catch fish in tanks after payment of rent or charge, and prohibits such without payment.

The Bangladesh Irrigation Water Rate Ordinance, 1983

Ordinance No. XXXI of 1983)

This ordinance, in addition to specifying rates for irrigation water supply, binds the owners or occupiers of land in a notified area to afford free passage for water through or over all lands in their possession, and allow construction and maintenance of such channels as may be necessary, provided flow due not exceed 2 cusecs. It also imposes a penalty for diversion of normal flow by an obstruction in the channel, and empowers the Deputy Commissioner to remove the obstruction.

The Embankment and Drainage Act, 1952

(Act I of 1953)

This act make better provisions for construction, maintenance, management, removal and control of embankments and water courses for better drainage of lands and for their protection from floods, erosion or other damage by water.

The Ground Water Management Ordinance, 1985

(Ordinance No. XXVII of 1985)

This ordinance specifies that tubewells can only be installed once licensed by the Thana Parishad. It requires that the condition of the aquifer be determined as well as other parameters, and that a local inquiry be held and a report be prepared. A licence would be granted if the tubewell would not have any adverse effect upon the surrounding area.

The Bangladesh Water and Power Development Boards Order, 1972

(P.O. No. 59 of 1972)

This order established the BWDB and defines its mandate.

Statute of the Indo-Bangladesh Joint Rivers Commission, 1972

This statute establishes the IBJRC and defines the work of the Commission.

Agricultural Laws

The Agricultural Pesticides Ordinance, 1971

(Ordinance No. II of 1971)

This ordinance regulates the importation, manufacture, formulation, sale, distribution and use of pesticides. [It does not include a list of banned pesticides.]

Laws of the Sea

The Territorial Water and Maritime Zones Act, 1974

(Act No. XXVI of 1974)

This act provides for declaration of territorial waters and maritime zones. It defines a contiguous zone which extends seaward from the territorial water for six nautical lines. It also empowers GOB to declare a high seas economic zone and conservation zones (the latter for purpose of maintenance of the productivity of living resources of the sea. The act allows the GOB to lay claim to the seabed and subsoil resources of the continental shelf, and take measures to control marine pollution and preserve the quality and ecological balance of the marine environment in the high seas adjacent to the territorial waters.

The Territorial Waters and Maritime Zones Rules, 1977

These regulations provide for:

- Regulation of conduct of foreign ships in the territorial waters;
- Construction of installations, artificial islands and other structures or carrying on scientific research, conservation of marine environment, pollution control, and other economic exploitation or exploration activities by the GOB in the economic zone;
- Regulation of conduct of persons in the economic zone;
- Reservation of certain areas in the economic zone for the purpose of exploration, exploitation and economic development;
- Regulation of fishing vessels in the economic zone;
- Prohibition of dynamiting and poisoning in the economic zone;

- Declaration of closed fishing seasons;
- Powers to stop and search vessels;
- Application of customs and fiscal laws to the economic zone;
- Punishment for contravention of rules.

Forest and Wildlife Laws

The Forest Act, 1927

(Act No. XVI of 1927)

This act confers comprehensive powers to the GOB to manage, conservation and regulate exploitation of forests.

The Private Forests Ordinance, 1959

(Ordinance No. XXXIV of 1959)

This act provides for conservation of private forests and for afforestation of waste lands.

Bangladesh Wild Life (Preservation) Order, 1973

(P.O. No.23 of 1973)

This order refers to wildlife but specifically excludes fish. It includes lists of:

- Crustaceans, amphibians, reptiles, birds and mammals of Bangladesh which are open to shooting and may be hunted on an ordinary game hunting permit (First Schedule, Part I), including the crab *Brachyura*, three species of frog, and four species of turtle.
- Wild animals, trophies or meat for the possession, transfer or import of which a certificate of lawful possession is required (Second Schedule), including skins of otter and crocodile.
- Protected animals ie animals which shall not be hunted, killed or captured (Third Schedule), including common dolphin, little Indian porpoise, gangetic dolphin, garial, estuarine crocodile and marsh crocodile. A large number of aquatic birds are listed including raptors.

A.2 Impact on Sustainability of Fisheries

The fisheries and environmental laws of Bangladesh in most respects reflect conventional approaches to protecting the fisheries resources and the surrounding environment. This approach designates a central authority (ie GOB) as the agent responsible and capable of managing fisheries and ensuring their sustainability. Thus, the various acts and ordinances confer policing and enforcement functions on the GOB, particularly how, where and when fish may be caught.

The widespread overexploitation of openwater fisheries through improper fishing practices, and decline in stock abundance due to environmental degradation in Bangladesh are clear symptoms of management failure. At least a part of this failure derives from the nature and intent of fisheries and environmental legislation.

Beels are not recognised as water bodies, but treated as areas of land which (inconveniently) happen to have water on them. Thus they have no legal status and are not protected by law. As a result beels can be drained without restriction. Baors are similarly disadvantaged.

A.3 Provision of Access to Fisheries Sectors

The fisheries laws provide access to fisheries resources for fishermen and for private fisheries investors. The latter are particularly favoured in inland fisheries under the *jalmohal* leasing system. The laws clearly identify the requirements for access to public or khas fisheries (payment of lease or license fee) and private fisheries (permission of owner). Moreover it gives subsistence fishermen and fisherwomen the right to angle in any navigable river.

The *jalmohal* leasing system however clearly discriminates against genuine fishermen, as the majority are unable to raise sufficient capital to pay the high lease fees specified by GOB. *Jalmohal* leases are routinely won by capital investors.

Because of the increasingly intense pressure on fisheries and other natural resources from all sections of the rapidly expanding population of Bangladesh, competition and conflict between different income groups and interest groups is escalating. Although fisheries and environmental laws are theoretically equity neutral, in practice they act to support the activities and intentions of the highest income groups (fisheries capital investors who are colloquially known as *jalmohal* leaseholders). The laws are thus regressive in an economic sense.

The failure of fisheries and environmental laws to protect low income groups has led to the adoption of an unfortunate political position among many NGOs that may be summarised as follows:

- Poor people are fully justified to take whatever steps necessary to derive a living from fish and other natural resources, even if it results in resource overexploitation and extinction, and even if it is in contravention of existing laws.
- Fisheries is to be regarded as a welfare sector that anyone who becomes poor enough has an automatic right to enter and eke out a living. Security of tenure and professionalism in the fisheries sector is in conflict with a philosophy of open access and therefore must be resisted. [Similar thinking is however not applied to rice farming, as it would no doubt be violently resisted by farmers.]

- GOB should continue to retain ownership and continue to extract tax from fisheries resources, as it is naively hoped that a future GOB would be more amenable to implementing the activities that NGOs would like. If fisheries resources are sold to fishermen (ie the private sector), NGOs would lose the possibility of exerting power over these resources. [State ownership is consistent with socialist philosophies that have been discredited the world over but curiously continue to survive among Bangladesh NGOs.]
- Most development projects (such as FCDI embankments, shrimp farms, floodplain stocking, fishpasses, fish processing for export) are not in the interests of low income groups and therefore are to be resisted at all costs.

The above approach will inevitably result in more resource depletion, more poverty and blockage of potentially effective mitigation interventions and development progress. Moreover a lack of technical and scientific expertise and knowledge is particularly rampant among many NGOs, who are in the habit of acquiring highly destructive "overnight expertise" in virtually any field. Lacking real content, arguments descend to the level of debate and clever machination - ultimately to the detriment of the low income groups that NGOs purport to represent or show concern for.

From an economic perspective, the exploitation of fisheries and other natural resources of Bangladesh would appear to be in a state of Pareto equilibrium (ie no one can increase their own benefits without having a negative impact on someone else's status). This may not be entirely correct due to the massive economic distortions that are caused by improper GOB ownership of natural resources (jalmohals and land) and interference with production and marketing. Nonetheless, the provisions of the fisheries and environmental laws has resulted in a state of virtual lawlessness in the fisheries and environmental sectors.

B. EXISTING ENFORCEMENT CAPACITY

(to be completed)

B.1 Institutional and Non-Institutional Enforcement Capacity

Institutional enforcement of fishery laws rests largely with the DOF. The enforcement capacity of the DOF is minimal, with no cadre of trained and equipped fish guards in existence.

The police or the army are rarely active in enforcing fisheries laws or intervening in conflicts.

The recently formed Bangladesh Coast Guard (BCG) will include in its mandate enforcement of fisheries laws and protection of fishermen from dacoity. BCG currently has two large patrol vessels, and will add another five in the next few years.

Non-institutional enforcement capacity (in the form of fishguards, *paharadar*) is contracted by jalmohal leaseholders. There are numerous such private fish guards throughout Bangladesh. Most are thugs, thieves and mercenaries who routinely threaten and abuse fishermen. Few are properly trained.

B.2 Impact on Sustainability of Fisheries

The impact on sustainability of institutional enforcement is almost non-existent. Fisheries and environment laws are routinely flouted throughout the country. Few arrests are made by the police for sale or use of current jal, fishing with poisons or failure to drain polders after shrimp growing leases expire.

Non-institutional enforcement reduces fishing mortality from unauthorised fishing effort in private and leased waters. However, the marginal gain in survival is usually eroded when the owner or leaseholder carries out jalmohal dewatering and complete harvesting.

B.3 Provision of Access to Fisheries Sectors

Institutional enforcement generally supports the rights of jalmohal leaseholders to exclude unauthorised fishing. In most cases however, this exclusion is actually enforced by privately-contracted fish guards. This has resulted in some extremely violent confrontations in the past, and will likely continue in the future until the practice is eradicated.

C. RECOMMENDATIONS FOR IMPROVEMENTS AND ADDITIONAL REGULATIONS

(to be completed)

C.1 Main Deficiencies of Existing Laws and Regulations

The main deficit of fisheries and environmental laws is that they do not specify, allocate or protect any roles, rights or responsibilities for genuine fishermen and fisherwomen in the management of fisheries, or in the management of fisheries environments. They also do not recognise the legal status of water bodies such as beel and baors, or specifically protect them from encroachment.

C.2 Recommended New Legal Instruments

It is recommended that a Community-based Fisheries Management Law be promulgated. This law should allocate access or ownership of fisheries resources, as well as fisheries environments as appropriate, to genuine fishing communities, and define management responsibilities. It should also specifically prevent and outlaw access or ownership by individuals or by capital investors (ie previous jalmohal leaseholders and moneylenders), but should at the same time guarantee subsistence fishing rights to individuals using low productivity gears in marginal fishing areas.

It is also recommended that a Wetland Conservation Law be promulgated. This law should protect beels and baors.

A new regulations should be promulgated by GOB which specify a complete ban on the use of pesticides to treat or preserve fish, especially dry fish.

IV. LINKAGES TO OTHER ENVIRONMENTAL PROJECTS

A. COASTAL WETLAND BIODIVERSITY MANAGMENT PROJECT (UNDP)

(to be completed)

A.1 Project Objectives and Components

This project aims to conserve biodiversity, including aquatic plants and animals, in the coastal region, with special focus on the Sunderban area.

A.2 Possible Complementary Activities

The main areas for collaboration are in protection of mangroves, and in reduction of fishing pressure on larvae and broodstock of fish and shrimp.

B. BIODIVERSITY CONSERVATION IN THE SUNDERBANS PROJECT (ADB)

B.1 Project Objectives and Components

This project aims to establish conservation systems in the Sunderban, while developing eco-tourism. It will institute a 30 km buffer zone around the Sunderban and develop alternative employment for local residents that have been displaced.

B.2 Possible Complementary Activities

The main areas for collaboration are in protection of mangroves, and possible development of sport fishing (catch and release) for *bekti* (*Lates calcarifer*) in the mangrove creeks.

C. SMALL SCALE WATER RESOURCES DEVELOPMENT SECTOR PROJECT (ADB, IFAD, GON)

C.1 Project Objectives and Components

This project is executed by LGED and aims to construct various small scale civil engineering works some of which could benefit fisheries. These include canal re-excavation, rubber dams (to create dry season water reservoirs in rivers), refuge duars, and small fishpasses.

C.2 Possible Complementary Activities

This project could undertake some of the canal re-excavation works proposed. LGED is responsible for about 80% of all canal re-excavations carried out in Bangladesh. Moreover LGED is active in promoting community-implemented O&M through Water Management Cooperative Associations (which have legal status). There are also opportunities for collaboration in fish sanctuary establishment and fishpass construction.

D. SUNDERBAN WORLD HERITAGE SITE PROJECT (UNESCO)

D.1 Project Objectives and Components

This project will declare the Sunderban as a World Heritage Site. It will provide funds to develop eco-tourism in the area.

D.2 Possible Complementary Activities

The main areas for collaboration are in protection of fish stocks, and possible development of sport fishing (catch and release) for *bekti* (*Lates calcarifer*) in the mangrove creeks.

E. INSTITUTIONAL SUPPORT TO DEPARTMENT OF ENVIRONMENT (CIDA)

E.1 Project Objectives and Components

This project aims to assist the DOE in institutional strengthening and development of programmes.

E.2 Possible Complementary Activities

The main areas for collaboration are in improvement of DOE policy and program related to fisheries, including the development of EIA guidelines for fisheries development projects.

F. NORTHEAST REGIONAL WATER MANAGEMENT PROJECT (CIDA)

F.1 Project Objectives and Components

This project has prepared a regional water management plan as a component of the Flood Action Plan. It has also constructed a pilot vertical slot fishpass at the Manu River FCDI project.

F.2 Possible Complementary Activities

The main area for collaboration are in termination of the jalmohal leases inside the Kawadighi Haor/Manu River FCDI project area, and implementation of the proposed pilot community-owned fisheries component. The CIDA fishpass project was intended to test the vertical slot fishpass as a mitigation measure for fish migration. This has been successful, but full realisation of benefits to the genuine fishing communities will require a major change in the fisheries management system (access and tenure)

APPENDICES

APPENDIX A: RECORD OF PERSONS MET

GOB

- Amin Uddin Choudhury, Rtd Divisonal Commissioner
- District Commissioner for Satkhira

MOFL

- Ayub Quadri, Secretary
- Syed Golam Kibria, Joint Secretary
- Azizul Huq, Joint Chief

DOF

- Md Liaquat Ali, Director General
- Masudur Rahman, Director (Marine)
- Nasir Uddin Ahmed, Director (Inland) and Project Director
- Tabibur Rahman, Deputy Director, Khulna Division
- Rezaul Karim, DFO, Khulna
- Swapan Kumar, DFO, Bagerhat
- K Habibur Rahman, TFO, Satkhira
- Yabub, TFO Paikgaacha
- Manmatha Nath Sarker, O-I-C, Marine Fisheries Survey Management Unit, Cox's Bazar
- Rakhal Chandra Kangsa Banik, SSO, Dhaka

FRI

- Md Salahuddin, PSO, Brackishwater Station, Paikgaacha
- Munirul Islam, RO, Brackishwater Station, Paikgaacha
- Gitali, RO, Brackishwater Station, Paikgaacha
- A K Yousuf Haroon, PSO, Riverine Station, Chandpur

NGOs

- Kushi Kabir, Executive Director, Nijera Kori, and Chairperson of Coalition of Environmental NGOs, Dhaka
- Greg Chapman, CARE, Dhaka
- Saleemul Huq, Bangladesh Centre for Advanced Studies, Dhaka
- Mohammad Ikramullah, Chairperson, PRISM Bangladesh, Dhaka
- Kazi Ali Toufique, Research Fellow, Bangladesh Institute of Development Studies, Dhaka
- Anwara Sheely, CARITAS, Dhaka
- Ferdooz, PRODIPAN, Dhaka
- A Rahman, Proshika, Dhaka

Private Sector Producers

- Afta Buzzaman, Secretary-General, Bangladesh Frozen Food Exporters Association, Dhaka
- Md Akhtar Ruzzaman, Carp hatchery owner, Dhaka (and MP)
- S Atiar Rahman, Prawn farmer, Dumuria
- Md Yunus Ali, Prawn farmer, Dumuria
- Shah Alam, Prawn farmer, Batiaghata
- M Shahjahan, Prawn farmer, Rupsa
- Maniklal, Prawn farmer, Phultola
- Shaibpada Acharya, Shrimp farmer, Kaliganj
- Jahurul Huq, Shrimp farmer, Shgamnagar
- Zahiruddin Mahmood, Pioneer Hatchery, Cox's Bazar
- Lufur Rahman, Niribili Hatchery, Cox's Bazar
- Mojam Ali, Shrimp seed collector, Paikgaacha
- Shajat Ali, Shrimp seed collector, Paikgaacha
- Young Tian, General Manger, United Food Import Corp., Norwalk, CT, USA
- Bob Tsai, President, Tsai Orient Products Corp, Taiwan

International Agencies

- Benson Ateng, World Bank, Washington
- Ronald Zweig, World Bank, Washington
- Imtiazuddin Ahmad, World Bank, Dhaka

FOURTH FISHERIES PROJECT PREPARATION Annex 9: Environmental Assessment

- Robert Robelus, World Bank, Washington
- Carter Brandon, World Bank, Washington

APPENDIX B: BIBLIOGRAPHIC REFERENCES

- ADB 1986. Bangladesh second aquaculture development project preparation report, final report. Prepared for Government of the People's Republic of Bangladesh and the Asian Development Bank. Aquatic Farms, Honolulu, February 1986.
- ADB 1997. Project completion report on the Second Aquaculture Development Project (loan no 821-BAN[SF]) in the People's Republic of Bangladesh. Asian Development Bank, PCR: BAN 16090.
- Adnan, S 1991. Floods, people and the environment - institutional aspects of flood protection programmes in Bangladesh, 1990. Research & Advisory Services, Dhaka, July 1991.
- Alam, M K, M Mohiuddin and M K Guha 1991. Trees for lowlying areas of Bangladesh. Bangladesh Forest Research Institute, Chittagong.
- Ali, M Youssouf 1991. National conservation strategy of Bangladesh, towards sustainable development: fisheries resources of Bangladesh. International Union for Conservation of Nature and Natural Resources - The World Conservation Union, Ministry of Environment and Forest, and National Conservation Strategy Secretariat, Bangladesh Agricultural Research Council, Dhaka. 96 pp.
- Ali, M Youssouf 1997. Fish, water and people - reflections on inland openwater fisheries resources of Bangladesh. University Press Ltd, Dhaka.
- Ali, Md L and Md Z Islam 1997. An assessment of the economic benefits from stocking seasonal floodplains in Bangladesh. Third Fisheries Project, DOF, Dhaka.
- Chaffey, D R, F R Miller and J H Sandom 1985. A forest inventory of the Sunderbans, Bangladesh, main report. Overseas Development Administration, Land Resources Development Centre, Suurey, England. Project Report 140.
- Clay, C H 1995. Design of fishways and other fish facilities, 2nd edition. Lewis Publishers, Boca Raton.
- Crow, B, A Lindquist and D Wilson 1997. Sharing the Ganges - the politics and technology of river devilmnt. University Press Ltd, Dhaka.
- DOE 1993. Water quality data of rivers Buriganga, Meghna, Balu, Sitalakhya, Jamuna (1981-90). Department of Environment, Dhaka, August 1993.

- DOF 1986. Fisheries information bulletin, vol 3, no 1, water area statistics of Bangladesh. Department of Fisheries, Fisheries Resources Survey System, December 1986, Dhaka.
- DOF 1997. Brief on Department of Fisheries and fisheries sector of Bangladesh, at a glance. DOF, Dhaka.
- DOF 1997a. Long-term perspective plan for development of fisheries. DOF, Dhaka.
- Dorcey, T A Steiner, M Acreman and B Orlando (editors) 1997. Large dams, learning from the past, looking at the future. Workshop proceedings, Gland, Switzerland April 11-12, 1997. IUCN and World Bank.
- FAO/UNDP 1992. Fisheries sector program TSS-1, draft report. FAO/UNDP, Dhaka.
- FAP 1992. Guidelines for environmental impact assessment (EIA). Flood Plan Coordination Organisation, The People's Republic of Bangladesh, Ministry of Irrigation, Water Development and Flood Control. October 1992.
- FAP 1995. Summary report, based on studies carried out under the Flood Action Plan. Main report and annexures. Flood Plan Coordination Organisation, The People's Republic of Bangladesh, Ministry of Water Resources. December 1995.
- FAP 16 1995. Manual for environmental impact assessment. Prepared by Environmental Study FAP 16, ISPAN Irrigation Support Project for Asia and the Near East, USAID, Bangladesh Flood Action Plan, Ministry of Water Resources, Dhaka, April 1995.
- FAP 17 1994. Fisheries studies and pilot project, final report (draft), main volume. Overseas development Administration, UK. June 1994, Dhaka.
- FAP 17 1994. Fisheries studies and pilot project, final report (draft), supporting volume No. 8, fisheries study, Manu irrigation project and Hakaluki Haor. Overseas development Administration, UK. June 1994, Dhaka.
- Farooque, M and S R Hasan 1996. Laws regulating environment in Bangladesh. Bangladesh Environmental Lawyers Association (BELA), Dhaka.
- FRI 1997. Bangladesh Fisheries Research Institute at a glance. FRI, Mymensingh.
- Global Aquatic 1997. Large dam fisheries of the lower Mekong countries, review and assessment. Main report, 151 p, and Database 220 p. Management of Reservoir Fisheries in the Mekong Basin Project, Prepared for Mekong River Commission, Bangkok, by Garry M Bernacsek, Global Aquatic Corporation Pty Ltd, Sydney.

- Global Aquatic 1997a. Review of impacts of irrigation projects on the fisheries sector. Agriculture and Irrigation Programme, Prepared for Mekong River Commission, Bangkok, by Garry M Bernacsek, Global Aquatic Corporation Pty Ltd, Sydney.
- GOB 1996. Bangladesh economic review 1996. Government of the People's Republic of Bangladesh, Economic Division, Ministry of Finance, Economic Adviser's Wing. August 1996, Dhaka.
- Haggart, K (editor) 1994. Rivers of life - Bangladeshi journalists take a critical look at the Flood Action Plan. Bangladesh Centre for Advanced Studies, Dhaka.
- Hempel, E and U Winther 1997. Shrimp farming and the environment, final report. KPMG Center for Aquaculture and Fisheries, World Bank. June 1997.
- Hettige, M and C Brandon 1997. Industrial pollution in Bangladesh: a detailed analysis. Workshop discussion draft. World Bank, May 1997, Dhaka.
- Hill, M and D Deppert 1994. Bangladesh flood action plan report, 1994, fisheries. Bangladesh Action Plan for Flood Control, Don Chapman Consultants, Inc, Dhaka.
- Hossain, Md S, Md A Ehshan and S Rahman 1996. Study on fish biodiversity of floodplains. Fisheries Research Institute, Third Fisheries Project, Dhaka, November 1996.
- Hughes, R, S Adnan and B Dalal-Clayton 1994. Floodplains or flood plans? A review of approaches to water management in Bangladesh. International Institute of Environment and Development, Research and Advisory Services, Dhaka.
- Imam, Md A (undated). Towards a national policy on security of tenure and lease fee for open water fisheries. Oxbow Lakes Project II, Dhaka.
- Katopodis, C 1992. Introduction to fishway design. Department of Fisheries and Oceans, Government of Canada. January 1992.
- Khan, M S, E Haq, S Hug, A A Rahman, S M A Rashid and H Ahmed (editors) 1994. Wetlands of Bangladesh. Bangladesh Center for Advanced Studies, Nature Conservation Movement, Dhaka.
- Khan, Md A R 1985. Mammals of Bangladesh, a field guide. Dhaka.
- Khan, Y S A 1994. Report on the environmental study of lotic (Meghna River) and lentic (Hamil Beel) water bodies of Bangladesh. Improved Management of Open Water Fisheries (Phase II), DOF, Dhaka.
- Khan, Y S A and Md S Hossain 1996. Impact of shrimp culture on the coastal environment of Bangladesh. *Int. J. Ecology and Environ Sci* 22:145-158.

- Khan, Y S A and A B Md A Talukder 1993. Pollution in coastal waters of Bangladesh. J. NOAMI, 10(1):1-11.
- Middendorp, H A J, Md R Hasan and N A Apu 1996. Community fisheries management of freshwater lakes in Bangladesh. Naga, April 1996: 4-8.
- MOFL 1997. National workshop on fisheries resources development and management in Bangladesh, Dhaka, 29 October - 1 November 1995. MOFL, FAO, BOBP and ODA. Bay of Bengal Programme for Fisheries Management, BOBP/REP/74, Madras, India.
- NERP 1994. Project monitoring programme, Manu River FCDI project (1992-94), draft final report. Flood Action Plan, Northeast Regional Water Management Project (FAP 6), Government of the People's Republic of Bangladesh, Bangladesh Water Development Board, Flood Plan Coordination Organisation, Shawinigan -Lavalin (1991) Inc., Northwest Hydraulic Consultants, Engineering and Planning Consultants Ltd., Bangladesh Engineering and Technological Services, Institute for Development Education and Action, Nature Conservation Movement and Canadian International Development Agency. November 1994, 72 pp + 10 appendices..
- NERP 1994a. Fisheries specialist study, Volume 1: Main report, and Volume 2: Appendices. Flood Action Plan, Northeast Regional Water Management Project (FAP 6), Government of the People's Republic of Bangladesh, Bangladesh Water Development Board, Flood Plan Coordination Organisation, SNC-Lavalin International, Northwest Hydraulic Consultants, Engineering and Planning Consultants Ltd., Bangladesh Engineering and Technological Services, and Canadian International Development Agency. December 1994, Vol 1, 301 pp, and Vol 2, 421 pp.
- NERP 1994b. Northeast region environment management, research and education project, pre-feasibility study, final report. Flood Action Plan, Northeast Regional Water Management Project (FAP 6), Government of the People's Republic of Bangladesh, Bangladesh Water Development Board, Flood Plan Coordination Organisation, SNC-Lavalin International, Northwest Hydraulic Consultants, Engineering and Planning Consultants Ltd., Bangladesh Engineering and Technological Services, and Canadian International Development Agency. December 1994.
- NERP 1995. Specialist study of wetland resources, final report. Flood Action Plan, Northeast Regional Water Management Project (FAP 6), Government of the People's Republic of Bangladesh, Bangladesh Water Development Board, Flood Plan Coordination Organisation, SNC-Lavalin International, Northwest Hydraulic Consultants, Engineering and Planning Consultants Ltd., Bangladesh Engineering and Technological Services, and Canadian International Development Agency. October 1995.
- NERP 1997. Fishpass pilot project, completion report. Flood Action Plan, Northeast Regional Water Management Project (FAP 6). Government of the People's Republic of Bangladesh.

Bangladesh Water Development Board, Flood Plan Coordination Organisation, SNC-Lavalin International, Northwest Hydraulic Consultants, Engineering and Planning Consultants Ltd., Bangladesh Engineering and Technological Services, and Canadian International Development Agency. December 1997.

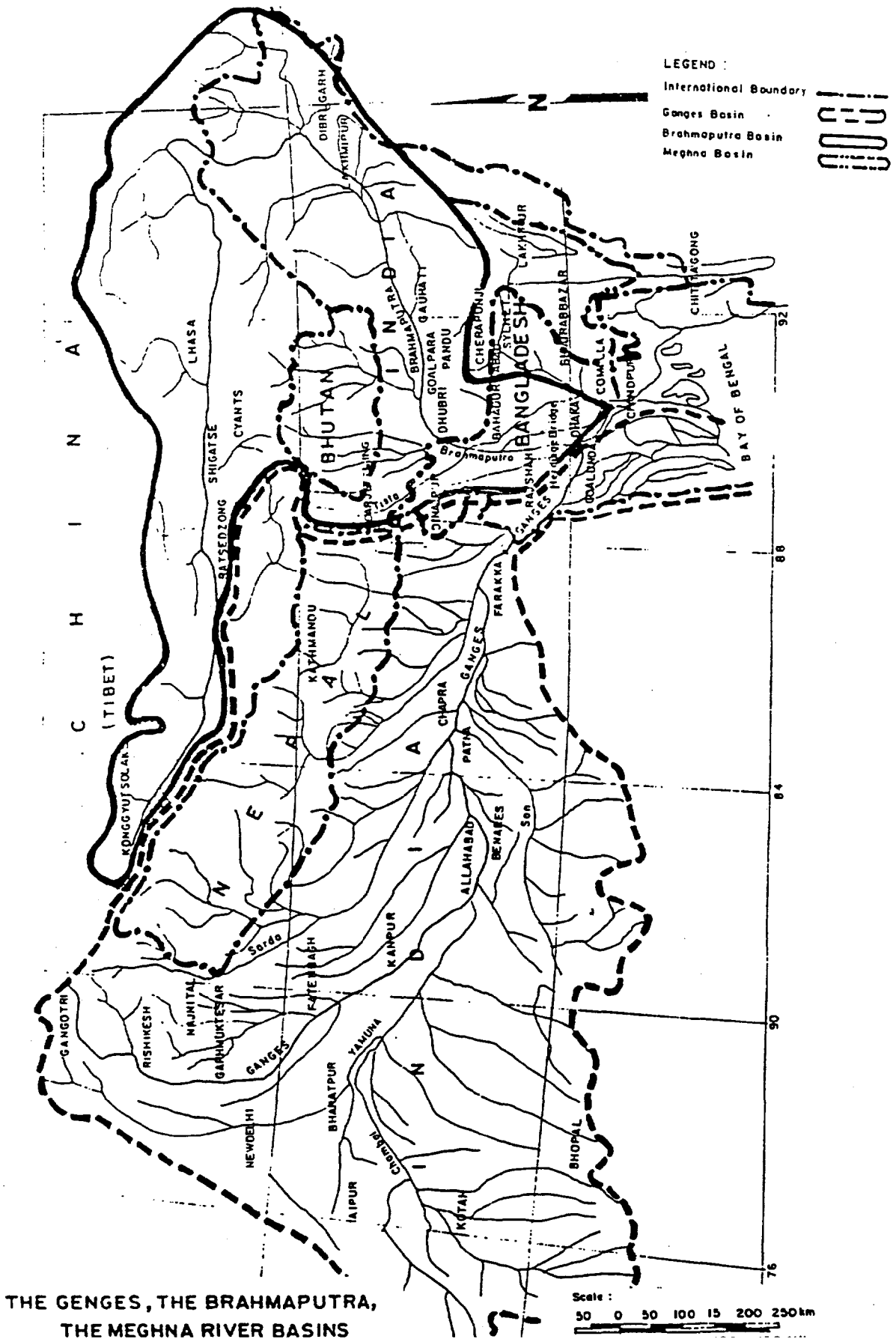
- Pavlov, D S 1989. Structures assisting the migrations of non-salmonid fish: USSR. FAO Fisheries Tech Pap: 308.
- Rahman, A 1995. Beel Dakatia, the environmental consequences of a development disaster. University Press Ltd, Dhaka.
- Rahman, A A, R Haider, S Huq and E G Jansen 1994. Environment and development in Bangladesh. Vols 1 and 2. University Press Ltd, Dhaka.
- Sarker, Md S U and N J Satker 1988. Wildlife of Bangladesh (a systematic list with status, distribution and habitat). Rico Printers, Dhaka.
- Tsai, C-f and Md Y Ali (editors) 1997. Openwater Fisheries of Bangladesh. University Press Ltd, Dhaka.
- United Nations 1989. Coastal environmental management plan for Bangladesh, Vol Two: Final Report. United Nations, Economic and Social Commission for Asia and the Pacific, Bangkok, Thailand.
- United Nations 1989. Coastal environmental management plan for Bangladesh, Vol Two: Final Report. United Nations, Economic and Social Commission for Asia and the Pacific, Bangkok, Thailand.
- World Bank 1990. Environmental assessment sourcebook, vol II, sectoral guidelines, Environment Department. World Bank Tech Pap 140.
- World Bank 1990a. Staff appraisal report, Bangladesh, Third Fisheries Project, May 2, 1990. World Bank, Agriculture Operations Division, Country Department I, Asia Region, Report No 8392-BD. World Bank, Washington, DC.
- World Bank 1992. Technical guidelines and strategic framework for applications of integrated coastal zone management. World Bank, Washington, DC. Draft September 1992.
- World Bank 1997. Bangladesh, annual economic update 1997, economic performance, policy issues and priorit reforms. World Bank, South Asia Region, October 1997.
- World Bank (undated). Implementation completion report, Bangladesh, Third Fisheries Project (Credit 2146-BD). World Bank, Dhaka.

FOURTH FISHERIES PROJECT PREPARATION Annex 9: Environmental Assessment

World Resources Institute 1990. Bangladesh: environment and natural resources assessment, final report. Prepared for USAID by WRI Center for International Development and Environment, Washington, DC, September 1990.

APPENDIX C: FIGURES

(to be completed)



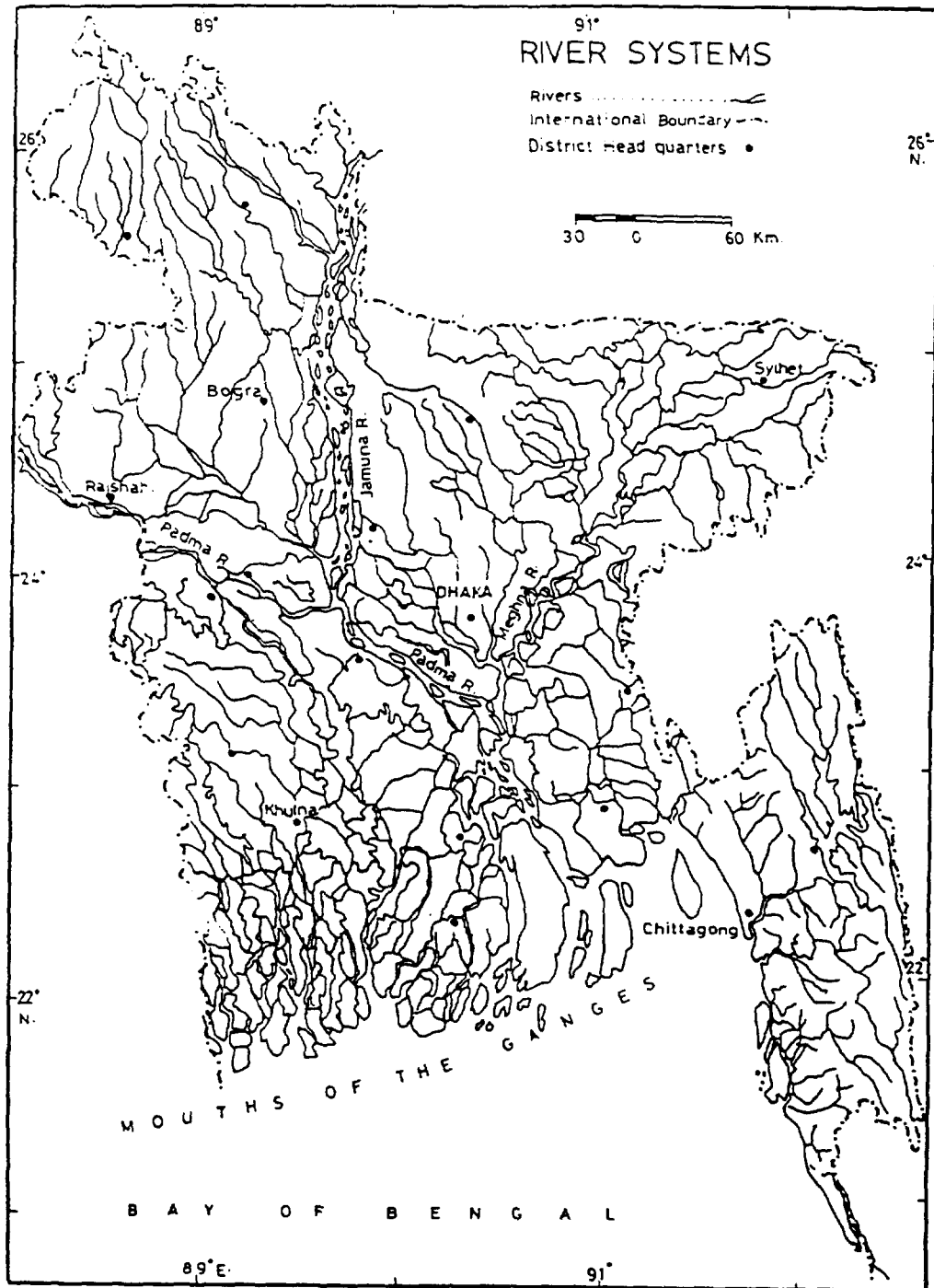
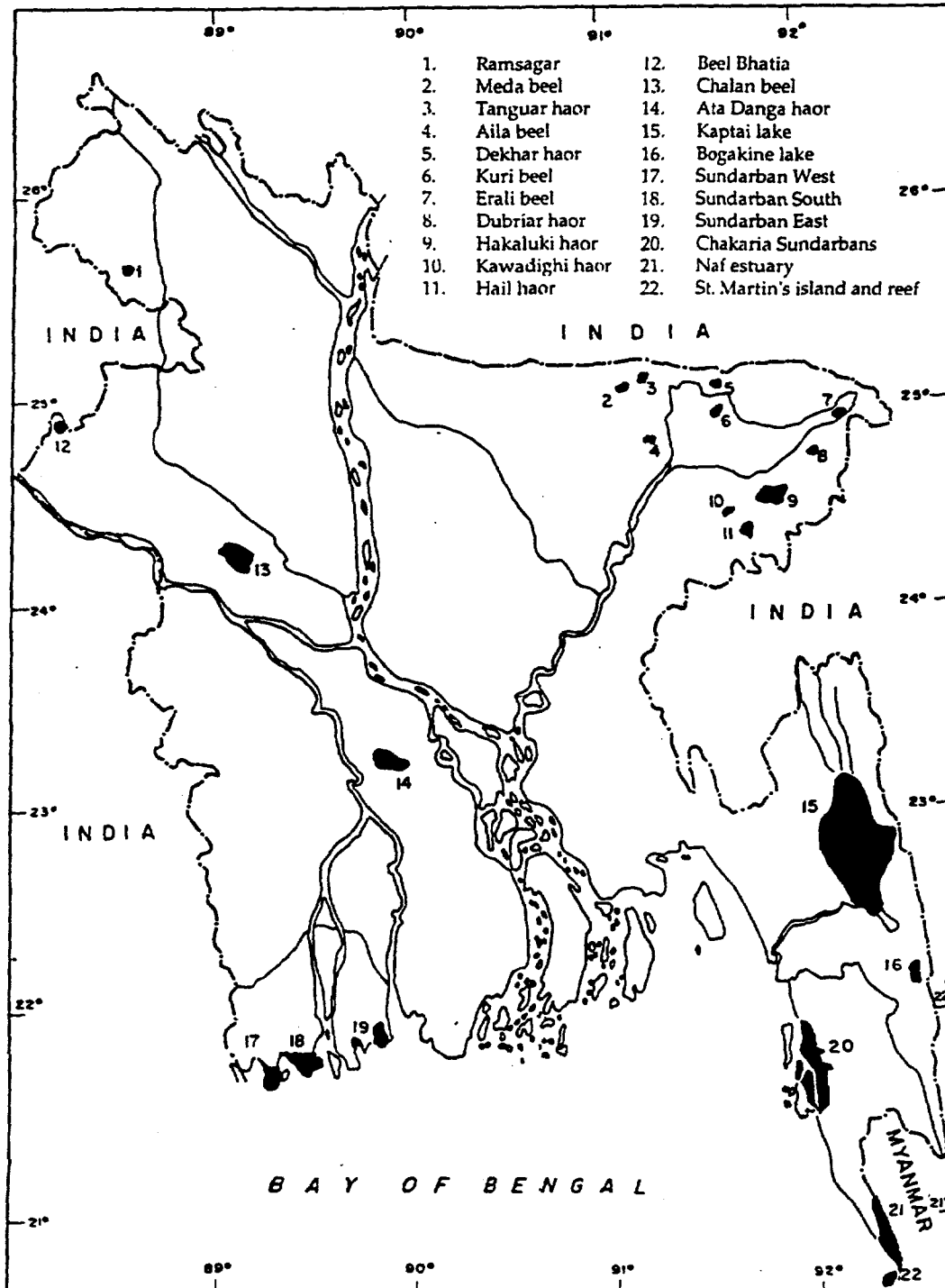


Fig. ● River systems of Bangladesh
 Source: Bangladesh in Maps, University of Dhaka, March 1981.

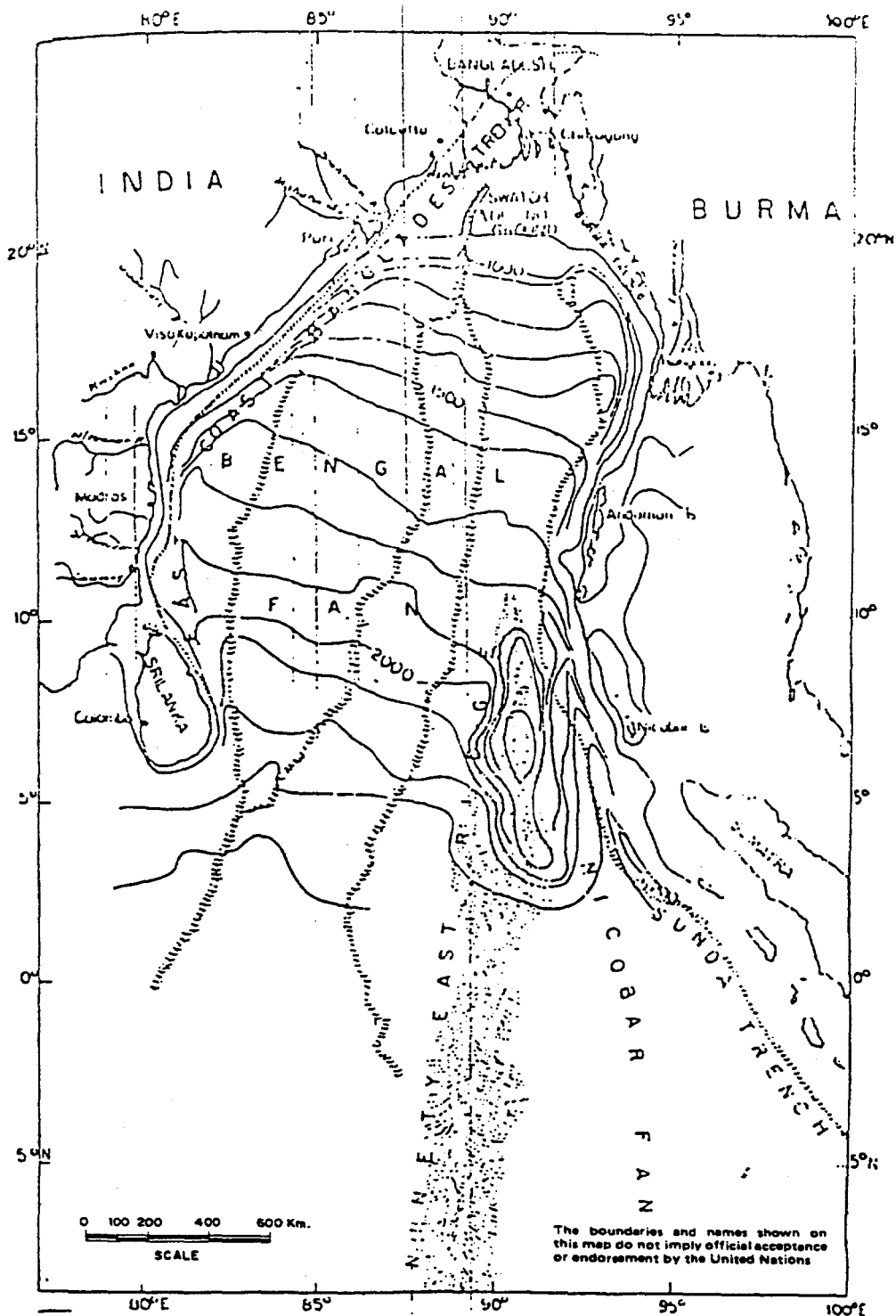
A. Ali (1991)

Figure 1 Major wetlands of Bangladesh



1 1 0 4 0 (1001)

Map 1 Overall depth configuration of the Bay of Bengal (modified after La Fond, 1957; Kibria, 1970; Curray and Moore, 1974; and Rahman, 1975) (depths in fathoms).



Map ● Current pattern of the Bay of Bengal (after Huh and others, 1985)



The boundaries and names shown on this map do not imply official acceptance or endorsement by the United Nations

Legend:

Western boundary current

Eddies and gyres

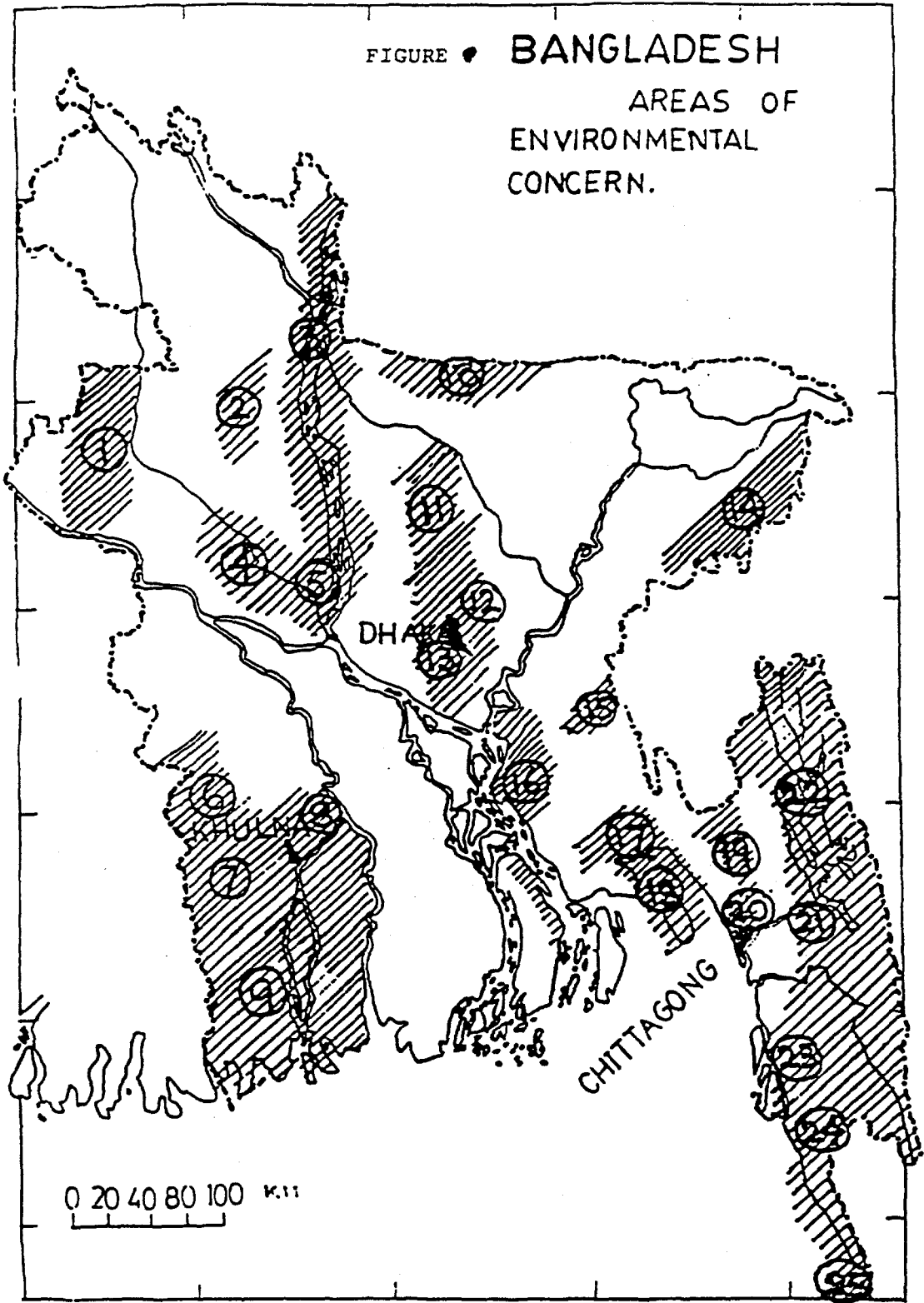
Persistent warm water zone, anomalous

Discharges, mouth of Ganges



from United Nations (1989)

FIGURE • BANGLADESH
AREAS OF
ENVIRONMENTAL
CONCERN.



Areas of Environmental Concern in Bangladesh

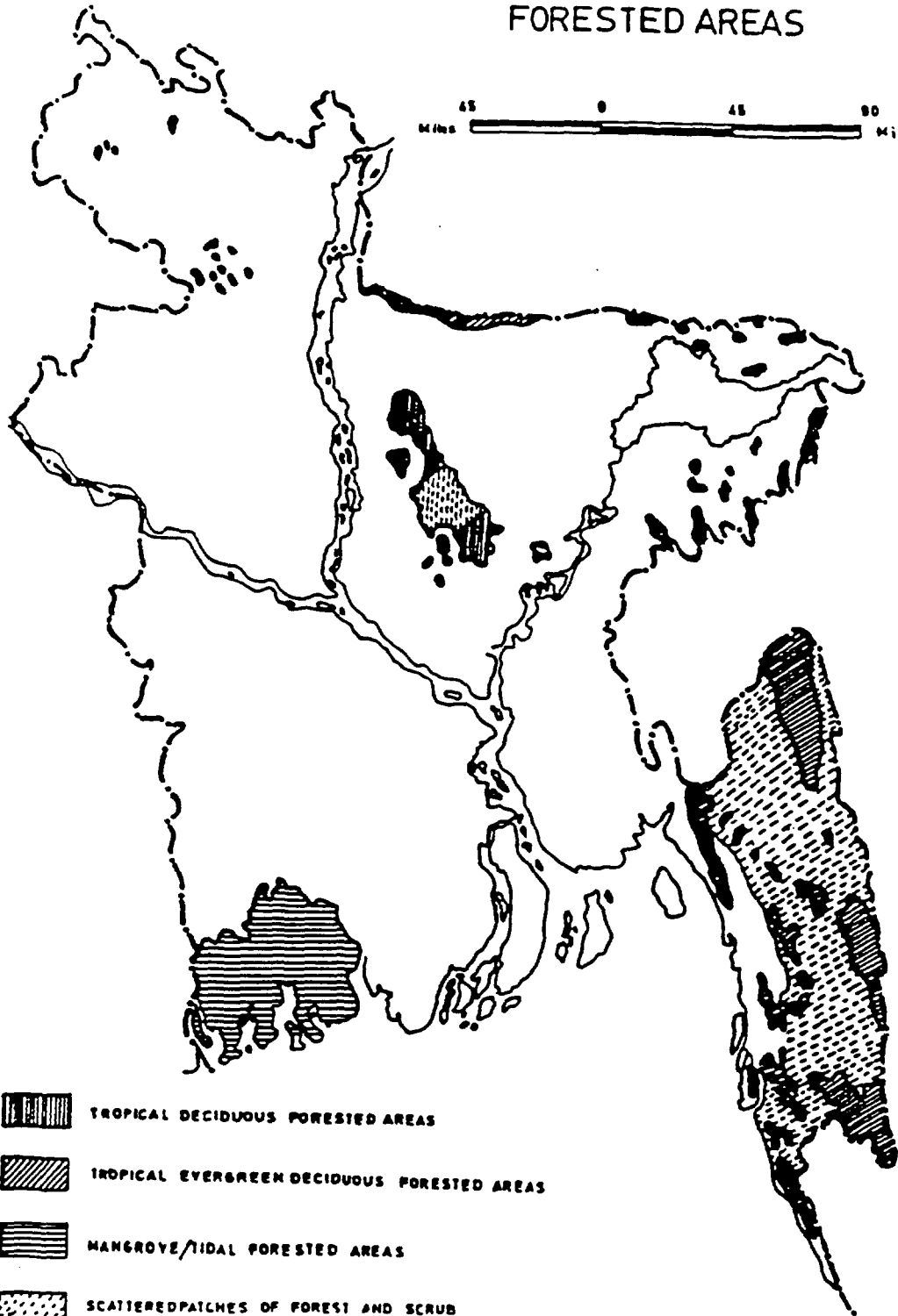
Legend

1. **West-Central Barind:** vulnerable to land desiccation through improper land-use. Low water-table, poor soils.
2. **Middle Karatoya floodplain:** Sulphur and zinc deficiencies in soils as a result of double-cropping of HYV Rice.
3. **Brahmaputra-Jamuna floodplain:** problems with Brahmaputra Right Bank embankment, which has breached 4 out of the last 5 years. Large population in the char-lands. Floods. Sand-deposit.
4. **Chalan Beel:** one of the richest wetland areas of Bangladesh, severely impacted by FCD/projects; need to re-assess polder development after 1987-1988 floods, and examine ways to combine agricultural production with fisheries production and wetland reserves.
5. **Atrai-Hurasagar drainage:** construction of embankments has impeded drainage and waterlogging has become a serious problem.
6. **South-west Jessore:** this area is vulnerable to low and variable rainfall and some soils are "droughty"; reduction in river flow from withdrawal at Farakka and irrigation uses has aggravated these natural conditions. Deep tube well irrigation in the south has drawn groundwater salinity inland.
7. **Northern Khulna:** large-scale shrimp farming has increased risk of salinization of soils, and competes with rice production.
8. **Khulna City and Mongla Town:** industrial pollution, oil spills from ships; urban congestion, etc.
9. **Sunderban:** increased salinity, increasing amounts of ship oil, industrial chemicals etc. has led to the top-dying of several species of trees. There has also been overcutting of the forest for industrial use.
10. **Garo Hills Piedmont:** erosion, flash floods, loss of agricultural productivity.
11. **Madhupur Tract:** deforestation and extensive degradation of remaining sal forests over the past 2 decades; improper use of sloping land leading to top soil erosion.
12. **Sitalakhya River:** industrial plants discharge toxic chemicals into this river: loss of fisheries and hazard for public health.
13. **Dhaka City:** industrial pollution; urban expansion destroying class 1 agricultural land.
14. **South Sylhet:** deforestation, flash floods, erosion.
15. **Gunti Basin:** flash floods.
16. **Lower Meghna:** floods, erosion, loss of fisheries. population pressure.
17. **Central Noakhali:** waterlogging in the wet season due to impeded drainage.
18. **Sandwip:** heavily populated island being eroded rapidly. Threat of natural hazards posed by non-consolidation of new alluvial land, and frequent cyclones and surges.
19. **Sitakunda Range:** deforestation, erosion, loss of productivity and major source of thatching grass; (urgently requires improved land use planning).
20. **Chittagong City and port:** industrial pollution, oil spills, cutting down of hill forests leading to increased erosion.
21. **Chandraghona:** industrial units discharge large quantities of chemicals into Karnafuli river, destroying fisheries and posing health hazard.
22. **Hill Tracts:** slash and burn cultivation and improper use of hill slopes has greatly increased erosion, and flooding of valleys and loss of productivity. Significant decline in tree-cover.
23. **Chakaria Sunderbans:** a forest area totally destroyed by fuelwood harvesting, cultivation and for use as shrimp farms. Shrimp yields are declining and soil acidity increasing.
24. **Cox's Bazar:** tropical moist forests with unique biodiversity being destroyed through conversion to plantations; heightened erosion and flood hazard from clear-felling and loss of forest cover.
25. **Jinjira Island and Reef (St. Martin's Island):** Coral reef being destroyed through overexploitation.

FIGURE ● BANGLADESH

LOCATION OF THE FORESTED AREAS

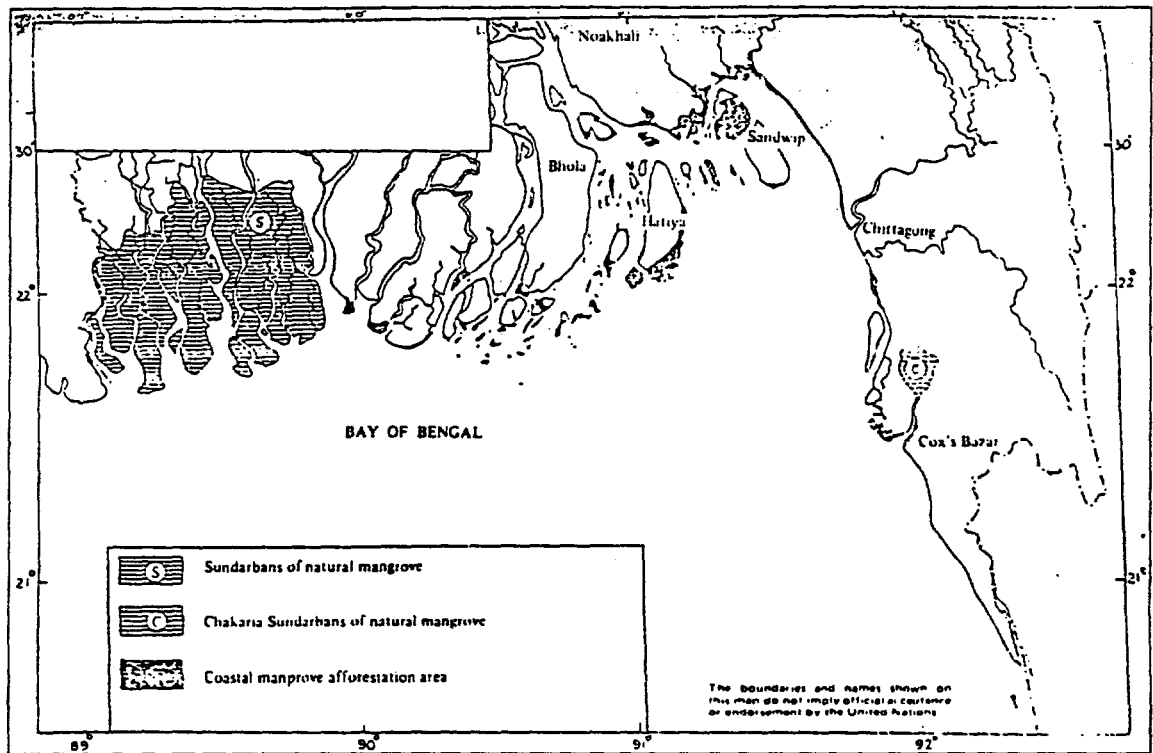
45 0 45 90 Miles



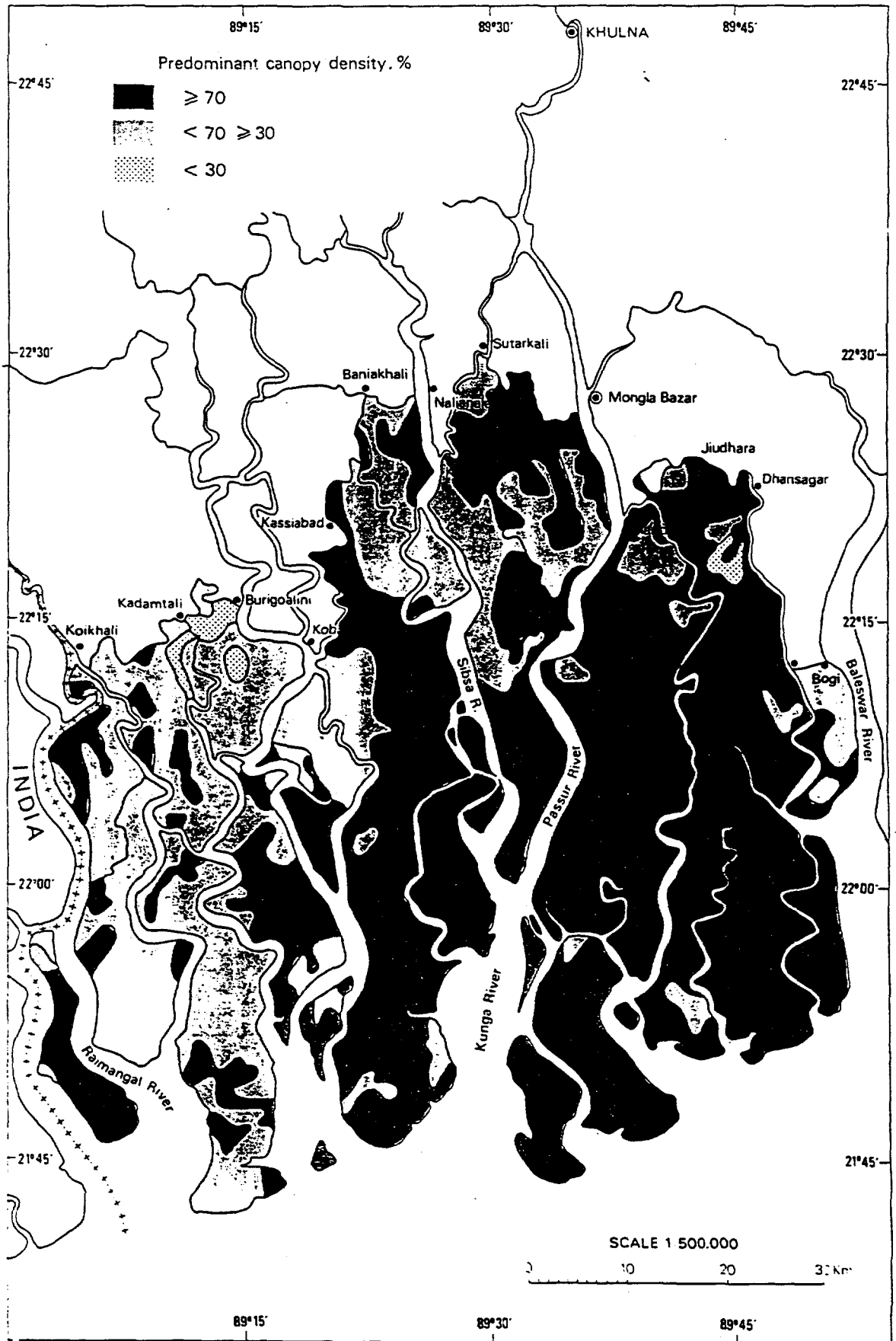
- TROPICAL DECIDUOUS FORESTED AREAS
- TROPICAL EVERGREEN DECIDUOUS FORESTED AREAS
- MANGROVE/TIDAL FORESTED AREAS
- SCATTERED PATCHES OF FOREST AND SCRUB

SCALE 1:2000000

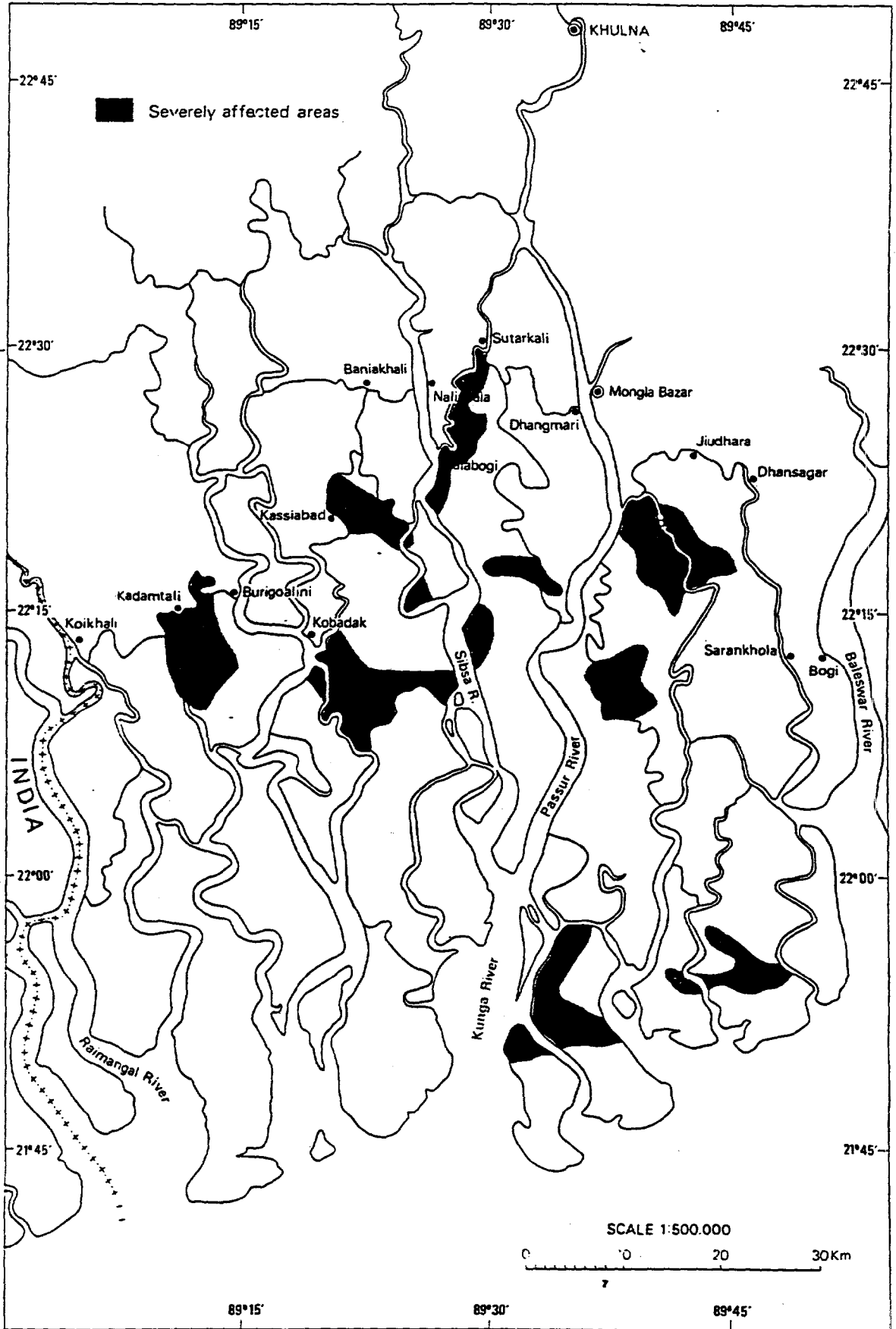
Map 1. Coastal area of Bangladesh showing the natural and planted mangroves



from United Nations (1989)



TEXT MAP ● Canopy density



POUSH
List of Notified and Proposed Protected Areas in Bangladesh
(Locations are Shown in Attached Map)

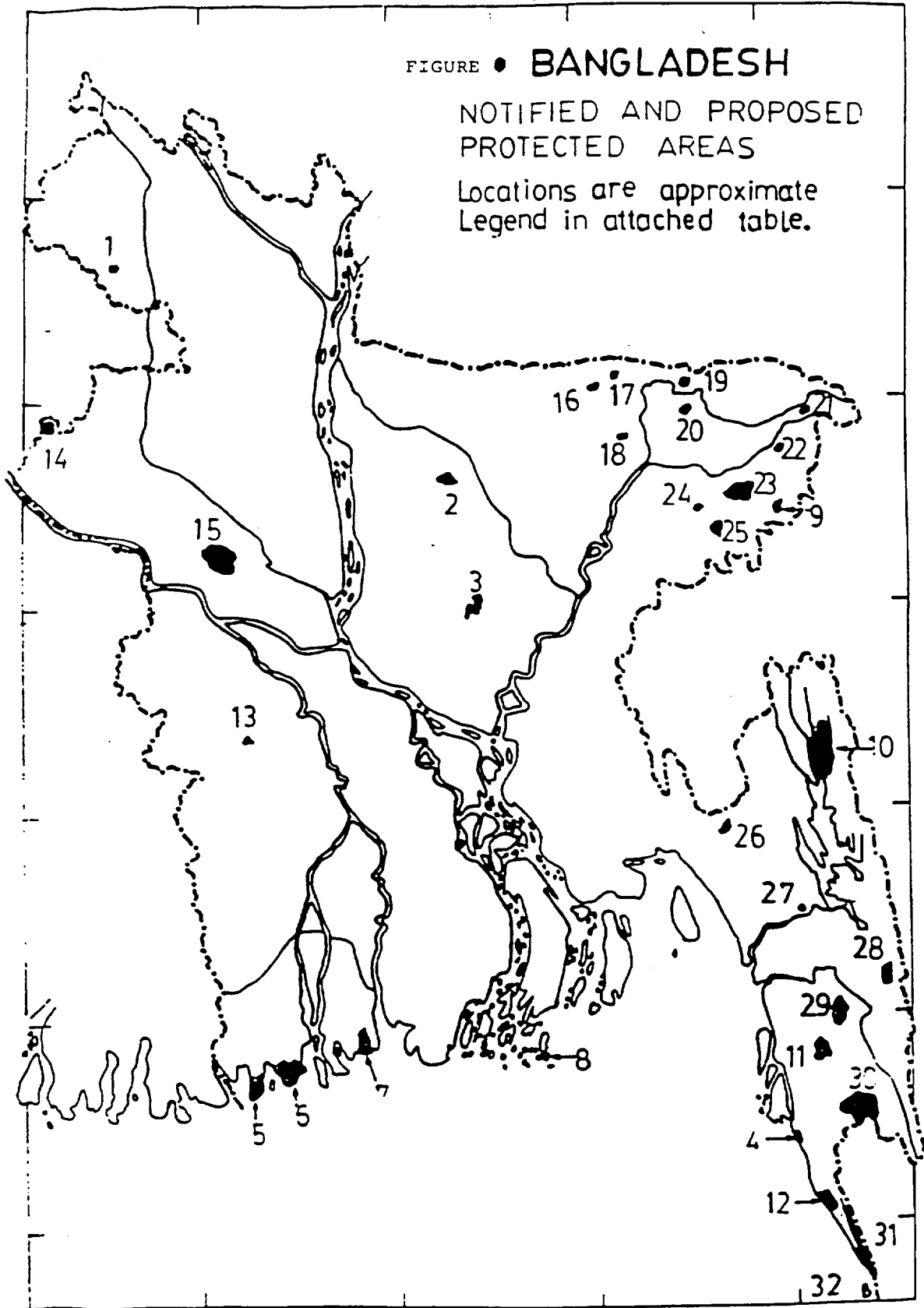
Name of Area	Area (hectares)	Year	Name of Area	Area (hectares)	Year
National Parks			Proposed Wildlife Sanctuaries		
1. Ramsagar NP	52	1974	13. Ata Danga Baor		
2. Madhupur NP	8,436	1987	14. Bil Bhatia		
3. Bhawal NP	5,022	1987	15. Chalan Beel		
4. Himchari NP	1,729	1980	16. Meda Beel		
Wildlife Sanctuaries			17. Tanguar Haor		
			18. Aila Beel		
5. Sundarbans West WS	9,069	1977	19. Dakhar Haor		
6. Sundarbans South WS	17,878	1977	20. Kuri Beel		
7. Sundarbans East WS	5,439	1977	21. Erali Beel		
8. Char Kukri-Mukri WS	40	1981	22. Dubriar Haor		
9. Rema Kalenga WS	1,095	1981	23. Hakaluki Haor		
10. Pablakhali WS	42,087	1981	24. Kawadighi Haor		
11. Chunati WS	7,761	1986	25. Hail Haor WS	(1,427)	
Game Reserves			26. Hazarikhil WS	(2,903)	
			27. Rampahar-Sitaphar WS	(3,026)	
12. Teknaf GR	11,615	1981	28. Bogakine Lake (Rinkheong)		
Note: List compiled by Haroun Er Rashid			29. Chimbuk		
			30. Sangu-Matamuhari		
			31. Naaf River		
			32. Jinjiradwip (St. Martin's Island) and Jinjira Recfs		

from World Resources Institute (1990)

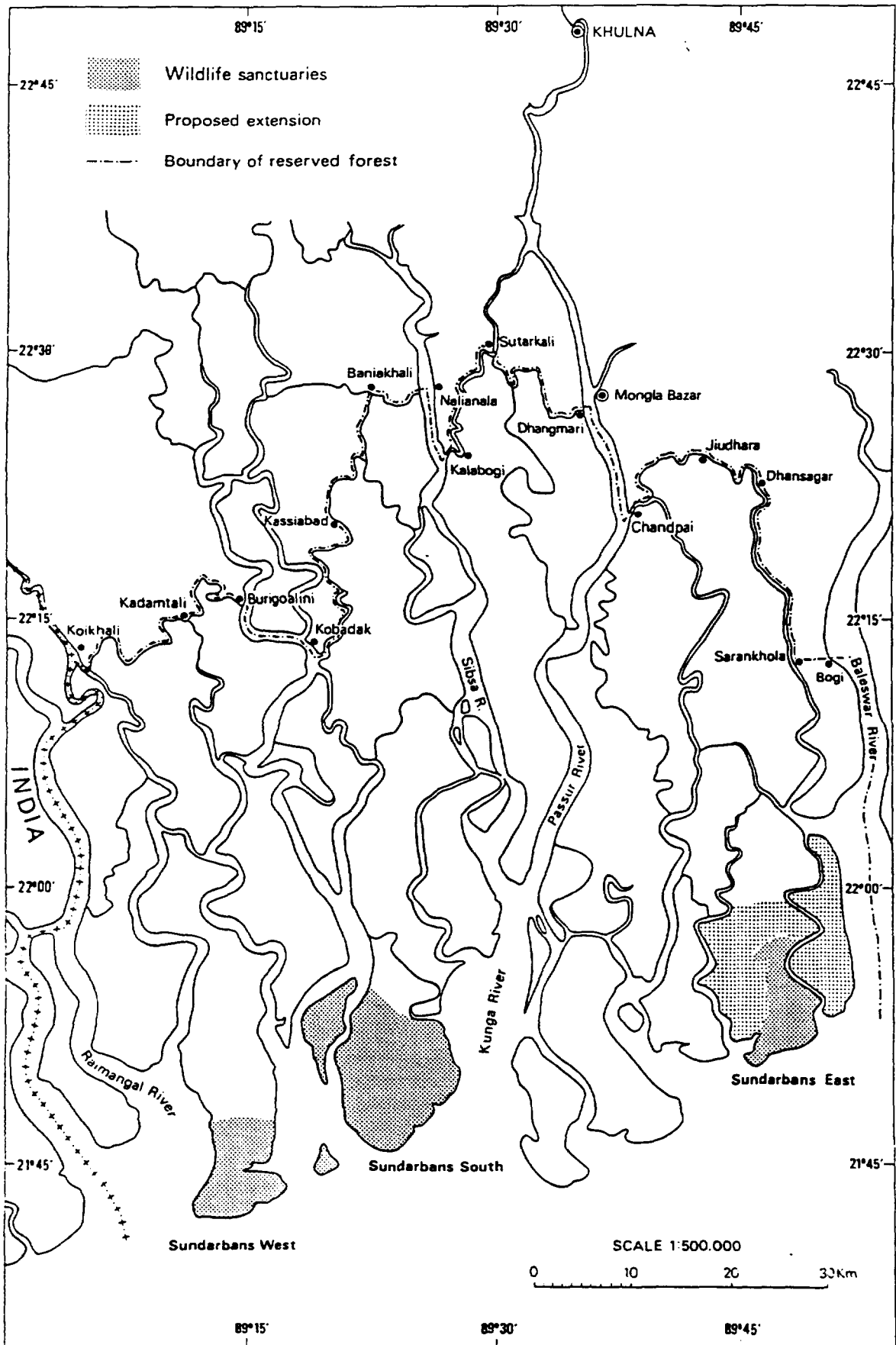
FIGURE • BANGLADESH

NOTIFIED AND PROPOSED
PROTECTED AREAS

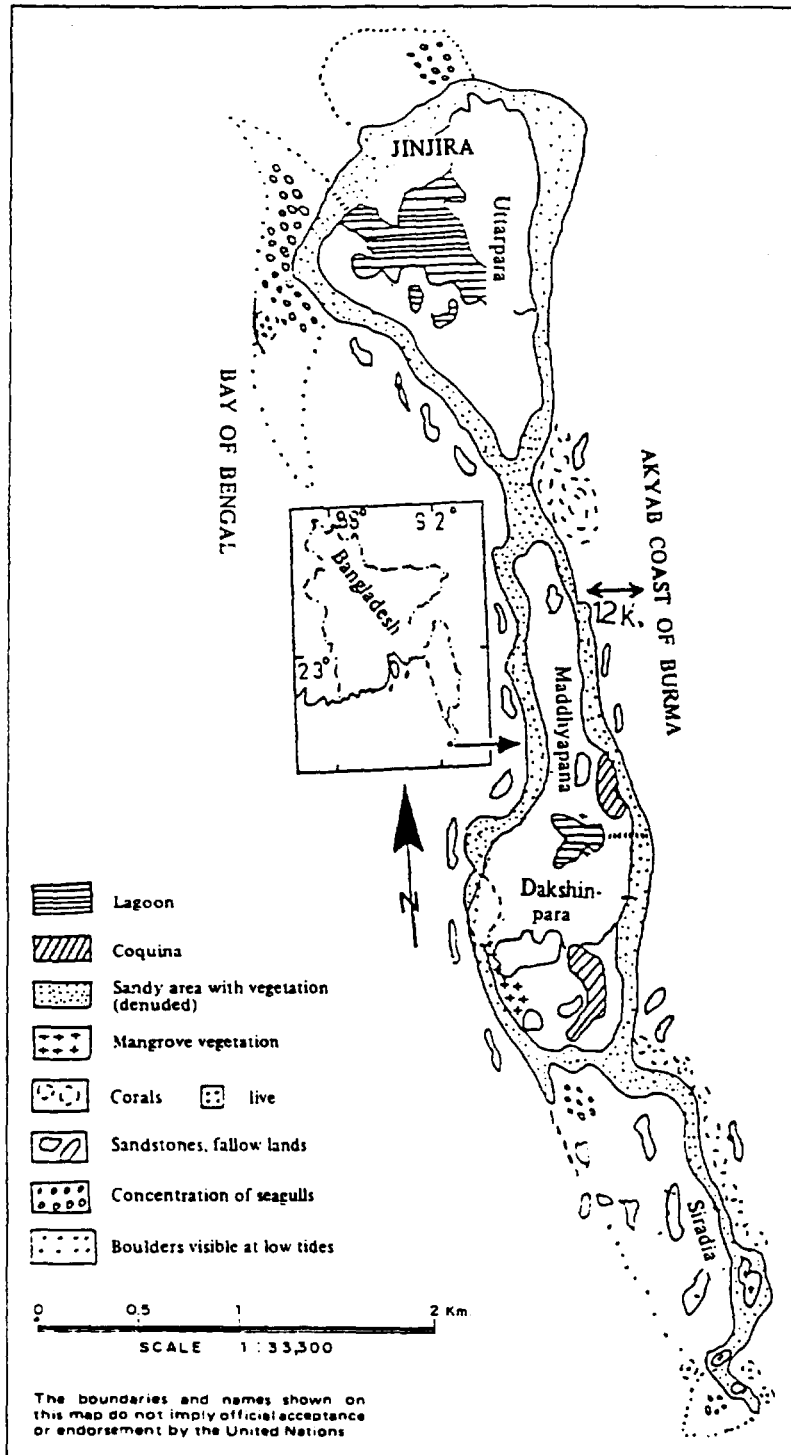
Locations are approximate
Legend in attached table.



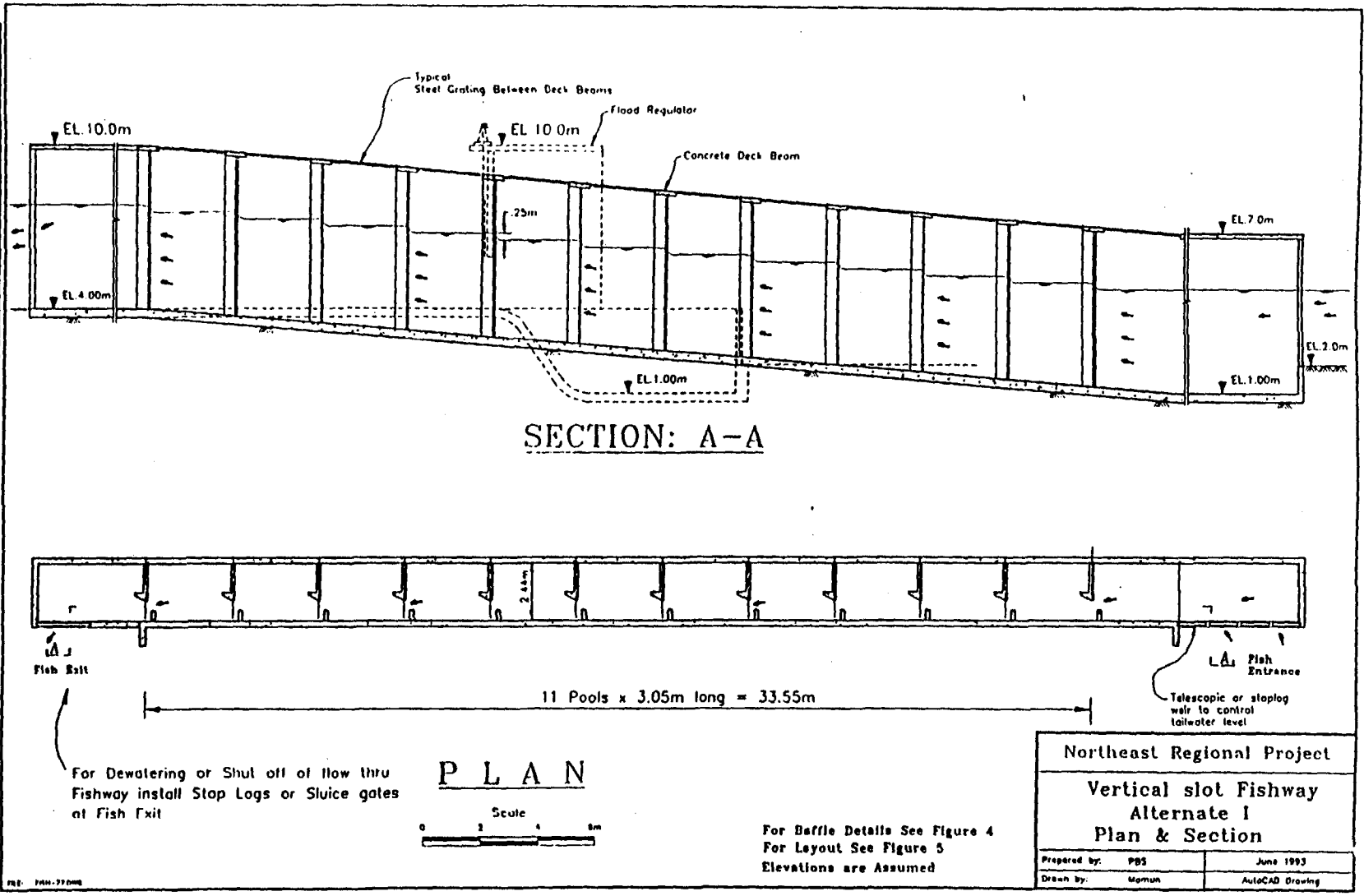
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Map 18. St. Martin's Island of Bangladesh

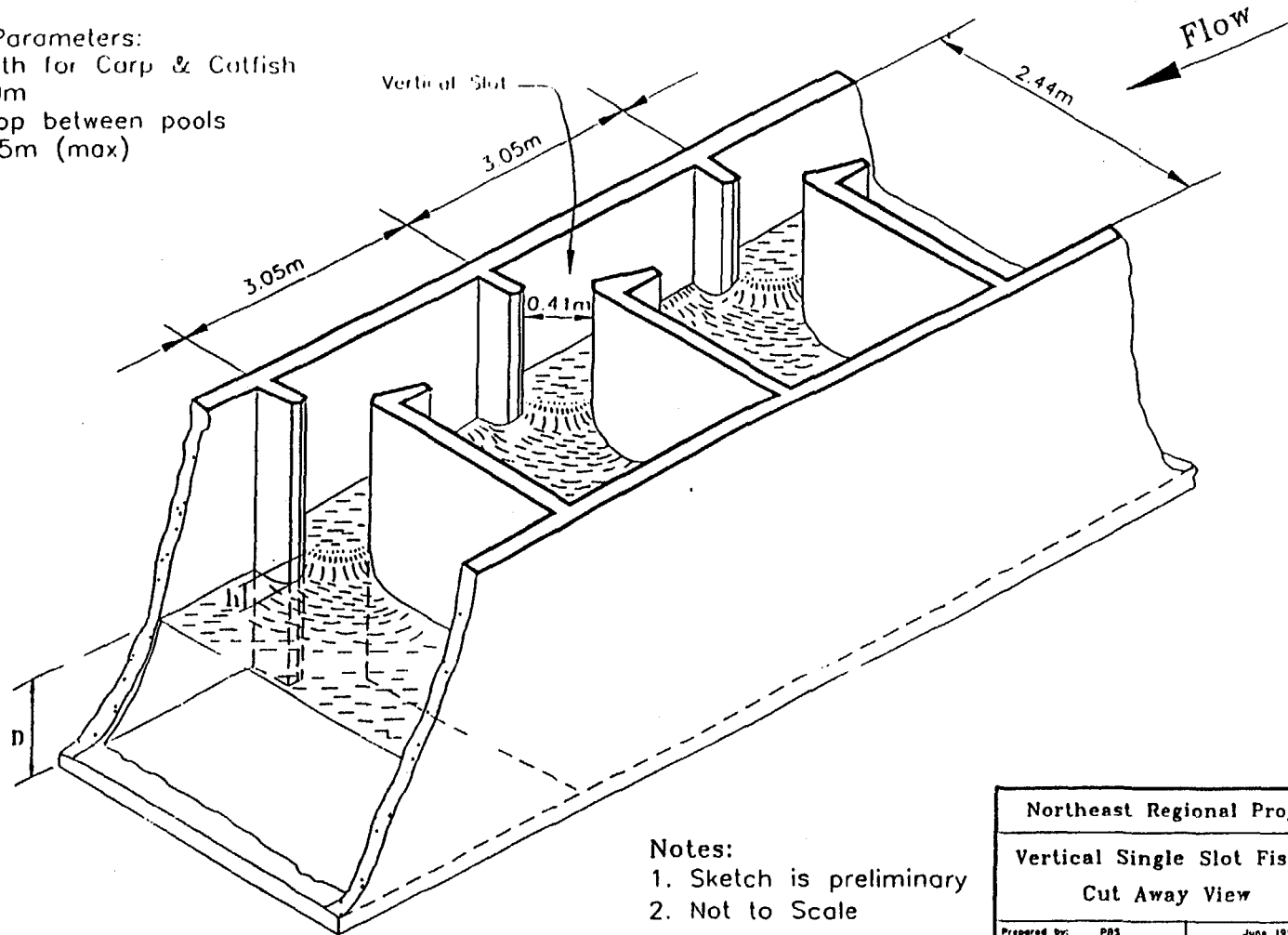


Handwritten notes: 11/11/11 + ()



from NERP (1994a)

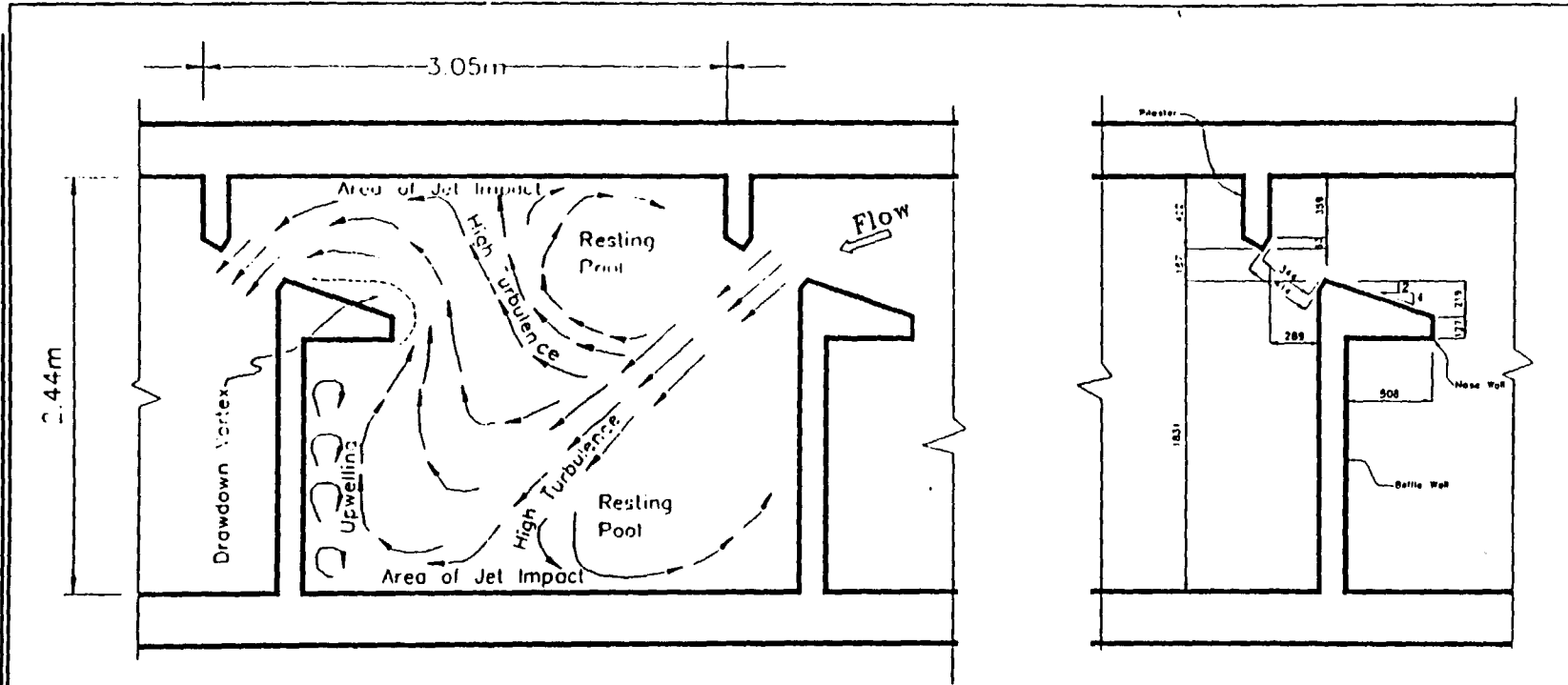
Design Parameters:
 Min. depth for Carp & Catfish
 $D = 1.0\text{m}$
 Head drop between pools
 $h \approx 0.25\text{m (max)}$



- Notes:
 1. Sketch is preliminary
 2. Not to Scale

Northeast Regional Project	
Vertical Single Slot Fishway Cut Away View	
Prepared by: P85	June 1993
Drawn by: Momun	AutoCAD Drawing

from NERP (1994 a)



Typical Flow Pattern

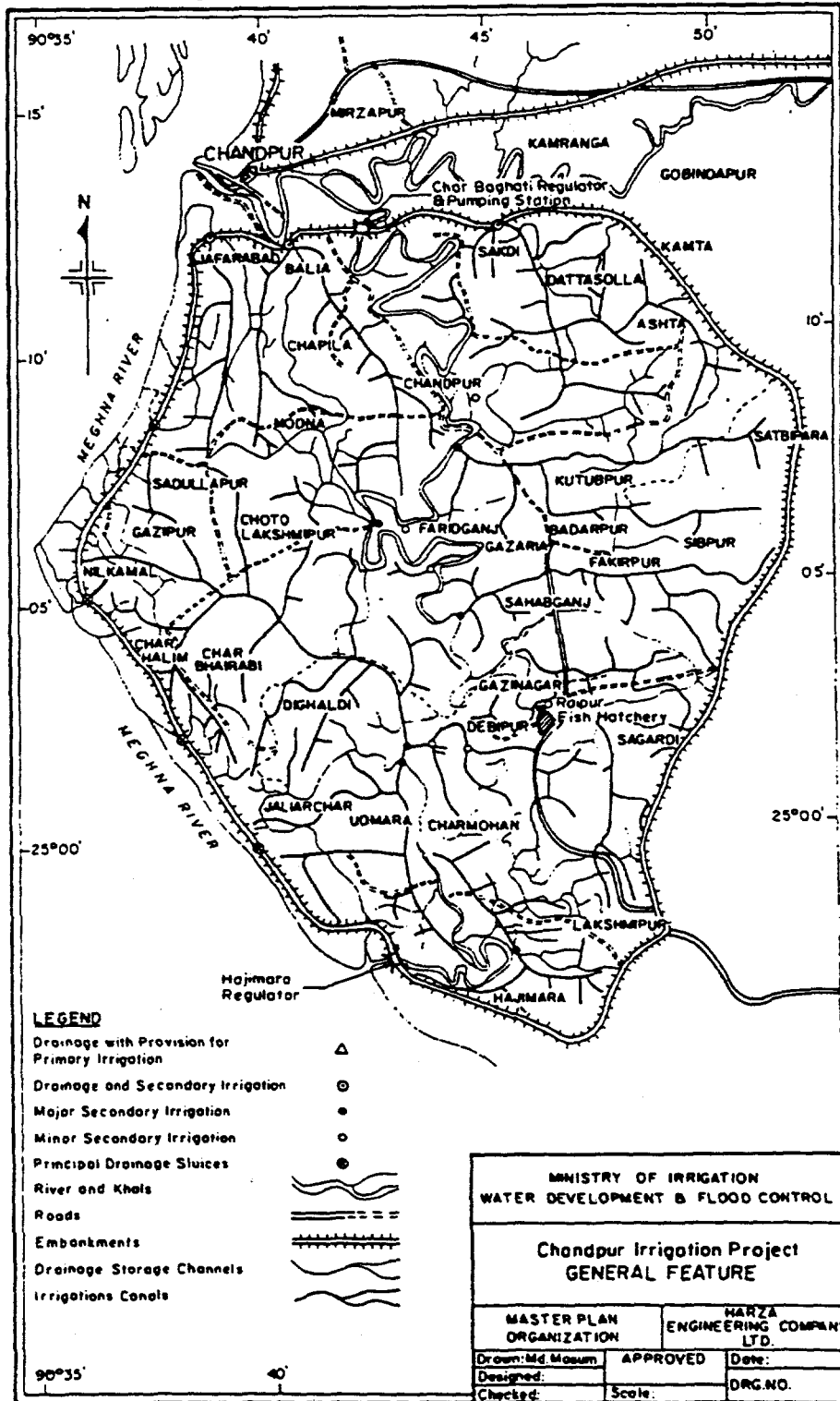
Slot & Baffle Details
Dim in mm

Not to Scale

Northeast Regional Project	
Vertical Single Slot Fishway	
Flow Pattern	
Prepared by: PBS	July 1993
Drawn by: Mamun	AutoCAD Drawing

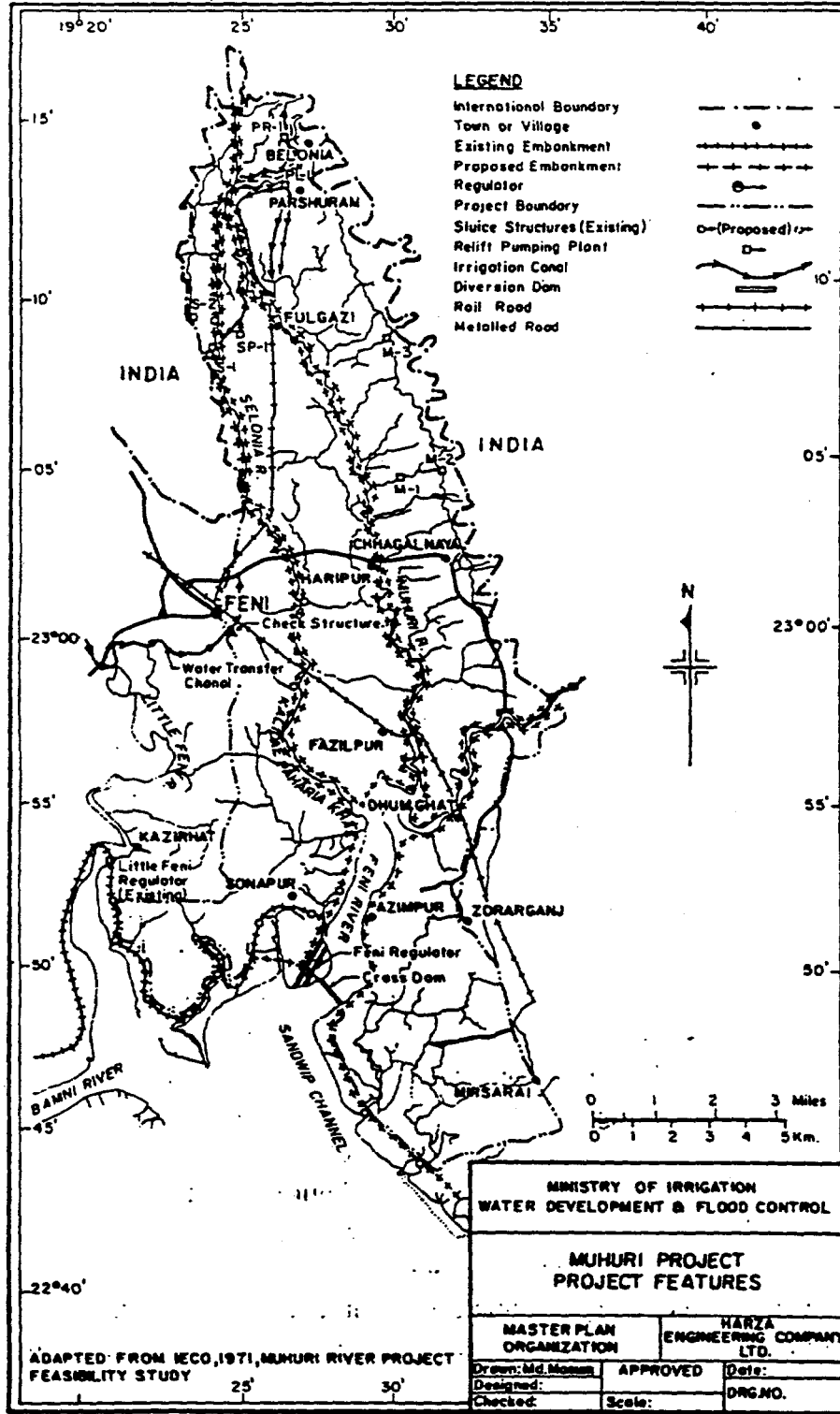
from NERP (1994a)

Chandpur Flood Control Irrigation Project Area



from Rahman et al (1994)

Muhuri Project Area



from Rahman et al (1994)

Indicative Pond Density (Number)

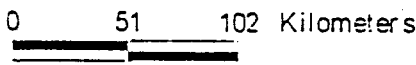
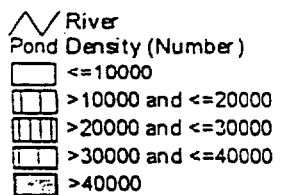
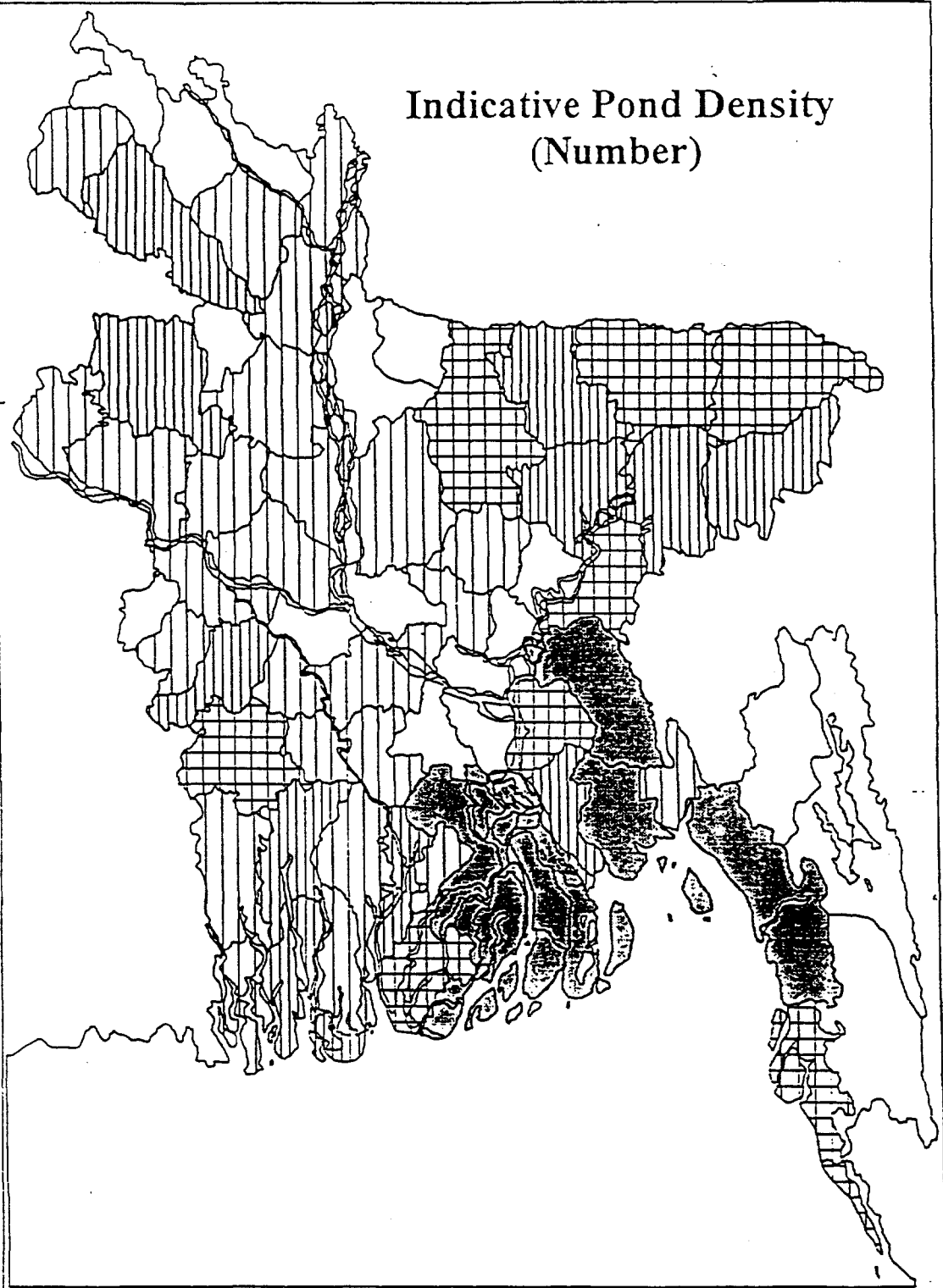


Figure 1 Life cycle pattern of penaeid shrimp

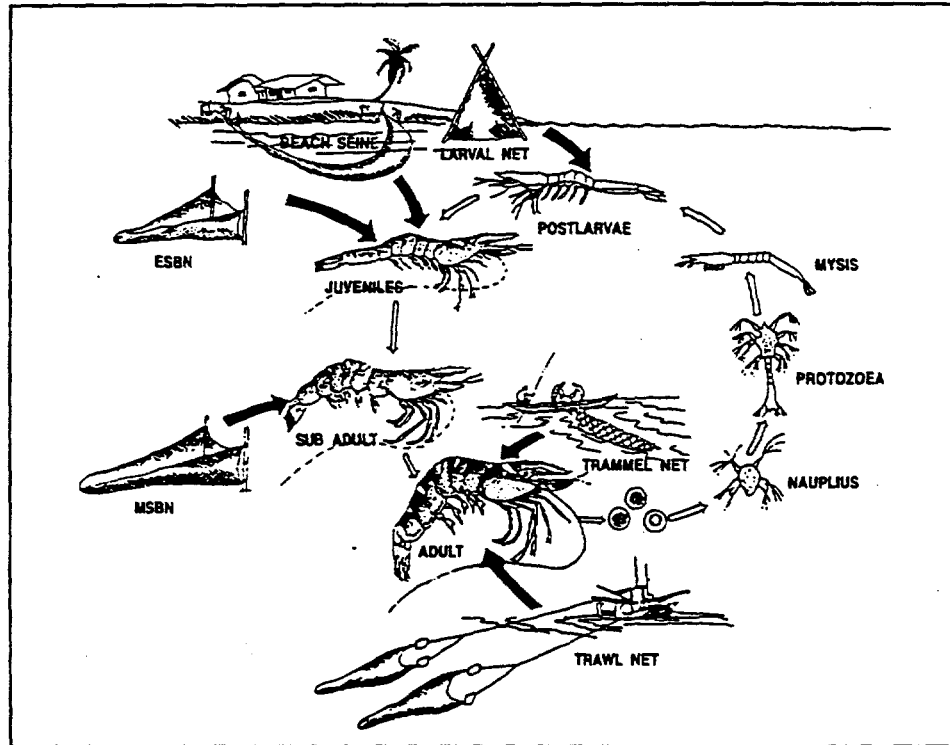


Figure 2 Annual catch (numbers) of Tiger shrimp (*P. monodon*) by length, exploited by different gears

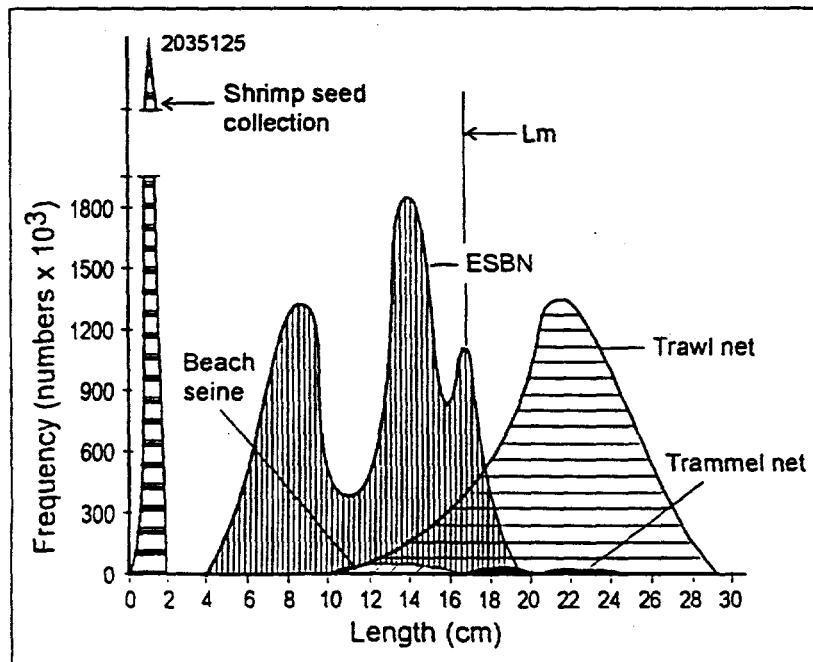
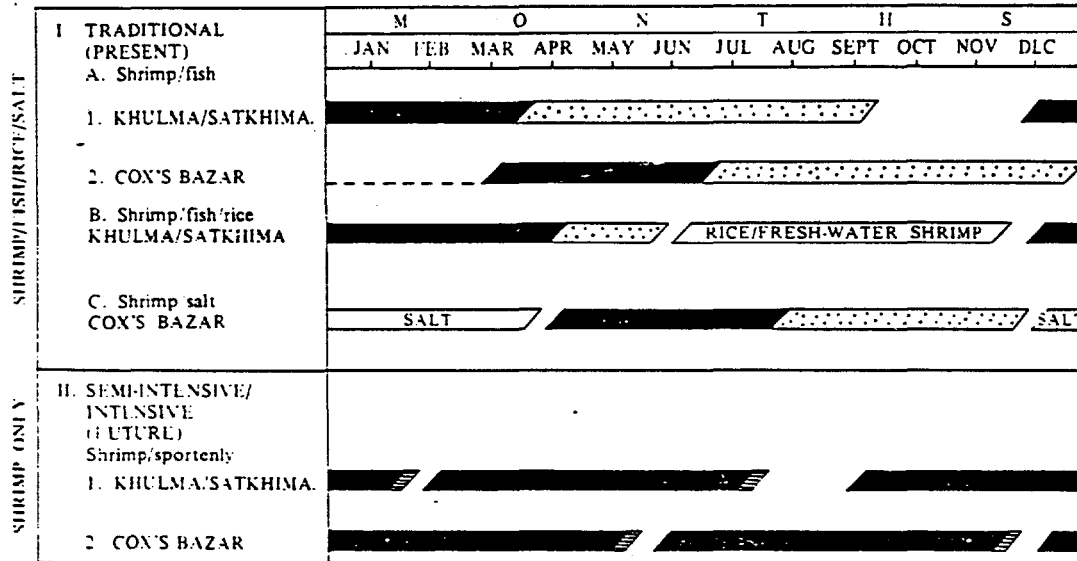






Figure 1 Bangladesh brackish-water shrimp and fish culture cropping pattern



- Legend:
-  Growth production of shrimp
 -  Growth production/harvest of shrimp
 -  Shrimp harvest
 -  Rice/fresh-water shrimp crop or salt.

Note: Brackish water required throughout growth and production period is 1-5 per cent of the total water volume exchanged per day.

from United Nations (1989)

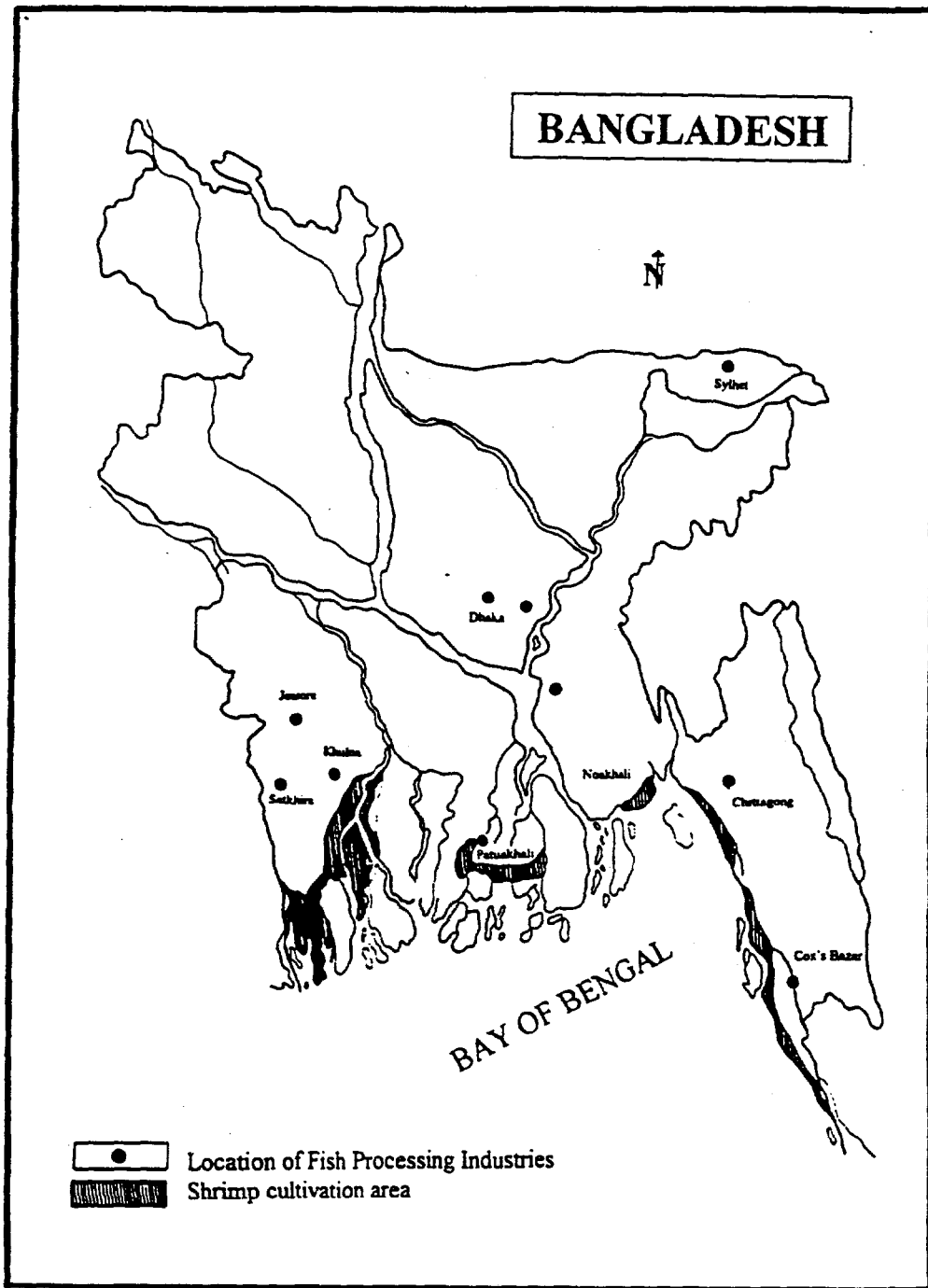
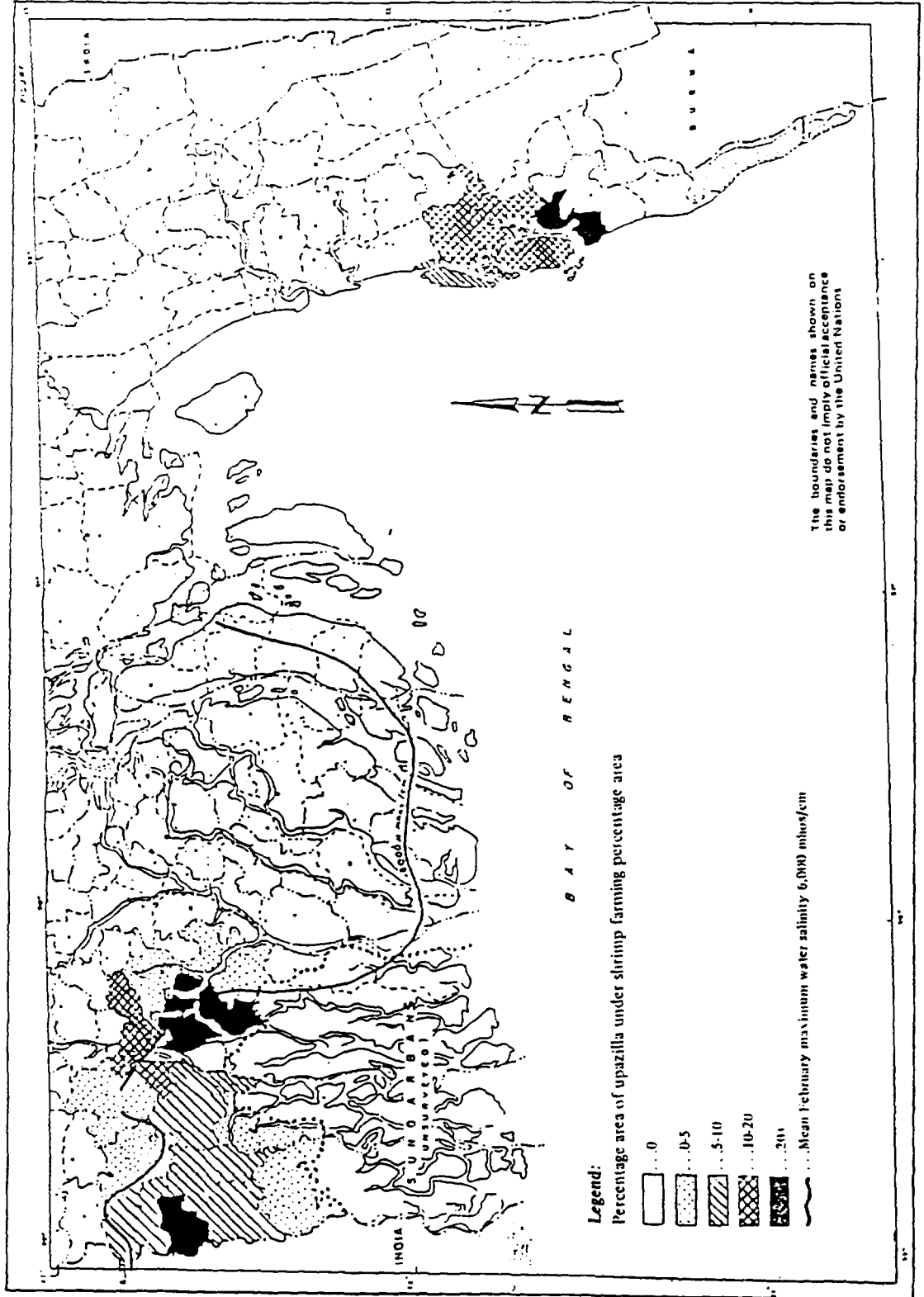


Figure ● Area of shrimp cultivation and location of fish processing industries.

from Khan and Hossain (1996)

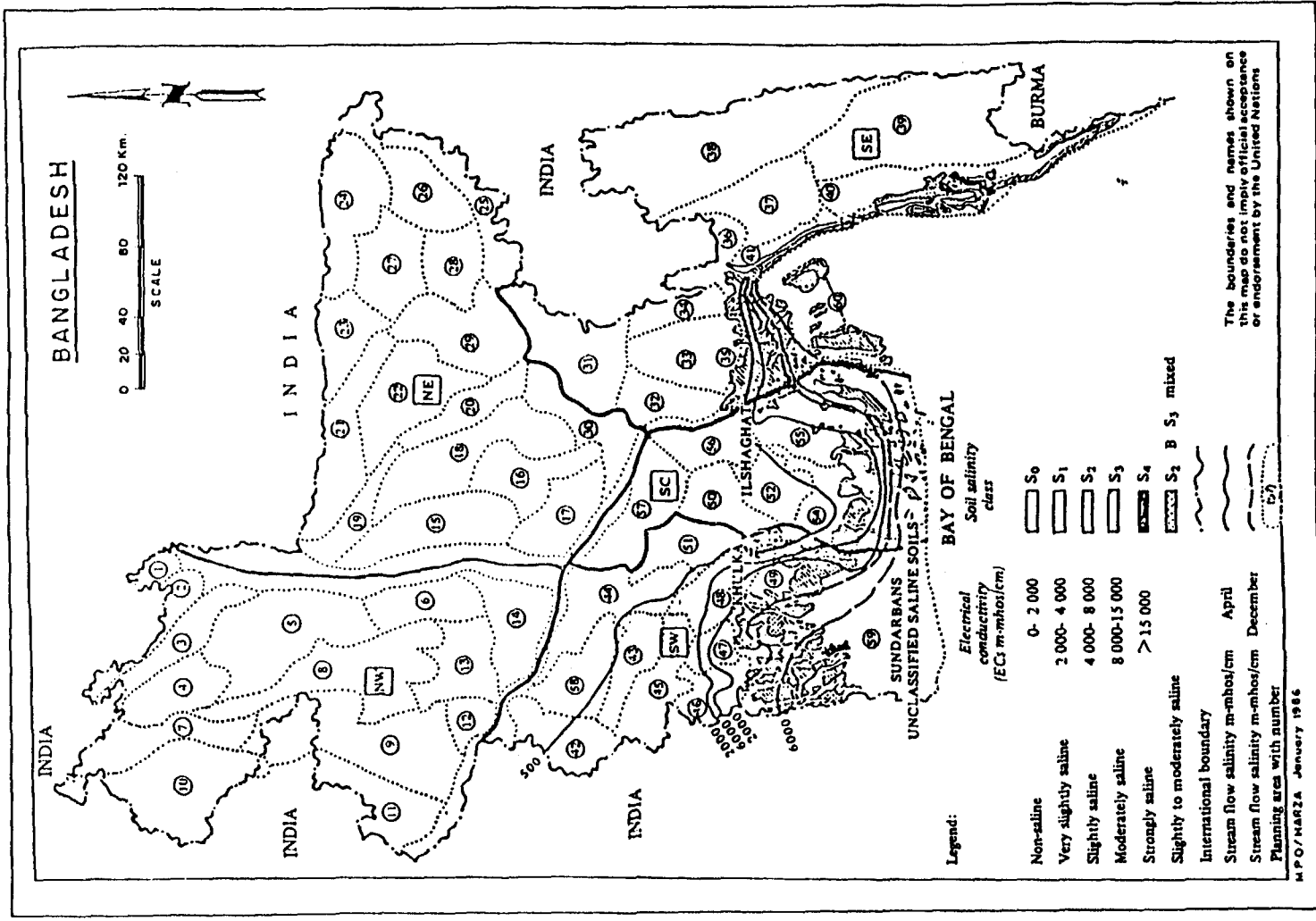
Map 1. Shrimp farm density by percentage area of upazilla



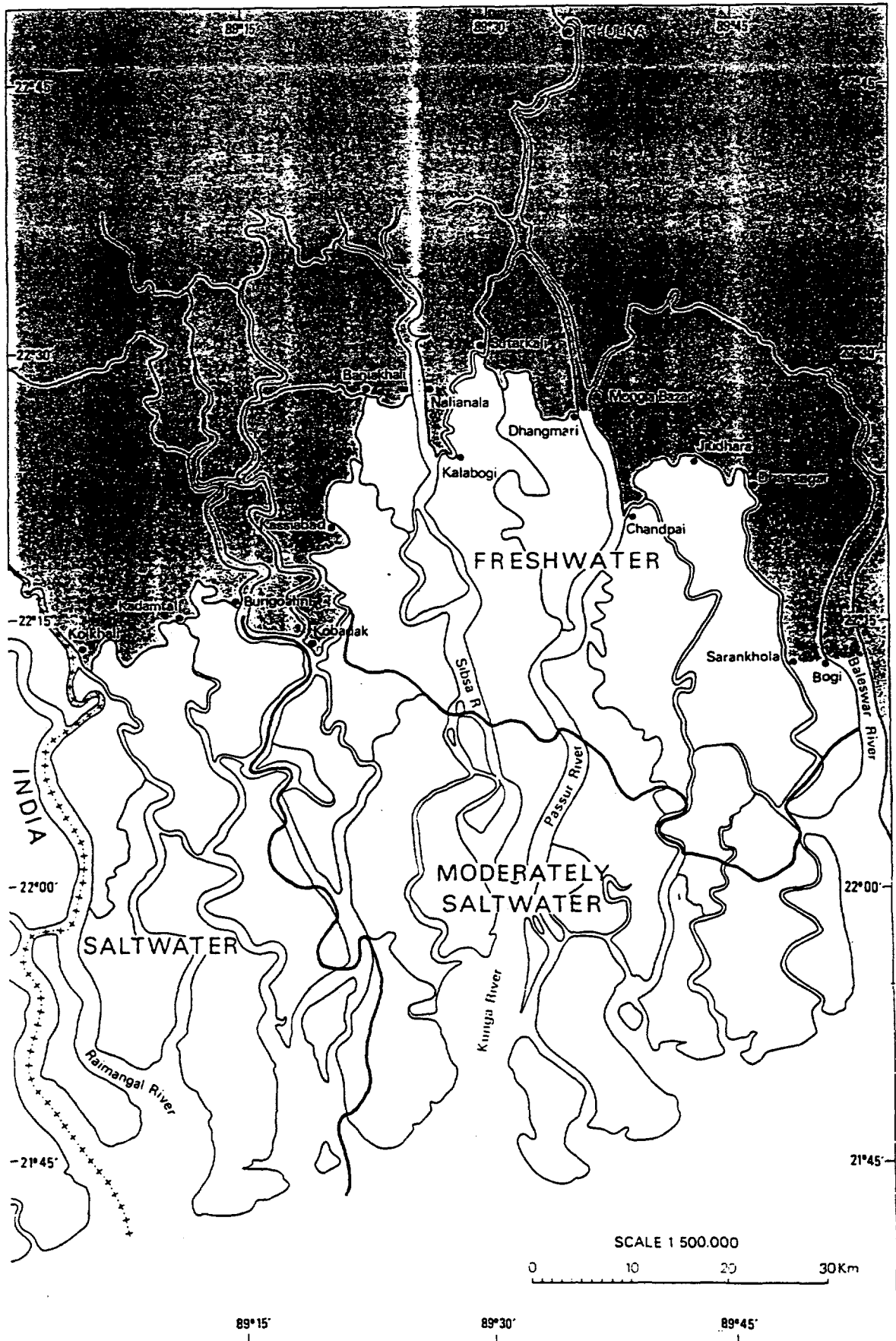
The boundaries and names shown on this map do not imply official acceptance or endorsement by the United Nations

from United Nations (1989)

Map • Soil salinity and river-water salinity conditions (December-April)

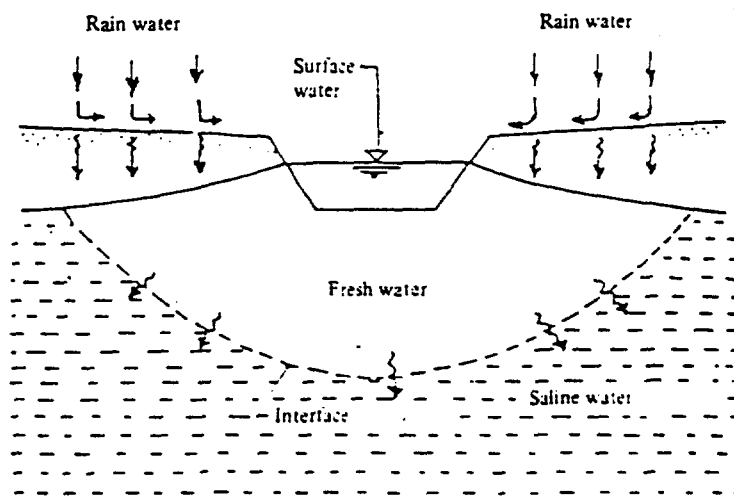


from United Nations (1989)



TEXT MAP ● Ecological zones

Figure 0. Fresh-water aquifer beneath surface-water source



from United Nations (1989)

Barringtonia acutangula (Linn.)
Gaertn.

Vernacular name : Hijal

Family : Lecythidaceae

Botanical features : A small to medium sized tree. Leaves alternate, crowded at the end of branches, 7-15 x 3-8 cm obovate, apex rounded or sub-acute. Flowers red in slender, drooping glabrous racemes, 14-45 cm long. Fruit a berry, about 3.5 cm long, oblong, quadrangular, crowned with the persistent calyx lobes.

Phenology : Fl. 3-6; fr. 9-2

Ecology : It grows chiefly on the banks of streams, water edges, moist places and fresh water swamps.

Geographical distribution : From Himalayas to SriLanka, Burma, Malayasia.

Occurrence in Bangladesh : Occurs in all districts along the edge of the haors and jheels.

Propagation and management : Generally propagated through seeds. The fruits fall into the moist, often muddy ground and the seedlings grow in quantity.

Wood : Wood is light pinkish to reddish grey, light, straight grained, medium-fine textured, lustrous, fairly durable. Heartwood is indistinct.



Barringtonia acutangula

Specific gravity : 0.58

Calorific value : 5078

Utilization : Wood is used for boat building, cabinet making and other purposes. Leaves are used as cattle fodder. The powdered seeds in doses of a few grains are given to children as an expectorant and emetic. The leaves and roots are better tonic. The bark, root and seeds are reported to be employed as fish poison. Tender leaves are edible.

from Alam et al (1991)

Crataeva magna (Lour.) DC.

Synonym : *C. nurvala* Buch. Ham.

Vernacular names : Barun, baruna, bonna, ladum

Family : Capparidaceae.

Botanical features : A small tree : bark blackish grey, lenticellate, exfoliating into thin flakes. Leaves alternate, trifoliate at the end of long petiole, common petiole 3.5-10.0 cm long; leaflets 6.5-16.0 x 3.0-6.5 cm, cuneate-ovate to elliptic-lanceolate, entire, lateral ones unequal at base, glabrous, glaucous beneath. Flowers white to pale yellow in terminal corymbs. Fruit a berry, 4-5 cm across, globose, many seeded.

Phenology : Fl. 3-4; fr. 7-9

Ecology : In marshy places and along the water edge. It can stand prolonged waterlogging.

Geographical distribution : India, Bangladesh, Burma, South China to West Malesia.

Occurrence in Bangladesh : It inhabits the lowlying areas in all the districts.

Propagation and management : It can be propagated easily through seeds. It can be lopped.



Crataeva magna

Wood : Wood is yellowish white in colour, light and soft, medium coarse textured, straight grained, dull to somewhat lustrous.

Specific gravity : 0.49

Utilization : The leaves are used to treat rheumatism and gout. The bark is considered good for indigestion and for promoting appetite. The fruit is said to be edible. The fruits after peeling is smashed and made into 'chutneys' in many parts of Bangladesh. Wood is used in turnery, and for making drums, combs and other small articles.

from Alam et al (1991)

Pongamia pinnata (Linn.) Pierre.

Vernacular names : Kerong, karanch, karanja, gorkanchi

Family : Leguminosae : **Sub-family** : Papilionoideae

Botanical features : A small or medium sized tree with a short trunk and spreading crown. Leaves imparipinnate, 15-25 cm long; leaflets opposite, rarely alternate, 5-7, 5-10 x 2.5-6.0 cm, ovate, elliptic, acuminate, dark green above, pale underneath. Flowers purplish or whitish, 2-4nate in simple, long-peduncled, axillary racemes. Fruit a pod, 2-5 x 2.5-3.0 cm, woody, flattened, much thickened at the sutures.

Phenology : Fl. 5-6; fr. 12-2

Ecology : A wonderful tree for adapting itself to diverse conditions, growing well with its roots in salt water or fresh water. Highly tolerant of salinity. It tolerates shade well.

Geographical distribution : India, Sri Lanka to Malacca, Malay islands, North Australia, Polynesia.

Occurrence in Bangladesh : Occurs in the tidal forests, often also along river and canal banks and along the ditches.

Propagation and management : Easily raised from seeds and cuttings; even branches stuck into moist ground develop roots readily. It produces root suckers and coppices well.



Pongamia pinnata

Wood : Wood is white, on age become cream coloured, often discoloured by fungal sapstain, moderately hard and heavy, interlocked grained and medium textured.

Specific gravity : 0.68

Calorific value : 4600

Utilization : Timber is used for tool handles. Oil obtained from seeds is being used for burning. The leaves are good cattle fodder. Its bark is used in fever treatment. It is a good fuel wood.

from Alam et al (1991)

Trewia nudiflora Linn.

Vernacular names : Bhuri, gota-gamar, mera, medda, pitali, batul, pitabara.

Family : Euphorbiaceae

Botanical features : A medium sized deciduous tree; bark smooth, greyish or brownish with wrinkles. Leaves opposite, about 13 x 10 cm, broadly ovate-cordate, entire, acuminate, glabrous, lateral veins 4-5 on either half; petiole 1-7 cm long. Flowers-male and female in separate plants; male in long pendulous racemes; females solitary or two to three together. Fruit woody, globose, 2.5-4.0 cm across.

Phenology : The leaves fall in the cold season. The male plants become covered with pendulous spikes at the end of December or January. Fl. 1-3; fr. 7-10. The new leaves appear soon after or at the time of flowering.

Ecology : Chiefly found in the moist forests, particularly along the streams and in moist and swampy places. It can stand prolonged flooding.

Geographical distribution : Bangladesh, India, SriLanka, South China to Thailand and West Malesia.

Occurrence in Bangladesh : It grows in low lying areas, along the swamps in all districts of Bangladesh.

Propagation and management : It can be propagated by seedlings. Fresh seeds give high percentage of germination. Cuttings establish in rainy season. It coppices vigorously and produces root suckers. It can be lopped.



Trewia nudiflora

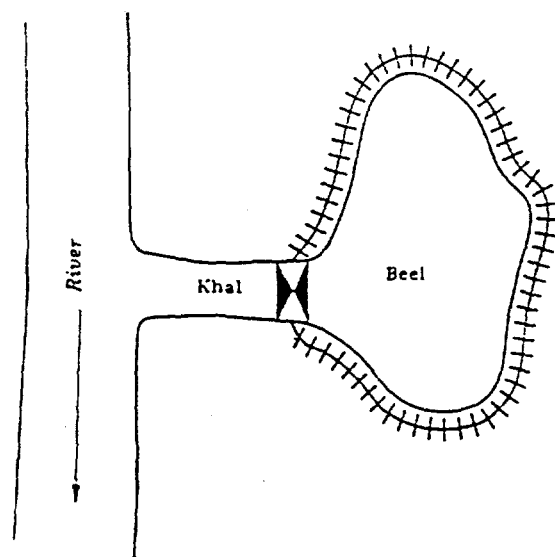
Wood : Freshly cut wood is white or cream coloured, turning greyish brown or yellowish on age, often discolouration by fungal sapstain. Wood is soft and light, fine even textured, straight grained.

Specific gravity : 0.44

Utilization : The ripe fruit are said to be sweet and edible. Wood is used in making packing cages, tea boxes, match boxes and splints, agricultural implements, drums, barrels, planks, slate and picture frames, toys, pencils, plywood, etc.

Root poultice is used in gout and rheumatism and shoot decoction is used to relieve flatulence and for the treatment of swelling.

from Alam et al (1991)



Structural scheme for transforming a seasonal beel into a permanent beel. Embankment material is excavated from the beel and khal

+++++ Submersible Embankment

⬠ Regulator

Northeast Regional Project

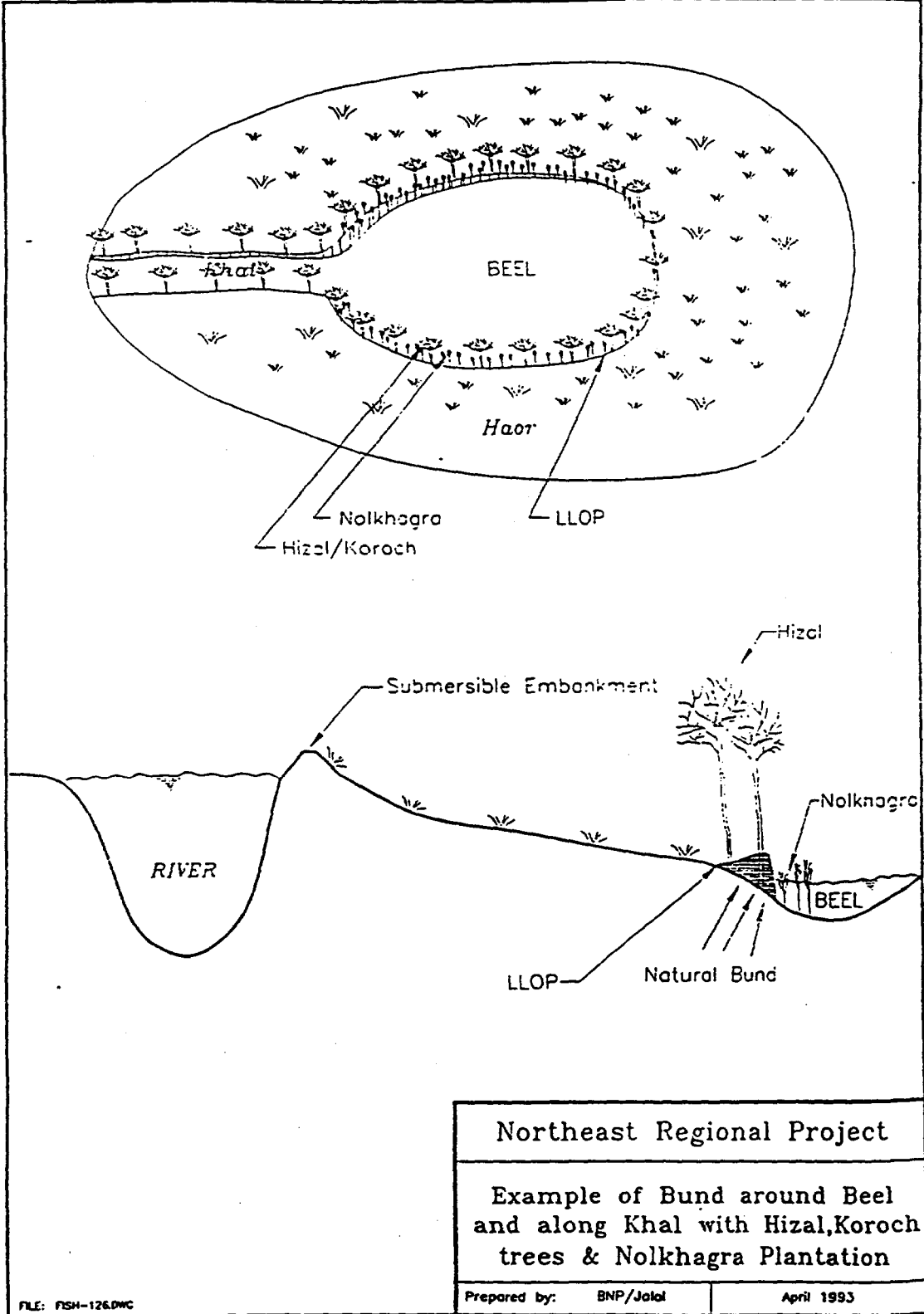
Beel Embankment
Scheme

FILE: FISH-143.DWG

Prepared by: BNP/Jalal

April 1993

NERP (1994)

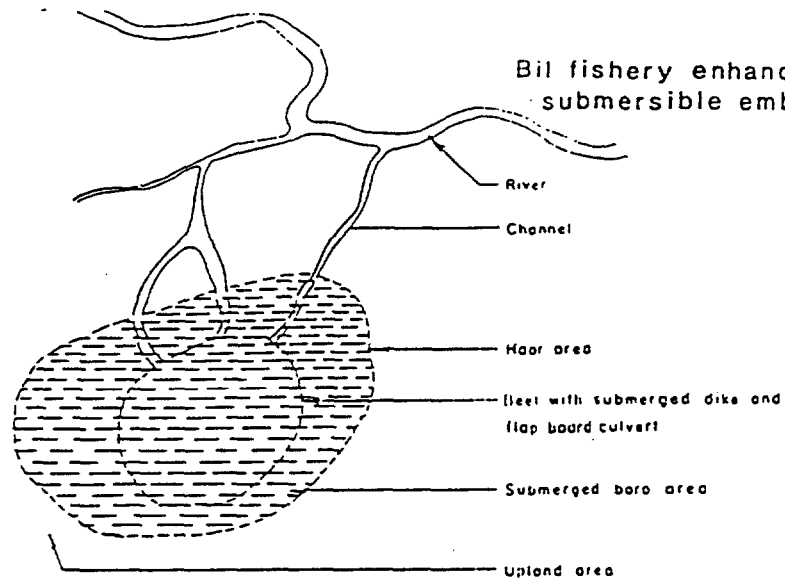


Northeast Regional Project

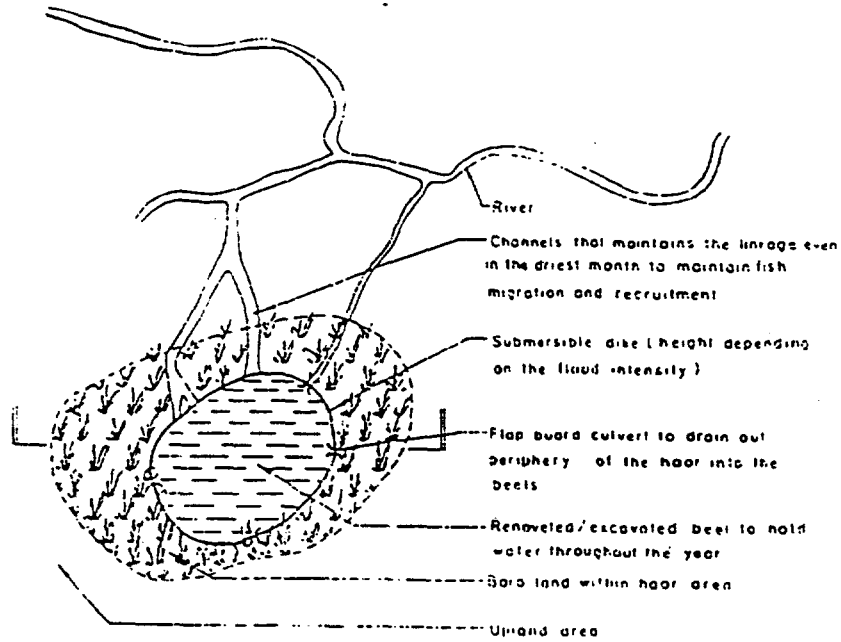
Example of Bund around Beel and along Khal with Hizal, Koroch trees & Nolkhagra Plantation

Prepared by: BNP/Jalal April 1993

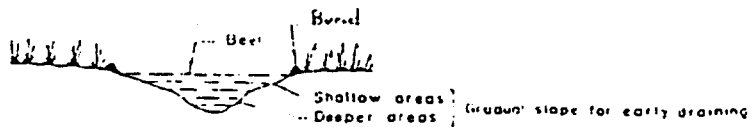
Bil fishery enhancement by submersible embankments



Conceptual picture during mid May through November: Water in the entire haar.



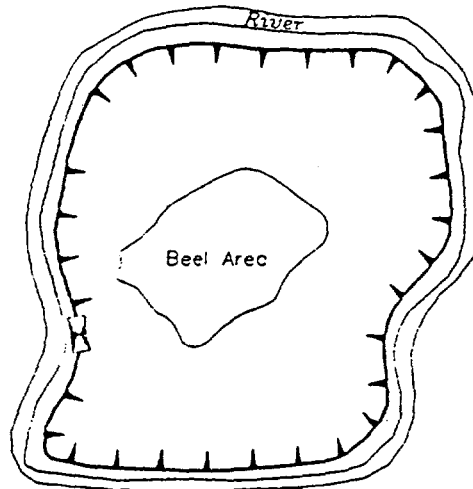
Conceptual picture during late November through before flood. Water only within the beel.



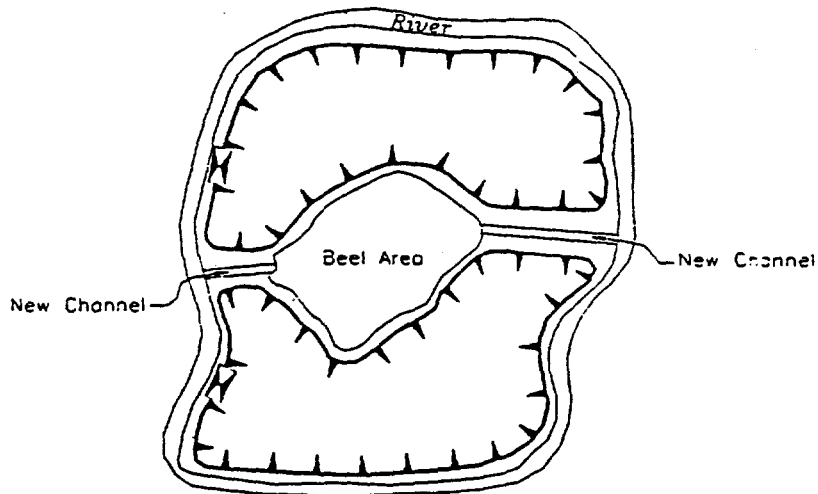
C.S. OF THE BEEL

From: NWHC/SAL (1986)

from NERP (1994a)



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

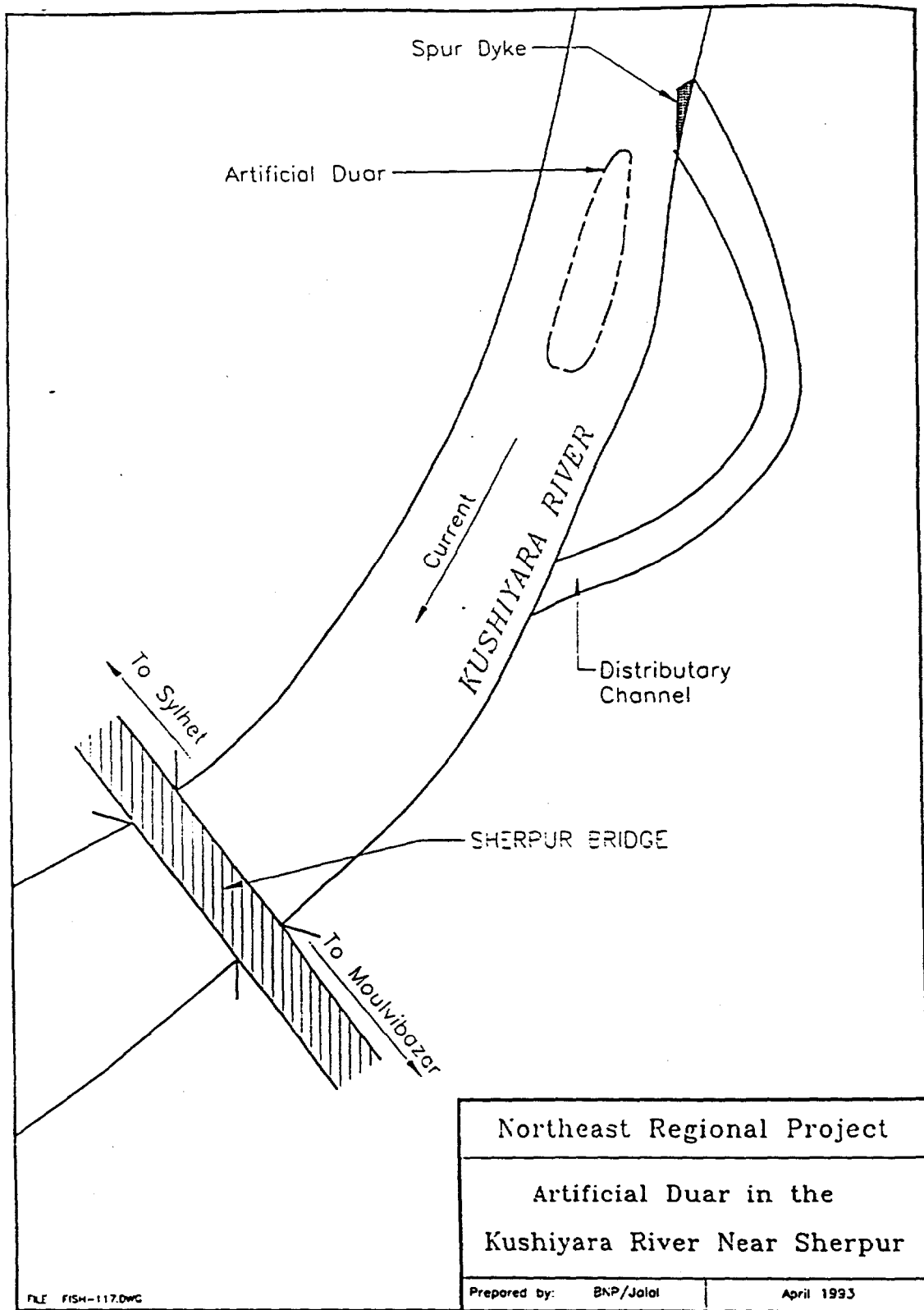
April 1993

Drawn By: Mamun

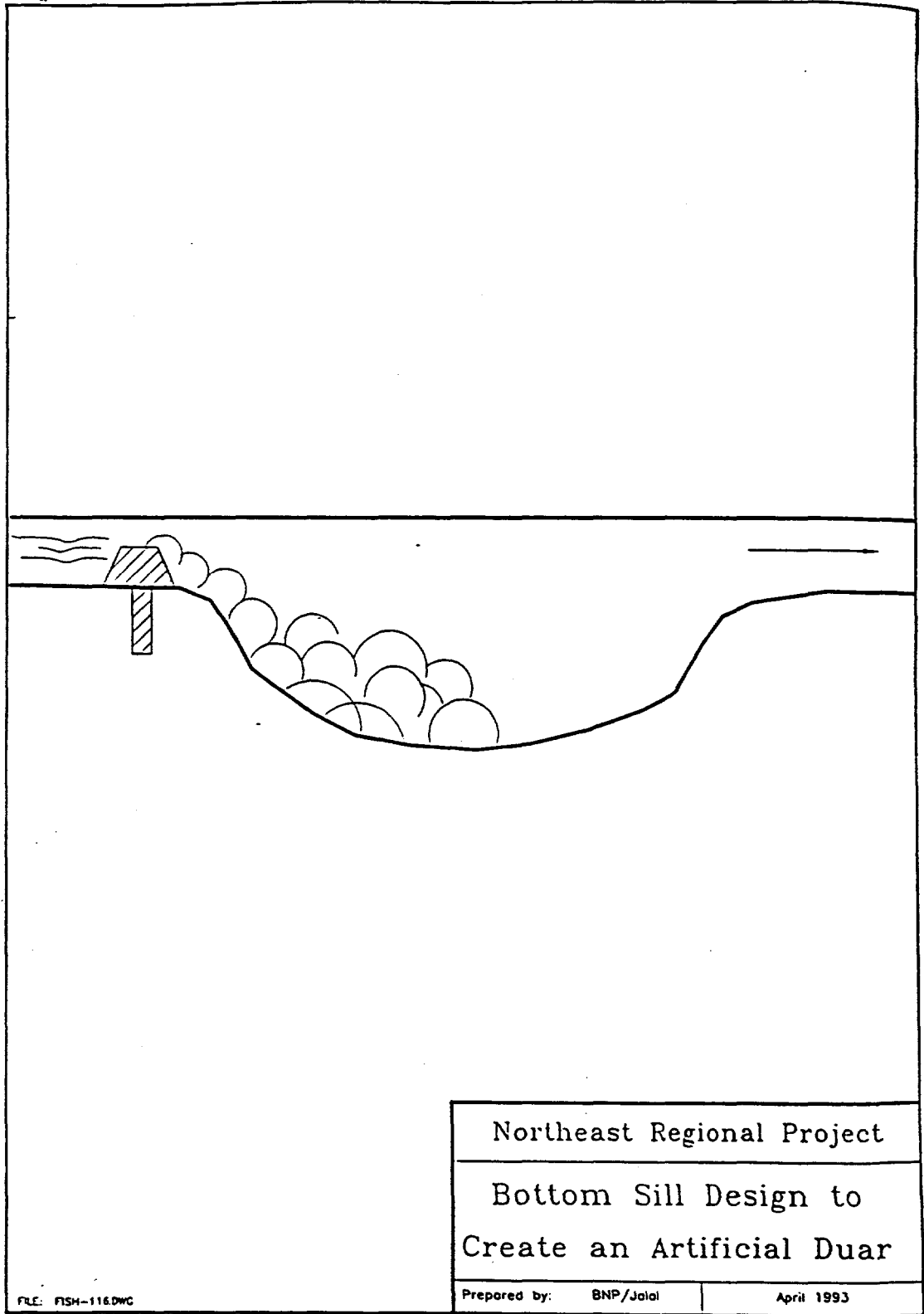
AutoCAD Drawing

FILE: FSH-58.DWG

from NERP (1994a)



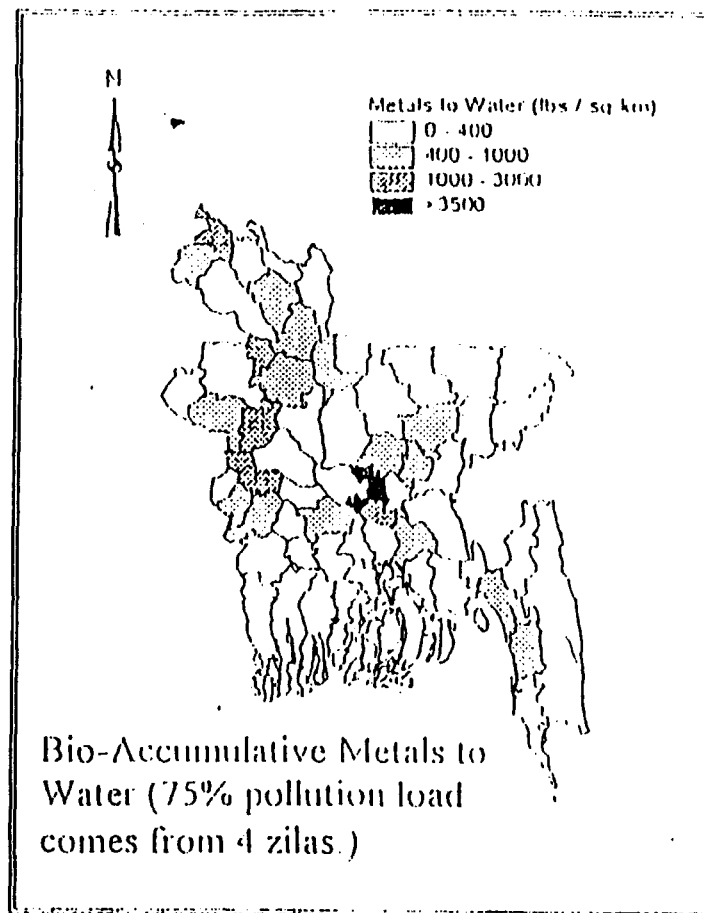
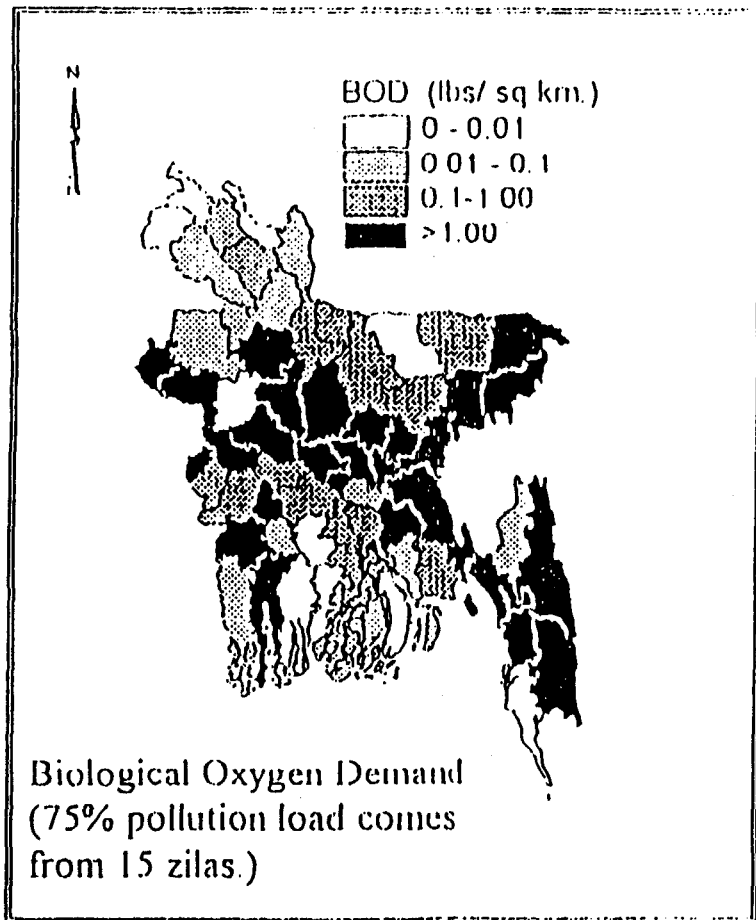
from NERP (1994a)



Northeast Regional Project	
Bottom Sill Design to Create an Artificial Duar	
Prepared by: BNP/Jalal	April 1993

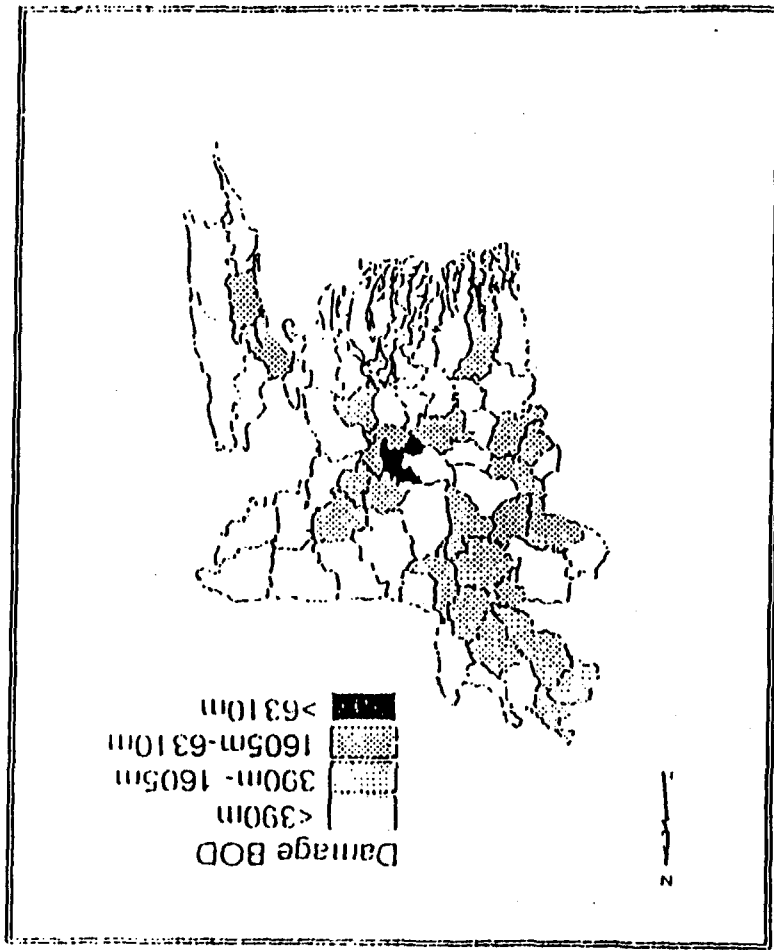
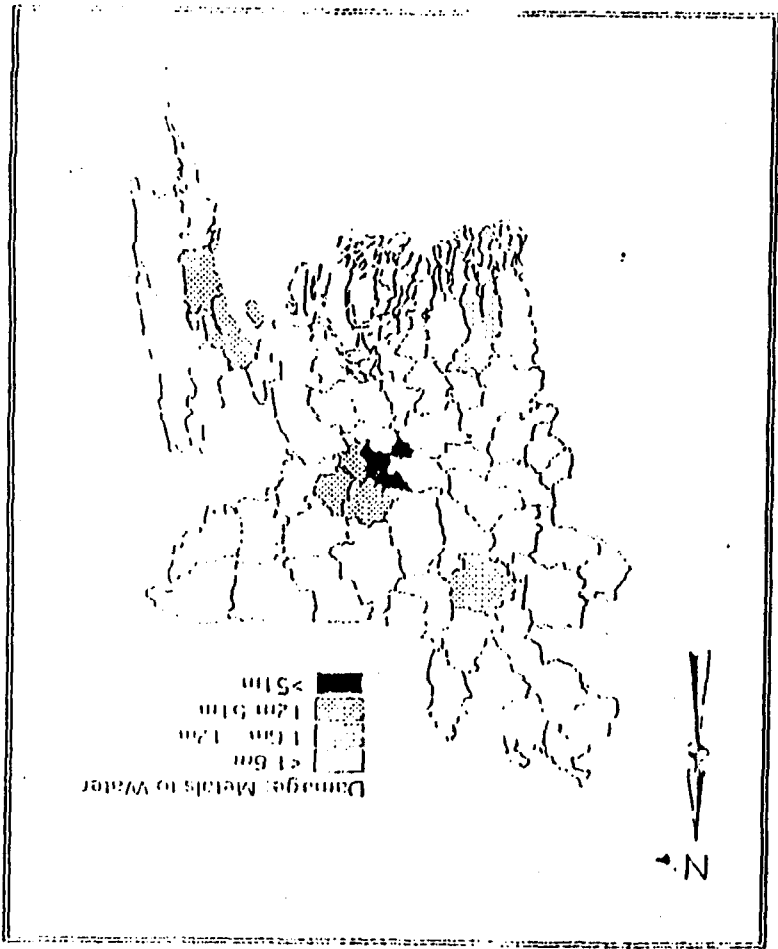
FILE: FISH-116.DWG

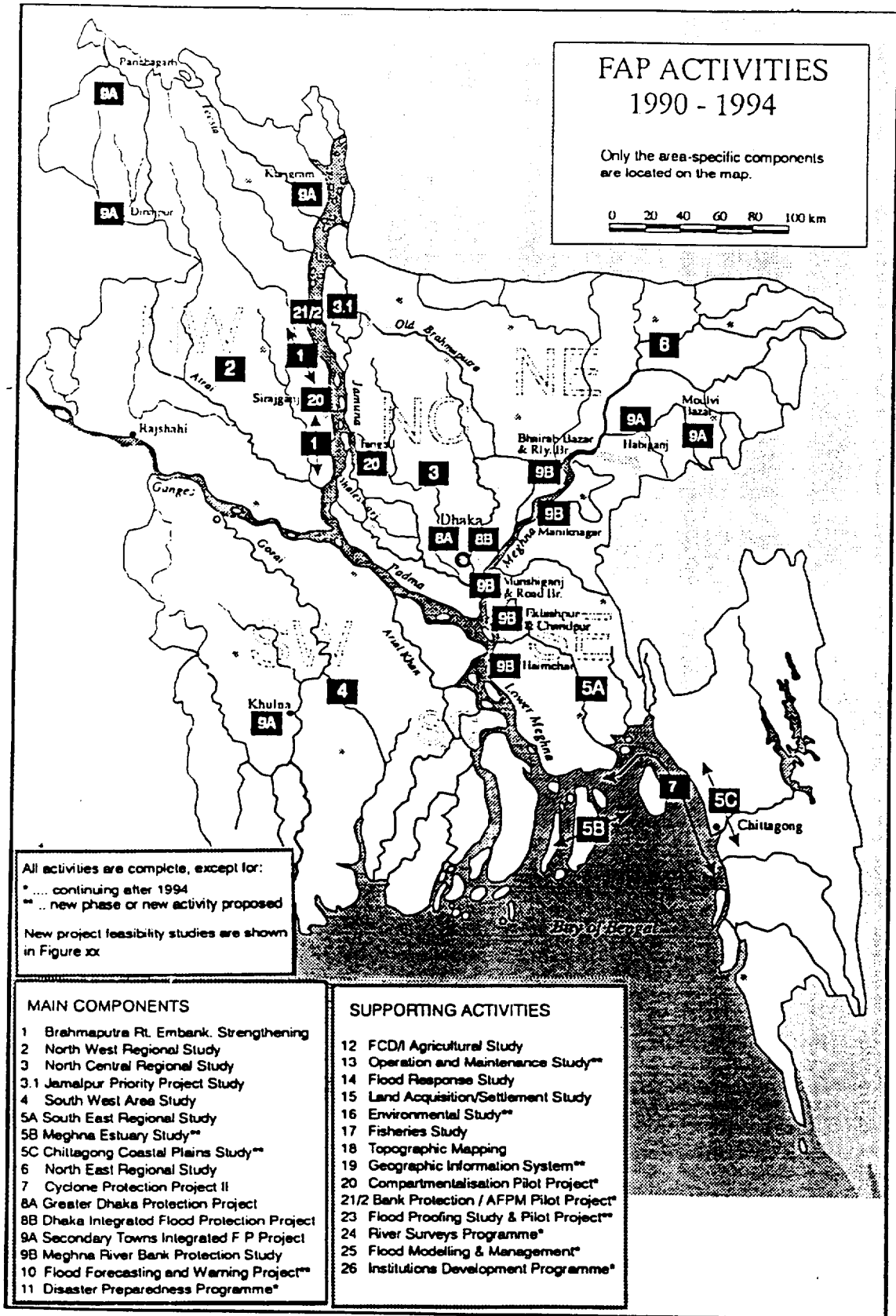
from NERP (1994a)



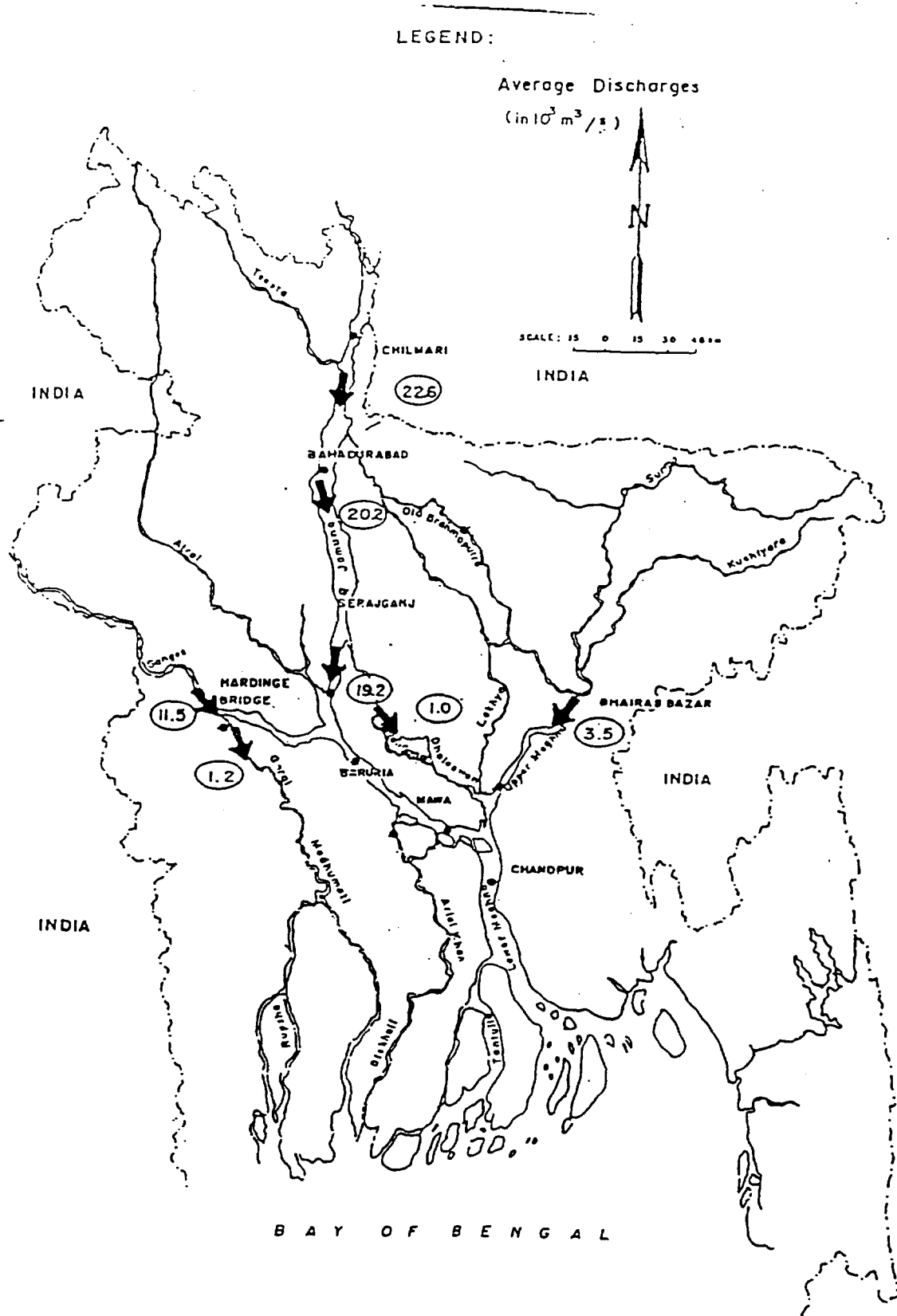
from Hettig and Brandon (1997)

from Holtby and Brandon (1997)





from FAP (1995)

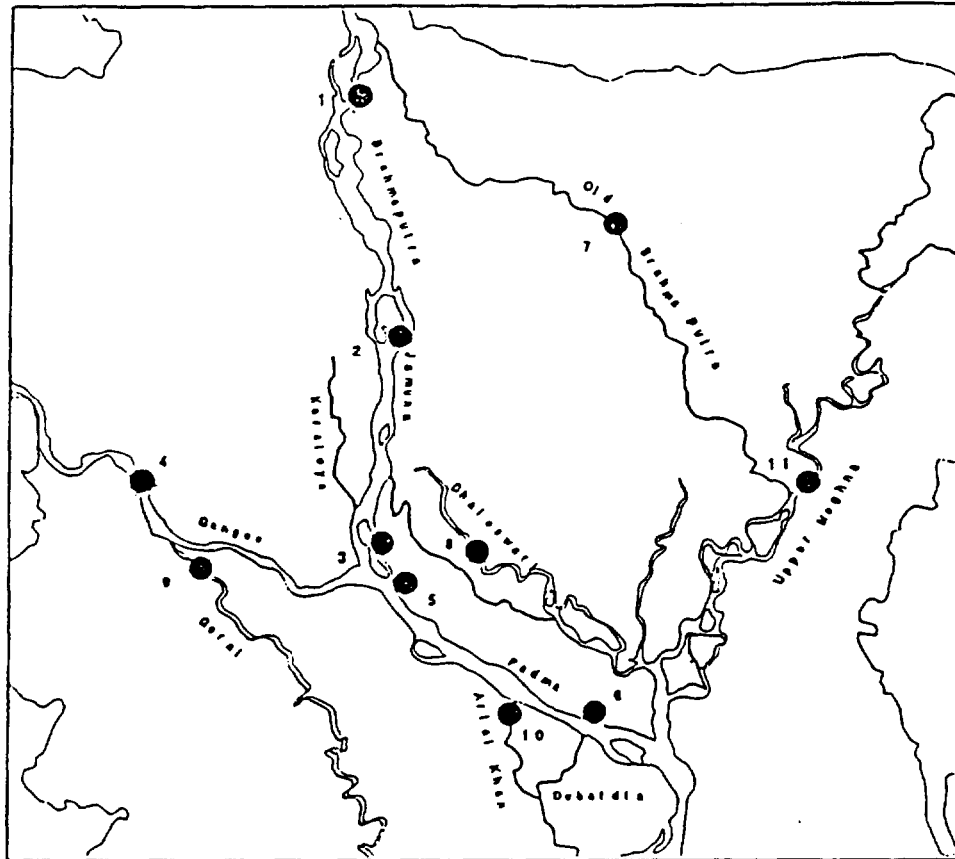


Some characteristics of the main river system (a):
Average discharges ($10^3 \text{ m}^3/\text{s}$)

from FAP (1995)

Water-levels

Measuring stations



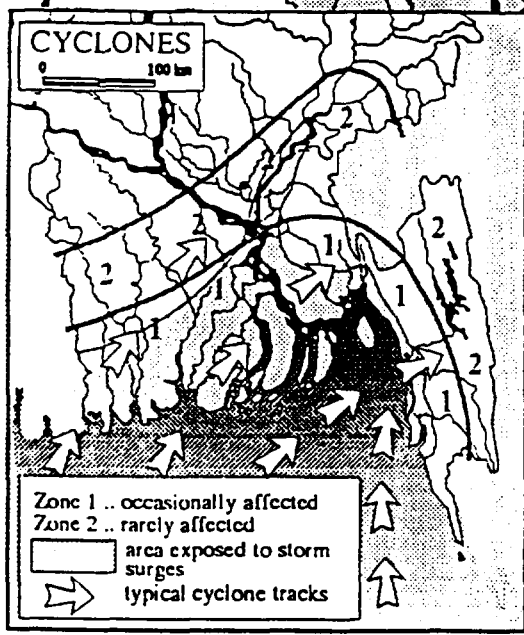
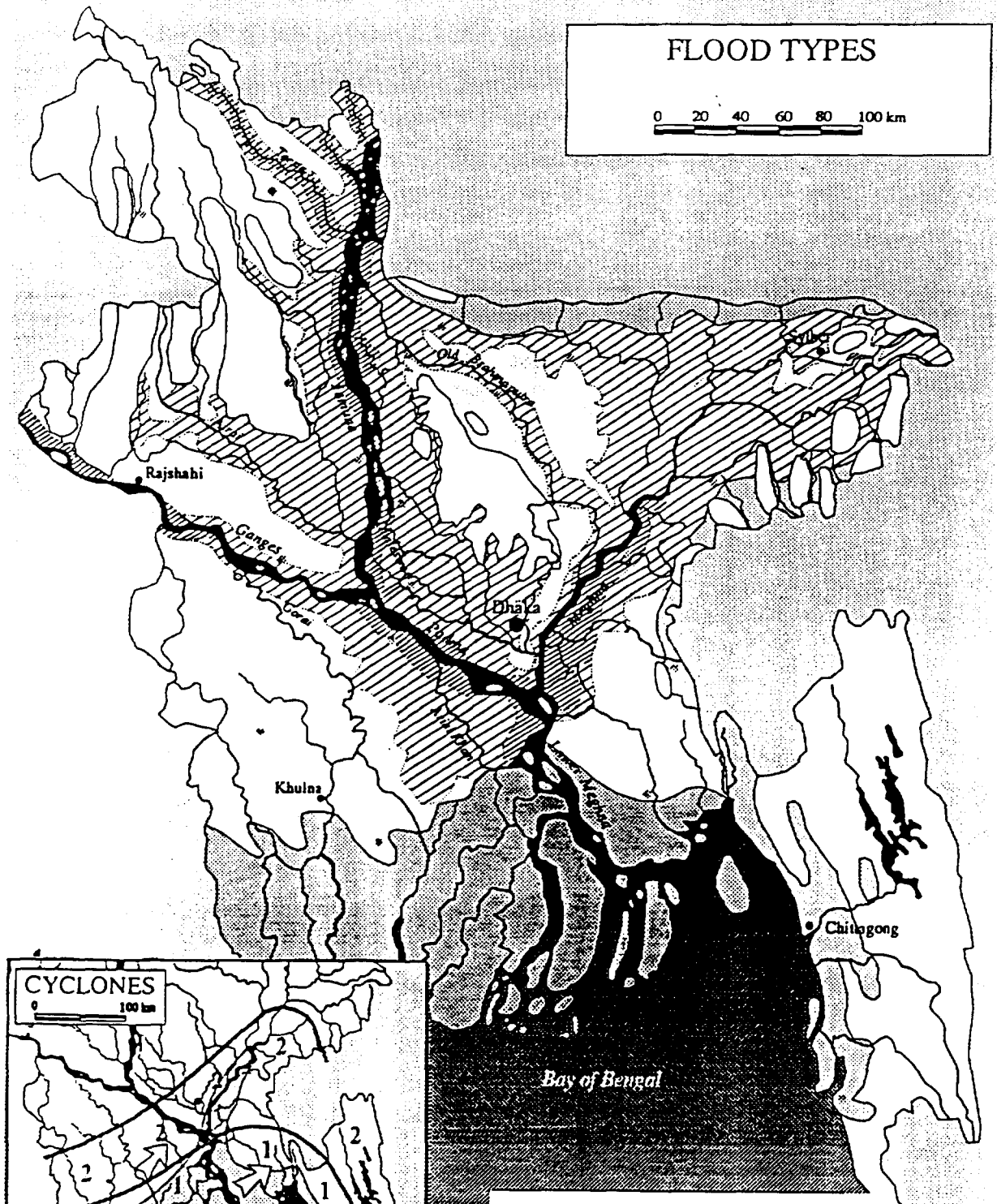
LEGEND			
1	Bahadurabad	Jamuna	
2	Bhuyanpur	Jamuna	
3	Aricha (Teota)	Jamuna	
4	Hardinge Bridge	Ganges	
5	Baruria	Padma	
6	Mawa	Padma	
7	Mymensingh	Old Brahmaputra	
8	Tilly	Dhaleswari	
9	Gorai off-take	Gorai	
10	Arial Khan	off-take	Arial Khan
11	Bhairab Bazar	Megna	

Location of AWLR gauges

from FAP (1995)

FLOOD TYPES

0 20 40 60 80 100 km



- above normal flood levels
- rainfall floods
- river flooding .. normal
- river flooding .. extreme (1988)
- flash floods
- tidal flooding

from FAR (1000)

APPENDIX D: TABLES

(to be completed)

Table 1. Areas under different types of inland water bodies

Water types	Area (hectares)
A. OPEN INLAND WATERS	
1. Rivers	
Ganges	27,165
Padma	42,325
Jamuna	73,666
Meghna (upper)	33,592
Meghna (lower)	40,407
Other rivers and canals	262,580
	479,735 a/
2. Estuarine area	551,828 a/
	1,031,563 a/
3. Beels and Haors	114,161 b/
	1,145,724 a/
4. Inundable floodplains	5,486,609 b/
5. Kaptai lake	68,800 a/
B. CLOSED WATERS	
1. Ponds	146,890 c/
2. Baors (Oxbow lakes)	5,488 c/
3. Brackishwater farms	108,000 d/

Sources :

a/ MPO (1986)

b/ MPO (1987, b)

c/ Water-area Statistics of Bangladesh. Fisheries Information Bulletin-Vol. 3. No. 1, DOF, 1986.

d/ DOF Survey of 1988-89.

from Ali (1991)

● MARINE WATER RESOURCES :

a. AREA :

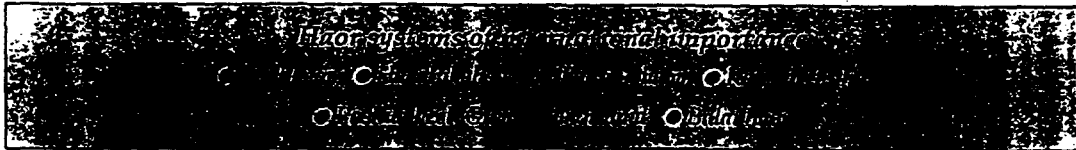
1. Coast Line	-	- 480km - 298 miles
2. Base Line	Upto 10 fathom depth from Coast Line	-
3. Internal Water	Upto Base Line	-7,325 sq.nautical mile -25,151 sq.km -25,15,100 ha
4. Territorial Water	Upto 12 nautical mile from Base Line	-2,640 sq.nautical mile -9,065 sq.km -9,06,470 ha
5. Exclusive Economic Zone (EEZ)	200 nautical miles from Base Line (this includes Territorial Waters)	-41040 sq.nautical mile -1,40,915 sq.km -1,40,91,500 ha
6. Total Marine Water area	Internal Water + EEZ	-48365 sq.nautical mile -1,66,066 sq.km -1,66,06,600 ha
7. Continental Shelf (upto 40 fathom depth)	excluding Internal and Territorial Waters	-24800 sq.nautical mile -85,153 sq.km -85,15,300 ha

from DOF (1997)

THE HAOR BASIN

It encompasses the floodplains of the Meghna tributaries and is characterised by the presence of numerous large, deeply flooded depressions known as haors between the rivers. The basin is bounded to the north by the hill ranges of Meghalaya (India), to the south by the hills of Tripura and Mizoram (India) and to the east by highlands of Manipur (India). This vast alluvial plain includes about 6,000 permanent shallow waterbodies known as beels surrounded by larger areas of seasonally flooded plains. The numerous rivers rising in the hills of India provide an abundant supply of water to the plains and cause extensive flooding during the monsoon upto a depth of six meters. During the dry season, most of the water drains out leaving one or more shallow beels which become mostly overgrown with aquatic vegetation or completely dry out by the end of dry season exposing rich alluvial soils extensively cultivated for rice. The haor basin includes about 47 major haors and some 6,300 beels of varying size, out of which about 3,500 are permanent and 2,800 are seasonal.

The haor systems support major subsistence and commercial fisheries, major rice growing, rich grazing ground for livestock and serve as a source of fuel, food and fertilizers for the local populations. They are home to a very wide variety of resident and migratory waterfowl including innumerable ducks, and provide refuge for many other species of wildlife. The swamp forests which were once dominant with the flood tolerant tree species like hijal (*Barringtonia acutangula*), and Koroch (*Pongamia pinnata*) have been reduced to a few small patches.



Hakaluki haor

Hakaluki haor consists of a large group of beels surrounded by heavy grazed grassland and ricefields. Despite high level of disturbance from hunters and fishermen, the haor remains very important for wintering ducks and migratory shore birds.

from Khan et al (1994)

Tangra haor

It is perhaps the largest natural wetland of the haor basin with relatively extensive stands of emergent and submerged aquatic plants of outstanding importance for its large and diverse waterfowl populations. This forms the core area of the northern haor system consisting of a group of koroch beds that are still in a near natural condition and has a major concentration of waterfowl.

Kawadighi haor

It comprises of two large shallow beels and a smaller beel. Despite the Manu River Project within which the haor lies it remains very important for a wide variety of waterfowl. The large areas of rotting aquatic vegetation and the exposed mud are particularly attractive to shore birds and several species of herons and egrets.

Pashua beel, Gurmar haor

The entire area consists of about 400 ha of a large Pashua beel with two smaller beels in the extreme southern portion of Gurmar haor. The surrounding high ground is relatively undisturbed with dense stands of koroch (*Pongamia pinnata*) which appear to be the best remaining part of the swamp forest, and large area of tall grasses and patches of shrubbery supporting a high diversity of waterfowl and other wetland birds. The vegetation provides secure roosting site for cormorants, herons, and egrets the number of which was recorded as at least 4,600 in late April of 1992, and also supports a number of species scarce elsewhere, viz. Purple heron, Black headed ibis, Spot-billed duck and Purple swamp hen. A globally threatened Pallas's sea-eagle was also observed here.

Balai Haor

It is an isolated haor between Surma and Kushiyara rivers including three beels surrounded by heavily grazed pasture land and rice fields. The haor is of considerable importance as a staging area for passage migrants. At least two threatened bird species, viz. Lesser adjutant and Pallas's fish eagle, were sighted in this area, and a presence of large concentrations of ducks (over 32,000 in late March 1992) was recorded when water level was high.

(from Khan et al (1994))

Table xx. Marine fish species and other aquatic biota of Bangaldsh

Fish:

Total fish species:	475
Families:	138
Commercially important fishes:	90

List of some commercially important bony fishes :

<u>Scientific name</u>	<u>English name</u>
Pampus chinensis	Chinese pomfret
Pampus argentens	Silver pomfret
Polyneonus indicus	Indian salmon
Hilsa ilisa	River shed
Latis calcarifer	Sea bas
Euthynus affinis	Tuna
Trichiurus haumela	Ribbon fish
Pamadasys hasta	White snappers
Sillago domina	Lady fish
Rostrelliger kanagurta	Indian mackerel
Haspodon nereus	Bomby duck

Sharks and Rays

Total species of cartilaginous fishes:	21
Genera:	11

Some dominant species:

<u>Scientific name</u>	<u>English name</u>
Sphyrna blochii	Wing head shark
Scoliodon sorrakowa	Spade nose shark
Pristis cuspidatus	Saw shark
Dayatis narnak	Ray

Shrimps :

Total species:	36
Dominant genera	3

Most important species:

<u>Scientific name</u>	<u>English name</u>
Penaeus monodon	Giant tiger shrimp
Penaeus indicus	white shrimp
Penaeus merguianus	Banana shrimp
Penaeus semisulcatus	Tiger shrimp

Metapenaeus monoceros	Brown shrimp
Metapenaeus brevicornis	Brown shrimp

Lobsters :

Total species 5

Scientific name

Panulirus polyphagus

Panulirus versicolor

Panulirus ornatus

Panulirus honorus

Thenus orientalis

English name

Mud spiny lobster

Painted spiny lobster

Painted spiny lobster

Slipper lobster

Crabs :

Total species 50

Families 7

Important species:

Scientific name

Scylla serrata

Calappa lophos

Cryptopodia angulata

Plagusia depress

Cephalopods :

Scientific name

Sepia officinalis

Loligo spp.

Octopus spp.

English name

Cuttle fish

Squids

Octopus

Other molluscs :

Commercially important marine molluscs:

Umbonium spp.

Lambis spp.

Cypraea spp.

Tonna spp.

Babylonia spp.

Oliva spp.

Perna spp.

Turtles :

Total number of species: 3

Most important species is Chelone mydas (Green turtle)

Crocodiles :

Total number of species: 2

Scientific name

Crocodilus porosus

Gavialis gangeticus

Corals :

Total number of genera: 13

Families: 6

- Stylophora Acropora
 Anacorpora Porites
 Asteropora Favia
 Povona Coniastrea
 Favorites Monastrea
 Pocillopora Stylocoenietla
 Madracis

Table 2 Percentage of arable lands in each salinity class

Administrative region	Arable lands (1,000 ha)	Percentage of arable lands				Total (%)	Saline area (1,000 ha)
		S ₁	S ₂	S ₃	S ₄		
Khulna	549.6	9.6	47.2	9.9	3.8	70.5	387.5
Barisal	620.0	3.0	10.2	—	—	13.2	81.8
Patuakhali	374.1	45.5	14.4	—	—	59.9	224.1
Noakhali	487.3	3.6	10.9	1.2	—	15.7	76.5
Chittagong	678.3	4.4	4.6	3.7	2.8	15.5	105.1
	2 709.3	10.7	17.0	3.1	1.5	32.3	875

Source: MPO as computed from SRDI and SODAPS data base (1985).

Note:

Salinity class	Salinity level (micro-mhos/cm)
S ₀	0 - 2 000
S ₁	2 000 - 4 000
S ₂	4 000 - 8 000
S ₃	8 000 - 15 000
S ₄	> 15 000

from United Nations (1989)

Table 1. List of transplanted of some exotic fishes into Bangladesh

Serial	Name of the Species	Common name	Natural habitat	Source	Year of introduction	Purpose	Remarks
1.	Tilapia mossambica	Tilapia	Africa	Thailand	1954	Insect control Experimental culture.	Well established in pond
2.	Tilapia nilotica	Nilotica	do	Thailand	1974	-do-	-do-
3.	Hypophthalmichthys molitrix	Silver Carp	China	Hongkong	1969	Experimental culture	Propagated and established in ponds
4.	Ctenopharyngodon idella	Grass Carp	China	Hongkong	1966	Weed control and experimental culture	-do-
5.	Aristichthys nobilis	Bighead	China	Nepal	1981	Experimental culture	-do-
6.	Mylopharyngodon piceus	Black Carp	China	China	1983	-do-	Under observation in ponds of Aquaculture Experiment Station, Mymensingh and Raipur Fish Hatchery
7.	Trichogaster pectoralis	Courami	Thailand	Singapore	1952	Insect control Experimental culture.	Did not survive
8.	Carassius auratus	Gold fish	Europe, Asia	Pakistan	1953	Aquarium decoration.	Used for decoration of aquarium & cement tanks
9.	Cyprinus carpio var. communis	Scale carp common carp	Temperate Asia, Europe	Not known	1960	Experimental culture	Established in ponds/tanks of Comilla, Noakhali, Jessore
10.	C. carpio var. specularis	Mirror carp	do	Nepal	1979	do	Under study in ponds of Raipur Hatchery and Aquaculture Experiment Station, Mymensingh
11.	Puntius gonionotus	Sawer punti	Thailand	Thailand	1977 and 1986	Culture	To obtain increased fish biomass production
12.	Clarias gariepinus	Cat fish	Africa	Thailand	1989	-do-	-do-
13.	Pangasius sutchi	Large Catfish	South-east Asia	Thailand	1989	-do-	-do-

Source : (1) Rahman, A.K. Ataur. (1985)

(2) Item Nos. 11-13 are based on information collected by this author

from Ali (1991)

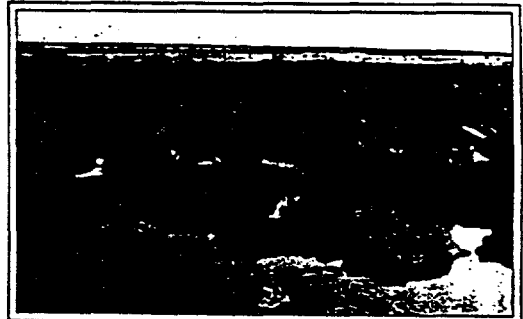
THE UNDEREXPLORED CORAL REEF IN THE BAY

The coral reef on the northern end of Narikel Jinjira (St. Martin's Island) extending into the bay between Teknaf and the island has never been scientifically investigated apart from taxonomic and ecological studies on the algal flora associated with the coral rocks near the shore. The activities of the coral colonies result in calcium carbonate deposit which is so important for the protection of the island and as a habitat for marine algae, a variety of fish, molluscs and other coelenterates. The sea weeds associated with the reef have a great potential as food and medicine if properly managed towards sustainable development or commercially cultivated.

The recent reports indicate extensive damage to this habitat resulting in an alarming degree of depletion of the associated algal flora. The coral rocks are being bodily removed to be used as fences around some of the houses near the shore. Direct physical damage to corals by the traders, who cut them up into pieces for sale, is the primary cause for the loss. Corals are very sensitive to environmental conditions and have highly specific requirements of light, temperature, water clarity, salinity and oxygen. Due to heavy pollution caused by dumping fish entrails in the shorewater soon after the fish landings and oil spills by the mechanized boats there will be a mass expulsion of the sensitive symbiotic zooxanthellae which live in the coral tissues. This will cause the death of coral colonies.

There have been scarcely any organized programmes involving diving and underwater photography towards obtaining scientific information regarding the status of the reef in the deeper part of the bay. There is a need for educational programmes on the

importance of reef but there is little investment in this field. Reef-related activities could become a major element in tourism and have positive economic benefits through recreation and education in the form of glass-bottom boat rides which are now the traditional tourist attraction in Green Island (northeastern Australia), Fiji and other islands of the South Pacific. The immediate need is to arrest the onslaught on the already damaged reef so that it may regenerate naturally and to prevent further pollution of shore waters to help sustainable development of both the coral colonies and the associated algal flora. Trade in the corals and the associated shells and other fauna should be immediately stopped by legislation and adequate protection given to the reef. If there is sufficient commitment on the part of the government and the people of Bangladesh the reef can be protected from insidious degradation. The area can be declared as a marine park prohibiting oil exploration, mining for limestone, littering, fishing and collection of corals, shells or other invertebrates.



The exposed coral rocks near St. Martin's island during ebb tide. The coral rocks are being used as fences resulting in depletion of associated algal flora. Photo by M S Khan

from Khan et al (1994)

BHERI FISH CULTURE IN THE COASTAL DISTRICTS

The brackish water aquaculture of shrimp and fin fish known as 'Bheri fish culture' was in existence for centuries in Satkhira of Khulna district. Large land owners used to encircle a chunk of land with dwarf dykes provided with small canals and wooden sluice gates connecting the enclosed area with tidal rivers or khals. Tidal water carrying juveniles of salt water shrimps and fin fish was allowed to enter the enclosed area during spring tides in the months of February to April. The trapped young were then reared for about four months before they were harvested for marketing. On the onset of monsoon, the land within the dykes was repeatedly washed with rain and became suitable for growing local transplanted aman rice during July to December. More than 100 such rice-cum-shrimp farms were in operation in Satkhira region around 1950. This tradition of Bheri fish culture came to an end with the construction of coastal embankments which have adversely impacted the natural life cycles of many fish and prawn inhabiting the sea and the estuaries. The international demand for shrimp led to the resumption, in the seventies, of brackish

water aquaculture within and outside the polders. Social conflicts which arose as a consequence over land tenure and user rights appeared to have declined as shrimp farming operations were placed under the control of upazila committees by a notification in 1986. The area under shrimp aquaculture, however, has steadily increased in the districts of Satkhira, Khulna and Bagerhat in the southwest region and Cox's Bazar district in the southeast region of Bangladesh.



Bheri fish culture in Cox's Bazar district. Note the dwarf dykes and the damage to the trees. Photo by Rashid/NACOM

Source : Ali M Y 1990

from Khan et al (1994)

OVERFISHING AND THE VANISHING FISH SPECIES

Studies on the populations of fish and prawn and their stock assessments in Bangladesh are virtually non-existent. It is hardly possible to relate overfishing to the decline of the stocks of different species. However, due to increase in the human population and consequent increase in the demand for fish, fishing pressures are intensifying every year. This is believed to have caused overfishing of all the stocks and populations of fish and prawn by the use of even banned gears and methods.

The decline or reduction in the stocks of different fish and prawn can perhaps be attributed to combined or synergistic effects of environmental modifications, water quality degradation by pollution, fish epidemics caused by ulcerative disease and heavy fishing pressure on the populations in different stages of their life cycles.

The fact, however, remains that many species of fin fish, once abundant, have now become rare. A listing of such species is lacking. Some of the important species which have either become extinct

or very rare are :

- a) *Labeo nandina* (Nandail) from waters in NE region.
- b) *Tor tor* (Mahseer) from waters in NE region.
- c) *Channa barca* (Pipla shol) from water in NE region.
- d) *Channa punctatus* (Taki) from all over the country.
- e) *Bagarius bagarius* (Bagh-Air) from the Gangetic waters in N-W region.
- f) *Rita rita* (Rita) from all over the country.
- g) *Puntius ticto* (Tit punti) from all over the country.
- h) *Silonia silondia* (Silond) from all over the country.
- i) *Eutropichthys vacha* (Bacha) from all over the country.
- j) *Scatophagus argus* (Bistara) from the estuarine water.

Proper investigations are necessary for preparing a list of rare or extinct species of fish and other aquatic animals.

from Khan et al (1994)

**IMPACT OF THE CHANDPUR FLOOD CONTROL AND
IRRIGATION PROJECT ON FISH SPECIES**

Species adversely affected	Species beneficially impacted
Freshwater fish	<i>Badis badis</i>
<i>Labeo rohita</i>	<i>Aplocheilus panchax</i>
<i>L. calbasu</i>	<i>Puntius gelius</i>
<i>L. gonius</i>	<i>Puntius puntius</i>
<i>Catla catla</i>	<i>Colisa fasciata</i>
<i>Cirrhinus mrigala</i>	<i>Ompok pabda</i>
Tidal/Estuarine fish	<i>Esomus danricus</i>
<i>Hilsa ilisha</i>	<i>Brachygobius nunnus</i>
<i>Pangasius pangasius</i>	<i>Channa marulius</i>
<i>Rhinomugil corsula</i>	<i>Chanda ranga</i>
<i>Glossogobius giuris</i>	<i>Notopterus: notopterus</i>
<i>Doryichthys cuncalus</i>	<i>Heteropneustes fossilis</i>
<i>Oryzias melanostigma</i>	<i>Mystus vittatus</i>
<i>Awaous stamineus</i>	<i>Mystus tergara</i>
<i>Corica soborna</i>	
<i>Sicamugil cascasia</i>	
<i>Leiognathus equulus</i>	
<i>Gobiopterus chuno</i>	
<i>Odontamblyopus rubicundus</i>	
<i>Pseudapocryptes lanceolatus</i>	
<i>Trypauchen vagina</i>	
<i>Scipinina phasa</i>	
<i>Macragnathus aculeatus</i>	

Source: Master Plan Organization (MPO) 1987 (in: WARPO)

from Khan et al (1994)

Table - ● Endangered Threatened Wildlife of Bangladesh (Tentative list)

* C- Common; E= Endangered; F= Fairly Common; T= Threatened; VC= Very Common

English name	Scientific name	Status	
		Past (i.e. early this century)	Present
Amphibia			
Green Frog	<i>Rana hexadactyla</i>	C*	T
Bull Frog	<i>R. tigrina</i>	VC	T
Reptilian			
Salt water/Estuarine Crocodile	<i>Crocodylus porosus</i>	C	E
Gharial	<i>Gavialis gangeticus</i>	C	E
Olive Ridley Turtle	<i>Lepidochelys olivacea</i>	C	E
Green Turtle	<i>Chelonia mydas</i>	C	E
Hawksbill Turtle	<i>Eretmochelys imbricate</i>	C	E
Loggerhead Turtle	<i>Caretta Caretta</i>	C	E
Leathery Turtle	<i>Dermochelys coriacea</i>	C	E
Batagur Turtle	<i>Batagur baska</i>	C	E
Bostami Turtle	<i>Trionyx nigricans</i>	C	E
Land Tortoise	<i>Geochelone emys</i>	C	E
Grey Lizard	<i>Varanus bengalensis</i>	C	T
Monitor/Ring Lisard	<i>V. salvator</i>	VC	T

Yellow Lizard	<i>V. flavescens</i>	C	T
Clouded/Black Lizard	<i>V. nebulosa</i>	C	T
Rock Python	<i>Python molurus</i>	FC	E
King Cobra	<i>Ophiophagus hannah</i>	FC	E
Dogfaced Water Snake	<i>Cerberus rhynchops</i>	C	T
Hook-nosed Sea Snake	<i>Enhydrina schistosa</i>	VC	T
Annulated Sea Snake	<i>Hydrophis cyanocinctus</i>	C	T
Banded Sea Snake	<i>H. fasciatus</i>	C	T
Estuarine Sea Snake	<i>H. obscures</i>	C	T
Common Narrowheaded Sea Snake	<i>Microcephalophis gracilis</i>	C	T
Cantor's Narrowheaded Sea Snake	<i>M. cantoris</i>	C	T
Aves			
Little Grebe	<i>Podiceps ruficollis</i>	VC	T
Darter/Snakebird	<i>Anhinga rufa</i>	FC	T
Purple Heron	<i>Ardea purpurea</i>	FC	E
Grey Heron	<i>A. cinerea</i>	C	T
Openbill Stork	<i>Anastomus oscitans</i>	C	E
Lesser Adjutant	<i>Leptoptilos javanicus</i>	FC	E
Whitenecked Stork	<i>Ciconia Episcopal</i>	FC	E
Glossy Ibis	<i>Plegadis facileness</i>	FC	E
Spoonbill	<i>Platalea leucorodia</i>	FC	E
Large Whistling Teal	<i>Dendrocygna bicolor</i>	C	E
Whitewinged Wood Duck	<i>Cairina scutulata</i>	F	E
Comb Duck/Nukta	<i>Sarkidiornis melanotos</i>	F	E
Blackwinged Kite	<i>Elanus caeruleus</i>	C	E
White bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	C	E
Pallas's Fishing Eagle	<i>H. leucoryphus</i>	FC	E
Greyheaded Fishing Eagle	<i>Ichthyophaga ichthyaetus</i>	C	T
Whitebacked Vulture	<i>Gyps bengalensis</i>	VC	T
Black Partridge	<i>Francolinus francolinus</i>	FC	E
Rain Quail	<i>Coturnix coromandelica</i>	C	E
Common Peafowl	<i>Pavo cristatus</i>	F	E
Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	FC	T
Painted Snipe	<i>Rostratula benghalensis</i>	FC	T
Brown Fish Owl	<i>Bubo zeylonensis</i>	C	E
Great Hombill	<i>buceros bicornis</i>	C	E
Hill Myna	<i>Gracula religiosa</i>	C	T
Paradise Flycatcher	<i>Terpsiphone paradisi</i>	FC	T
Mammalia			
Slow Loris	<i>Nycticebus coucang</i>	FC	E
Common Langur	<i>Presbytis entellus</i>	F	E
Crabeating Macaque	<i>Macaca fascicularis</i>	F	T
Hoolock Gibbon	<i>Hylobates hoolock</i>	C	E
Large Civet	<i>Viverra zibetha</i>	C	E
Bantering	<i>Arctictis binturong</i>	C	E
Fishing Cat	<i>Felis viverrina</i>	FC	E
Jungle Cat	<i>F. chaus</i>	FC	T
Tiger	<i>Panthera tigris</i>	FC	E
Leopard	<i>P. pardus</i>	C	T
Clouded Leopard	<i>Nefelis nebulosa</i>	FC	E
Asiatic Elephant	<i>Elephas maximums</i>	C	E
Barking Deer	<i>Muntiacus muntjak</i>	C	T
Sambar	<i>Curves unicolor</i>	C	T

Serow	<i>Capricornis sumatraensis</i>	F	E
Hispid Hare/ Assam Ribbat	<i>Caprolagus hispidus</i>	C	E*

Table xx. Extinct Wildlife Species of Bangladesh

Note: Species which have become extinct from Bangladesh during this century

Reptiles

Marsh Crocodile *Corcodylus palustris*

Birds

Pinheaded Duck *Rhodonessa caryophyllacea*
Burmese Peafowl *Pavo mulicus*
Greater Adjutant *Leptoptilos dubius*
King/Black Vulture *Scarcogyps calvus*
Bengal Florican *Euphodotis bengalensis*

Mammals

Great One-horned Rhinoceros *Rhinoceros unicornis*
Lesser One-horned Rhinoceros *R. sondaicus*
Asiatic Two-horned Rhinoceros *Didermocerus sumatrensis*
Blue Bull/Nilgai *Boselaphus tragocamelus*
Wild Buffalo *Bubalus arnee/bubalis*
Gaur *Bos gaurus*
Banteng *B. banteng*
Swamp Deer/Barasingha *Curves duvauceli*
Hog Deer *Axis porcinus*
Wolf *Canis lupus*
Marbled Cat *Felis marmorata*
Golden Cat *F. temmincki*

(From the presidential address of Prof. K. Z. Husain, 11th Annual Bangladesh Science Conference, 1986.)

List of Trees for Lowlying Areas (Including Exotics) : Compiled from Literatures

Botanical names and families	Habit and habitat	Geographical distribution	References
<i>Acacia seyal</i> Del. (Leguminosae)	Small tree.	It is native to the Sahelian zone from Senegal to Sudan, Egypt, S. Africa.	Nat. Academy of Science (1983), 2: 72
<i>Acronychia laurifolia</i> Blume (Rutaceae)	Tree. It usually occurs in marshy places or at higher elevation.	Northern India. In Bangladesh it occurs in the forests of Chittagong and Sylhet	Puri (1960), 1: 228
<i>Alstonia angustifolia</i> Wall. ex DC. (Apocynaceae)	Small tree. It tolerates the seasonal swamps and remain found in the low lands.	Singapore, Sumatra, Borneo and Selangor, Malacca, Johore in Malaysia.	Whitmore (1973), 2: 9
<i>Altingia excelsa</i> Noronha (Altingiaceae)	Medium tree. The soils which remain under water for the greater part of the rains are suitable for this species.	It is apparently restricted to limited areas in the Brahmaputra Valley.	Champion and Seth (1968): 168
<i>Anogeissus acuminata</i> Wall. (Combretaceae)	Tree. It is restricted to the savannah and swamp forests	Frequent in the mixed forests all over Burma from Ava down to Tenasserim. Occurs in the forests of Chittagong and Hill Tracts of Bangladesh.	Kurz (1877), 1: 466
<i>Aporosa aurea</i> Hk. f. (Euphorbiaceae)	Small tree. It can tolerate seasonal swamp.	Scattered throughout Malaya, Siam, Sumatra, Borneo. It is also found in Chittagong, Chittagong Hill Tracts, Sylhet of Bangladesh.	Whitmore (1973), 2: 59
<i>Beilschmiedia roxburghiana</i> Nees (Lauraceae)	Large tree.	It is found along rivers of Chotanagpur. Occurs in the forests of Sylhet and Chittagong of Bangladesh.	Haines (1908) : 151
<i>Bhesa paniculata</i> Arn. (Celastraceae)	Tall tree. It is found in well drained, riverine, swampy land including peat swamps, low land and mountains.	All states of Malaya, South India, Peninsular Siam and Malesia east to Philippines.	Whitmore (1972), 1: 161
<i>Bhesa robusta</i> (Roxb.) Hou (Kurnmia pulcherrima Wall.) (Celastraceae).	Tree. It is one of the most wide spread of Malayan trees in primary and secondary forests. Well drained riverine, swampy land including peat swamps, lowlands and mountains to 4500 ft.	Recorded throughout Malaya except Perlis, Trengganu and Johore; S. E. Asia from India and Indo-China to Sumatra and Borneo. Occurs in the forests of Chittagong, Cox's Bazar and Sylhet of Bangladesh.	Whitmore (1972), 1: 161

from Alam et al (1991)

Botanical names and families	Habit and habitat	Geographical distribution	References
<i>Bombacopsis quinatum</i> (Jacq) Dugand. (Bombacaceae)	Tall tree. It can tolerate free draining or seasonally water logged condition.	Found in Central and South America from Nicaragua to Venezuela.	Webb <i>et al.</i> (1980) : 70
<i>Calophyllum incrassatum</i> Henderson et Wayati-Smith (Guttiferae)	Tall tree. It is found sometimes in seasonal swamp.	Common species of the east coast, Kelantan southwards also Malacca and abundant in E. Johore, Borneo.	Whitmore (1973), 2 : 183
<i>Calophyllum kunstleri</i> King (Guttiferae)	Medium tree. It is found in the lowland forest, sometimes in fresh water swamps.	Malesia particularly in Negri Sembilan and Pahang (Rompin) southwards.	Whitmore (1973), 2 : 187
<i>Calophyllum macrocarpum</i> Hk. f. (Guttiferae)	Very big tree. It is found occasionally in seasonal swamp forest.	Throughout Malaya, commonest in the Centre, Borneo.	Whitmore (1973), 2 : 187
<i>Calophyllum soulattri</i> Burm. (Guttiferae)	Big tree. It is found occasionally in swampy forests.	SriLanka and India to the Solomon Island.	Whitmore (1973), 2 : 192
<i>Camposperma brevipetiolata</i> Volkens (Anacardiaceae)	Tall tree. It can tolerate moist and seasonally water logged condition.	It is available in the Solomon islands, Moluccas, New Guinea, Indonesia and Malaysia	Webb <i>et al.</i> (1984) : 117
<i>Colophospermum mopane</i> (Kirk ex Benth.) Kirk ex J. Leonard (Leguminosae)	Medium tree. It can tolerate moist or water logging condition.	It is available in the central and southern Africa and also naturalized in arid zones of India.	Webb <i>et al.</i> (1984) : 128
<i>Ctenolophon parvifolius</i> Oliv. (Linaceae)	Small, medium or occasionally large tree. It can tolerate seasonal swamp.	It is found in all states except Perak and Kelantan of Malaysia.	Whitmore (1972), 1 : 306
<i>Cyclostemon assamicus</i> Hook, f. (Euphorbiaceae)	A small tree.	Assam, Sundarban, Chittagong in Bangladesh	Puri (1960), 1 : 228; Singh (1982) : 533
<i>Dacryodes macrocarpa</i> (King) Lam (Burseraceae)	Tall tree. It is found in the low lands and lowlying swampy forests.	It is found in Perak, Selangor and Johore,	Whitmore (1972), 1 : 142
<i>Dialium patens</i> Baker (Leguminosae)	Big tree. It is common in lowlying swampy areas including peat swamp forests	It is found in Perak, Selangor, Malacca, Johore, Singapore.	Whitmore (1972), 1 : 260

Botanical names and families	Habit and habitat	Geographical distribution	References
<i>Duria carinatus</i> Masl (Bombacaceae)	Medium tree. It is found in the peat swamp forest.	It is found in Johore, E. Pahang, Sumatra, Borneo.	Whitmore (1972), 1: 109
<i>Dyera costulata</i> (Miq.) Hk. f. (Apocynaceae)	Medium tree. It is found in low lands, plains, low undulating country, occasionally in swampy places.	Throughout Malaya except Peries, Langkawi.	Whitmore (1973), 2: 15
<i>Elgeocarpus hygrophilus</i> Kurz (Elaeocarpaceae)	Tree. It is frequent in the swamp forest.	It is found in the alluvial plains of Pegu and Martaban and also upper Tenasserim.	Kurz (1877), 1: 168
<i>Engelhardtia serrata</i> Bl. (Juglandaceae)	Medium tree. It is found in peat swamps and lowlying fresh water alluvial swamps.	Penang, Kedah, Perak, Malacca, Johore, Singapore, Burma, Siam, Indo-China, Sumatra, Java, Borneo, Philippines, Celebes, Moluccas.	Whitmore (1972), 1: 236
<i>Eucalyptus botryoides</i> Sm. (Myrtaceae)	Tall tree. It can tolerate seasonally water logged condition.	It is available in Australia, Coastal Victoria and New South Wales.	Webb <i>et al.</i> (1984) : 140
<i>Eucalyptus camaldulensis</i> Dehnh. (Myrtaceae)	Tall tree. It can tolerate seasonally water logged condition	It is mainly found in Australia. Planted in Bangladesh	Webb <i>et al.</i> (1984) : 142
<i>Eucalyptus largiflorens</i> F. Muell. (Myrtaceae)	Medium tree. It can tolerate seasonally water logged condition.	It is found in semi arid areas of central Australia.	Webb <i>et al.</i> (1984) : 156
<i>Eucalyptus microtheca</i> F. Muell. (Myrtaceae)	Medium tree. It can tolerate seasonally water logged condition.	It is found in the arid and semi arid zones of North Australia.	Webb <i>et al.</i> (1984) : 161
<i>Eucalyptus occidentalis</i> Engl. (Myrtaceae)	Tall tree. It can tolerate seasonally water logged condition.	It is found in the semi arid zones of South Australia.	Webb <i>et al.</i> (1984) : 164
<i>Eucalyptus robusta</i> Sm. (Myrtaceae)	Tall tree. It can tolerate seasonally water logged condition.	The species is found in Australia and particularly in the coasts of S. Queensland and New South Wales.	Webb <i>et al.</i> (1984) : 170

Botanical names and families	Habit and habitat	Geographical distribution	References
<i>Eucalyptus sideroxylon</i> A. Cunn. ex Wolls.	Tall tree. It can tolerate seasonally water logged condition.	It is found in inland Victoria of Australia.	Webb <i>et al.</i> (1984) : 174
<i>Eucalyptus tereticornis</i> Sm. (Myrtaceae)	Medium tree. Along river banks and in alluvial valleys in many parts of the Australian continent.	It is found along the eastern Australian Coast from Southern Victoria to Queensland. Planted in Bangladesh.	Nat. Academy of Sciences (1983), 2 : 33
<i>Ganua motleyana</i> (de Vr.) Pierre ex Dubard (Sapotaceae)	Medium to very big tree. It can tolerate fresh water and peat swamps.	Throughout Malaya, Sumatra, Borneo.	Whitmore (1972), 1: 399
<i>Glochidion lanceolarium</i> Dalz. (Euphorbiaceae)	Tree. It is found in river beds and along the streams.	Mothronwala, Dehra Dun, India; Sylhet and Chittagong of Bangladesh.	Puri (1960), 1 : 228
<i>Gymnacranthera eugenifolia</i> (A. DC) Sinclair (Myristicaceae)	Tree. It is found in low land and hill forest and fresh water and peat swamps.	Common in Malaya, Sumatra Lingga, Banka, Sarawak and Sabah.	Whitmore (1972), 1: 320
<i>Hieronima chocoensis</i> Cuatrec. (Euphorbiaceae)	Tall tree. It can tolerate moist and seasonally water logged condition.	It is found from the Ecuador Coast to the Amazon Basin.	Webb <i>et al.</i> (1984): 187
<i>Horsfieldia irya</i> (Gaertn.) Warb. (Myristicaceae)	Medium to tall tree. It is found along rivers and near the east specially swampy places.	Throughout Malaya, very widespread, Andamans, Burma, Indo- China.	Whitmore (1972), 1: 326
<i>Hymenocardia plicata</i> Kurz (Euphorbiaceae)	Tree. It is found in the swamp forests and in swampy depressions of the Savannah forests.	It is found from Pegu and Martaban down to Tenasserim.	Kurz (1877), 2:395
<i>Jacaranda copaia</i> (Aubl), D. Don. (Bignoniaceae)	Medium tree. It can tolerate moist and seasonally water logged condition.	This species is available from Brazil at Tropical America.	Webb <i>et al.</i> (1984) : 188
<i>Kneria malayana</i> Warb (Myristicaceae)	Medium tree. It is found in low lands, occasionally in health or swampy forest.	Scattered through Malaya, Lower Siam, Sumatra.	Whitmore (1972), 1: 338
<i>Koompassia malaccensis</i> Maign ex Benth. (Leguminosae)	A very big tree. It is found in peat and fresh water swamps.	Abundant throughout Malaya.	Whitmore (1972), 1: 265

Botanical names and families	Habit and habitat	Geographical distribution	References
<i>Lithocarpus urceolaris</i> (Jack) Merr. (Fagaceae)	Big tree. It is found in low land and lower montane rain forest, also in secondary and swampy forest often on volcanic soil.	Panang trangane, E. Johore, Sumatra, Borneo, etc.	Whitmore (1972), 1: 227
<i>Litsea angustifolia</i> Wall. (Lauraceae)	Bushy shrub, usually growing on rocks near water edge.	Sibsagar, Sylhet, Lushai hills, Cachar, Manipur, Garo hills.	Kanjilal <i>et al.</i> (1940), 4: 87
<i>Lophopetalum multinervium</i> Ridley (Celastraceae)	Medium to big tree. It is found in swamp forest especially on shallow peat.	Perak, Pahang, Johore and Singapore, E. Sumatra, Borneo.	Whitmore (1972), 1: 168
<i>Lophostemon suaveolens</i> (Soland) ex Gaertn. (Myrtaceae)	Tall shrub or small tree. It tolerates infertile and periodically water logged soils.	It is found in Queensland, Irian, Jaya, Indonesia and Papua New Guinea.	Turnbull (1986) : 270
<i>Mangifera longipes</i> Griff. (Anacardiaceae)	Tree. It is frequent in the swamp forest.	It is frequent in the swamp forest of the Pegu plains, also in Tenasserim; and Chittagong in Bangladesh.	Kurz (1877), 1: 303
<i>Melaleuca cajuputi</i> Powell (Myrtaceae)	Tree. It grows on water logged soils in the lowland tropics.	Malaysia and Indonesia.	Turnbull (1986) : 276
<i>Melaleuca leucadendra</i> (L.) L. (Myrtaceae)	Tree. It can tolerate water-logged soils in the lowland tropics.	It occurs mainly in coastal areas of tropical Queensland. The northern territory and western Australia. It is also found in Papua New Guinea, Irian, Jaya and Maluku provinces in Indonesia.	Turnbull (1986) : 278
<i>Melaleuca quinquenervia</i> (Cav.) S. T. Blake (Myrtaceae)	A small or medium sized tree. It can tolerate continuous or periodic flooding in the humid and subhumid tropics.	Eastern Australia from near Sydney in New South Wales to northern Queensland. It extends into southern Papua New Guinea and Irian Jaya and Indonesia.	Turnbull (1986) : 282
<i>Melaleuca symphyocarpa</i> F. Muell. (Myrtaceae)	Small tree. It is adapted in the periodically waterlogged soils in the low lying tropics.	It is found in the northern parts of Queensland and the Northern Territory of Australia and extends on Southern Papua New Guinea.	Turnbull (1986) : 286

Botanical names and families	Habit and habitat	Geographical distribution	References
<i>Melaleuca viridiflora</i> Sol. ex Guertner. (Myrtaceae)	A small tree. It can tolerate seasonally water logged sites.	It occurs throughout much of northern Australia and extends into Southern Papua New Guinea, Irian, Jaya, Indonesia.	Turnbull (1986) : 288
<i>Mesua kochummeniana</i> Whitmore (Guttiferae)	Medium to big tree. It is found often in the drier parts of seasonal swamp forests, also on low hills.	Low land South and South East Johore and also S. E. Pahang in G. Lesong.	Whitmore (1973), 2: 234
<i>Mesua lepidota</i> T. Anders (Guttiferae)	Small to medium tree. It is found in low lands, plains sometimes in seasonal swamp forest.	Trengganu Pahang, Perak, Selangor, Negri, Sembilan, Malacca, Johore, Sumatra, etc.	Whitmore (1973), 2:235
<i>Morindopsis capillaris</i> Kz. (Rubiaceae)	Tree. Frequent in swamp forests.	Frequent in the swamp forest of Pegu and Maraban down to Tenasserim.	Kurz (1877), 2 : 52
<i>Musanga cecropioides</i> R. Br. (Urticaceae)	Medium tree. It can tolerate seasonally waterlogged condition.	It is found in west and Central Tropical Africa	Webb et al. (1984) : 196
<i>Myristica elliptica</i> Hk. f. et Thom. (Myristicaceae)	Medium to large tree. It is found in seasonal and permanent swamps, river banks, less often in undulating country.	Common throughout Malaya, Siam, Sumatra, Billiton and Borneo.	Whitmore (1972), 1 : 342
<i>Neesia malayana</i> Bakh. (Bombacaceae)	Big tree. It is found in fresh water swamp forest.	Trengganu, Pahang, S. Johore, Singapore, Sumatra, Borneo.	Whitmore (1972), 1 : 118
<i>Palaquium burckii</i> Lamk. (Sapotaceae)	Tall tree. It is found in peat swamp forest.	S. W. Johore (Pontian), Riouw, Sumatra.	Whitmore (1972), 1 : 419
<i>Palaquium macrocarpum</i> Burk (Sapotaceae)	Medium tree. It can tolerate fresh water swamp.	Selangor, Johore, Mawai, Sumatra.	Whitmore (1972), 1 : 422
<i>Palaquium ridleyi</i> K. et G. (Sapotaceae)	Big tree. It is scattered in peat swamps, fresh water swamps of seasonal swamps.	Perak, Selangor, Pahang, Johore and Singapore,	Whitmore (1972), 1 : 426
<i>Palaquium xanthochymum</i> (de Vr.) Pierr. (Sapotaceae)	Big tree. It is found in fresh water swamps and nearby low hill sides.	Trengganu, Perak, Pahang, Selangor, Johore, Singapore, Sumatra, Riouw, Lingga, Java, Borneo, Luzon.	Whitmore (1972), 1 : 428

Botanical names and families	Habit and habitat	Geographical distribution	References
<i>Pimelodendron griffithianum</i> (M.A.) Senth. (Euphorbiaceae)	Medium to big tree. It is found in low lands to 300 m. mainly hill sides and also in swampy places.	Common in all states of Malasia, except Perles, Kedah and Penang.	Whitmore (1973). 2 : 125
<i>Pinus carbaea</i> Morelet var. <i>hondurensis</i> (Senecl) Barr. and Golf (Pinaceae)	Tall tree. It prefers free draining and occasionally seasonally water logged condition is also preferable.	The species is found in Atlantic Coast of Central America from Brazil to N Nicaragua.	Webb <i>et al.</i> (1984) : 210
<i>Pinus ellottii</i> Engelm var. <i>ellottii</i> (Pinaceae)	Tall tree. It prefers free draining and can also tolerate seasonally waterlogged condition.	Coastal plains of South Eastern U. S. A	Webb <i>et al.</i> (1984) : 212
<i>Pinus taeda</i> L. (Pinaceae)	Tall tree. It tolerates moist and seasonally waterlogged condition.	Eastern and South Eastern U. S. A.	Webb. <i>et al.</i> (1984) : 231
<i>Polyalthia glauca</i> (Hassk.) Boerl. (Annonaceae)	Medium sized tree.	It is rare but widespread in the swamp forest of Malasia.	Whitmore (1972). 1 : 88
<i>Polyalthia hypoleuca</i> Hk. f. et Thom. (Annonaceae)	Medium sized tree. It is common in peat swamp forest.	All states except Perlis, Kedah, Sumatra, Borneo.	Whitmore (1972). 1 : 88
<i>Populus celtoides</i> Bartr. var <i>deltoides</i> (Salicaceae)	Tall tree. It can tolerate free draining, moist and also occasionally seasonal waterlogged condition.	The natural occurrence of this species is the Missouri-Mississippi basin of U. S. A.	Webb <i>et al.</i> (1984) : 232
<i>Prosopis cineraria</i> (L.) Druce (Leguminosae)	Small tree. It can tolerate both free draining and seasonal water logged condition.	India and Near East.	Webb <i>et al.</i> (1984) : 234
<i>Prosopis tamarugo</i> F. Phil. (Leguminosae).	Small tree. It can tolerate seasonally water logged condition.	It is available in Northern Chile.	Webb <i>et al.</i> (1984) : 236
<i>Salix babylonica</i> L. var. <i>sacramenta</i> (Salicaceae)	Small tree. It can tolerate moist and seasonally water logged condition.	It is found in Far East Europe, many warm-temerate to subtropical countries. This variety developed in Brazil.	Webb <i>et al.</i> (1984) : 239
<i>Santiria laevigata</i> f. <i>glabrifolia</i> (Engler) Lam. (Burseraceae)	Tall tree. Peat swamp forests.	Mainly in Selangor and Johore, mainly restricted to peat swamp forests, Sumatra Borneo.	Whitmore (1972). 1 : 150

Botanical names and families	Habit and habitat	Geographical distribution	References
<i>Sesbania grandiflora</i> (L.) Poir. (Leguminosae)	Small tree. It tolerates seasonal water logging.	The natural occurrence of this species are South East Asia from India, through Malaysia, Indonesia to the Philippines, Bangladesh.	Webb <i>et al.</i> (1984) : 243
<i>Tabebuia rosea</i> (Betrol.) DC. (Bignoniaceae)	Medium tree. It prefers free drainage and can also tolerate seasonally waterlogged condition.	The natural occurrence of this species are southern Mexico to Venezuela and Ecuador including West-Indies.	Webb <i>et al.</i> (1984) : 246
<i>Terminalia brassi</i> Exell. (Combre- taceae)	Tall tree. It can tolerate moist and seasonally water logged condition.	The natural occurrence of this species are Solomon Islands, Bougainville and New Ireland.	Webb <i>et al.</i> (1984) : 250
<i>Terminalia ivorensis</i> A Chev. (Combre- taceae)	Tall tree. It can tolerate free draining and even seasonally waterlogged conditions.	The natural occurrence of this species are West Africa from Guinea to Cameroon.	Webb <i>et al.</i> (1984) : 252
<i>Xanthophyllum</i> <i>glaucum</i> Wall. (Polygalaceae)	Tree. Common in the swamp forests and around inundated jungle swamps of the alluvial plains.	Base of hills of Pegu and Martaban and Tenasserim.	Kurz (1877). 1 : 81

LIST OF COMMON PLANTS IN THE SUNDARBAN FORESTS

Scientific name	Family	Vernacular name	Type of plant
<i>Acrostichum aurcum</i>	<i>Pteridiaceae</i>	Hodo, tiger fern	Gregarious fern
<i>Aegialitis rotundifolia</i>	<i>Plumbaginaceae</i>	Dhalehaka	Small tree
<i>Avicennia officinalis</i>	<i>Avicenniaceae</i>	Baen	Tree
<i>Bruguiera gymnorhiza</i>	<i>Rhizophoraceae</i>	Kankra	Tree
<i>Ceriops decandra</i>	<i>Rhizophoraceae</i>	Goran	Shrub or small tree, usually coppice
<i>Dalbergia spinosa</i>	<i>Leguminosae</i>	Chanda katta	Scandent, armed shrub
<i>Excoecaria agallocha</i>	<i>Euphorbiaceae</i>	Gewa	Tree
<i>Heritiera fomes</i>	<i>Sterculiaceae</i>	Sundri	Tree
<i>Myriostachya wightiana</i>	<i>Gramineae</i>	Dhanshi	Grass, common on new accretions
<i>Nypa fruticans</i>	<i>Palmae</i>	Golpatta	Palm with underground stem
<i>Phoenix paludosa</i>	<i>Palmae</i>	Hental	Thorny palm
<i>Sonneratia apatala</i>	<i>Sonneratiaceae</i>	Keora	Tree
<i>Xylocarpus mekongensis</i>	<i>Meliaceae</i>	Passur	Tree

from United Nations (1989)

Table 1 Contribution to National Pollution Load by Selected Sectors and Pollutants

ISIC	ISIC Description	% Employment	Toxic Chemicals to Land	Toxic Chemicals to Air	Toxic Metals to Water	BOD	SO2	Total Particulates	# of pollutants with > 5% contribution
3211	SPINNING, WEAVING AND FINISHING TEXTILES	45.78	14.02	21.72	8.20	10.72	23.60	7.11	6
3720	NON-FERROUS METAL BASIC INDUSTRIES	0.78	12.01	6.52	6.10	13.41	13.28	1.88	5
3710	IRON AND STEEL BASIC INDUSTRIES	1.34	12.09	3.04	53.55	0.07	8.67	3.88	3
3118	SUGAR FACTORIES AND REFINERIES	2.70	2.02	0.61	0.00	41.34	11.13	12.42	3
3511	BASIC INDUSTRIAL CHEMICALS EXCL. FERTILIZERS	0.10	6.25	2.59	8.09	3.08	0.80	0.22	2
3692	CEMENT, LIME AND PLASTER	0.17	0.03	0.01	0.00	0.00	10.42	8.49	2
3231	TANNERIES AND LEATHER FINISHING	0.78	15.64	8.40	1.56	1.90	0.36	0.07	2
3512	FERTILIZERS AND PESTICIDES	0.89	10.03	10.66	2.09	0.36	0.79	0.37	2
3115	VEGETABLE AND ANIMAL OILS AND FATS	0.90	4.65	1.15	0.06	2.19	10.47	18.06	2
3529	CHEMICAL PRODUCTS NEC	0.94	1.76	5.58	6.31	0.06	2.28	1.34	2
3140	TOBACCO MANUFACTURES	4.22	0.53	7.71		0.08	5.65	0.18	2
3522	DRUGS AND MEDICINES	1.78	8.99	8.55	0.58	0.64	1.71	0.54	2
Subtotal, % Contribution to nation-wide Load		60.37	88.02	76.64	86.55	71.84	89.15	54.56	
3112	DAIRY PRODUCTS	0.23	0.19	0.53	0.00	15.14	0.02	0.02	1
3116	GRAIN MILL PRODUCTS	4.78	0.13	0.04	0.00	0.00	1.21	10.07	1
3411	PULP, PAPER AND PAPERBOARD	0.08	1.02	0.31	1.50	6.83	1.11	0.38	1
3691	STRUCTURAL CLAY PRODUCTS	4.31	4.80	1.53	3.45	0.01	2.51	32.10	1
Subtotal, % Contribution to nation-wide Load		69.77	94.16	78.57	91.50	93.82	94.02	97.13	

from Hettige and Brandon (1997)

Table 2. Estimated amount of pesticides and other persistent organics used in agriculture in Bangladesh and probable pollution load in sea water

Persistent organics by type	Sales of pesticides throughout the country, July 1984-June 1985 (tons)	Amount received by coastal water through river run-off (tons/year)	Direct discharge or dumping in coastal water (tons/year)	Estimated pollution in Bay of Bengal (tons/year)
Organo-mercurial fungicides	0	—	—	0
Halogenated hydrocarbons	40.6120	10.453	—	10.153
Carbamates	891.805 ^a	222.95	—	222.95
Polychlorinated biphenyls	0	0	—	0
Organo-phosphorus	1 991.2642 ^a	498.06	—	498.06
Other toxic agro-chemicals	74.328 ^a	18.582	—	18.582
DDT	1 038.00 ^b	250.00	—	250.00

Note: It is assumed that 25 per cent of the total amount used may reach the coastal water and cause pollution of sea water. During 1979/80 total use of pesticides in Bangladesh was nearly 2,347 tons, whereas the use during 1984/85 rose to nearly 4,000 tons. The increase and indiscriminate use may present a high risk of marine pollution.

^a *Source:* Pesticide Association of Bangladesh and Plant Protection Department, 1986.

^b *Monthly Statistical Bulletin of Bangladesh, 1985.*

from United Nations (1989)

Table 2. Pollution (BOD₅) load from industries in and around Dhaka

Location	No. of Industries	Effluent m ³ /day	Pollution (BOD ₅ load, kg/day).
Hazaribagh Tannery Area	151	13,000	19,000
Tejgaon Industrial Area	61	3,000	4,500
Dhaka-N'ganj Indus. Belt	53	3,500	5,000
Tongi Industrial Area	29	5,000	10,000
Sitalakhya Indus. Belt	30	5,500	9,000
Scattered	4	1,000	1,500
Total	328	31,000	49,000

Source : Ahmad, Feroze, M. (1988)

from Ali (1991)

Table 2. Estimated pollution load as biodegradable organics in terms of kg BOD/day in the Chittagong area

Industrial zone Polluting source in Chittagong area	Pollution load (kg BOD/day)				
	Total	Textile	Paper	Leather	Others
Karnaphuli River					
Kalurghat	2 500	—	—	1 400	110
Nasirabad/Sholoshahar	6 400	800	—	4 100	1 500
Patenga	2 000	200	—	—	1 800
Kaptai	5 800	2 550	2 100	—	1 150
Bay of Bengal					
Bhatiari	1 000	600	—	—	400
Kumira	380	380	—	—	—
Barabkunda	600	600	—	—	—
Fauzdarhat	3 200	2 300	—	—	900
	21 800				
Karnaphuli River					
Domestic waste load from Chittagong city	3 500	—	—	—	—
Bay of Bengal					
Pollution load from domestic and industrial sewage from the south-eastern part of the country through run-off along the Karnaphuli River system	20 000	—	—	—	—
Projected domestic waste load by the year 2000	5 070	—	—	—	—
Projected load for industrial sewage by the year 2000	2 000	—	—	—	—

Source: Chittagong waste-water: mission report, 1985.

from United Nations (1989)

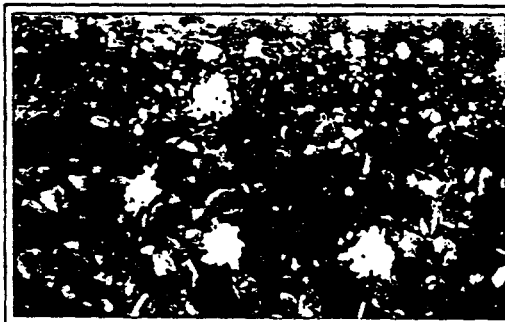
WATER HYACINTH : PEST OR PANACEA

Today plants are introduced all over the globe for commercial, horticultural or agricultural purposes. A small minority of these 'aliens' become ecological as well as economic disasters in the region where they are introduced. Although they have been innocuous in their native region, these species transform themselves into aggressive pests or weeds that invade and dominate their new environment. The water hyacinth (*Eichhornia crassipes*) exemplifies the problem such pests can create; it has worked havoc on waterways throughout the tropics and subtropics, causing severe hardship and immense economic difficulties on waterways and devastating many aquatic communities. It slows down boat transportation, asphyxiates fish and plankton throwing the entire food chain out of gear and causing disease by harbouring the microbes. Two special characteristics -- high mobility and quick clonal propagation -- have enabled the water hyacinth to dominate the rich aquatic ecosystems. Air-filled tissues of stems and leaves of these plants provide considerable buoyancy enabling them to float with wind and water currents to unoccupied wetlands where they can grow and multiply at a rapid rate. The plant breaks apart into many separate pieces each having a potential to grow into a complete organism. In four months two plants can yield 1200 offspring. This extraordinary pace of multiplication results in some of the highest rates of biomass production recorded in the plant world.

First discovered in 1824 in the Amazon basin in western Brazil, the water hyacinth has now spread to more than 50 (according to some over 80) countries in five continents. The plants have beautiful clusters of light violet flowers with a prominent yellow spot

on one of the petals, and since 1884 have become favourites in the garden ponds in the United States. In 1894 it had become a nuisance in the Bogor botanic garden of Indonesia. It invaded the South Asian subcontinent around 1898. Worldwide, it has defied all attempts to eradicate it using biological and chemical control methods besides mechanical or manual removal.

Despite its notoriety as an aggressive weed, water hyacinth has proved its worth as a pollution filter extracting lead, cadmium, chromium, copper, iron, nickel and zinc from contaminated waters. It can also remove most of the nitrogen and phosphorus eliminating these pollutants from the aquatic system when the plants are harvested. These qualities of water hyacinth are being exploited for waste water treatment and to clean tannery effluents which pollute the groundwater resources. It is well-known as an excellent fertilizer as its ash contains potash and lime. It also forms a useful feed for cattle, is used in board and paper products and as material for wicker work and for biogas.



Dense growth of water hyacinth impeding fishing and navigation. Photo by Rashid/NACOM

from Khan et al (1994)

Table 2. List of fish species observed with positive EUS infections in three floodplains during 1992/93 and 1993/94.

Fish spp.	Floodplain			
	Chanda	Hali	BSKB	Hilna
Stocked fishes				
<i>Catla catla</i>	X	X	X	X
<i>Cirrhinus mrigala</i>	X	X	X	X
<i>Cyprinus carpio</i>	X	X	X	X
<i>Hypophthalmichthys molitrix</i>	X	X	X	X
<i>Labeo rohita</i>	X	X	X	X
<i>Puntius gonionotus</i>	-	-	-	X
Indigenous fishes				
<i>Anabas testudineus</i>	X	X	X	X
<i>Clarias batrachus</i>	X	X	X	-
<i>Colisa fasciata</i>	X	X	X	-
<i>Etenopharyngodon idella</i> ^{1/}	-	-	X	-
<i>Glossogobius giuris</i>	-	X	X	-
<i>Heteropneustes fossilis</i>	X	X	X	X
<i>Mastacembelus</i> sp.	X	X	X	X
<i>Mystus</i> air	-	X	-	-
<i>M. vittatus</i>	X	X	X	-
<i>Nandus nandus</i>	X	-	X	-
<i>Notopterus chitala</i>	-	X	-	-
<i>Ompok pabda</i>	-	X	X	-
<i>Ophiocephalus marulius</i>	X	X	-	-
<i>O. punctatus</i>	X	X	X	X
<i>O. striatus</i>	X	X	X	X
<i>Puntius stigma</i>	X	X	X	X
<i>Wallago attu</i>	X	X	X	X

^{1/} *Etenopharyngodon idella* is not indigenous species. The species is also not included in the stocking programme.

Table 3. List of ectoparasites observed in fish from four floodplains during 1993. Note that the parasites given under one floodplain represent the total number of parasites observed from all fish examined in that particular floodplain.

Location	Fish Species	Parasite Species
Chanda	<i>Channa punctatus</i>	<i>Trichodina</i> spp.
	<i>Anabas testudineus</i>	<i>Tripartiella</i> sp.
	<i>Heteropneustes fossilis</i>	<i>Dactylogyrus</i> sp.
BSKB	<i>Channa punctatus</i>	<i>Trichodina</i> spp.
	<i>Anabas testudineus</i>	<i>Tripartiella</i> sp.
	<i>Heteropneustes fossilis</i>	<i>Dactylogyrus</i> sp.
	<i>Mastacembellus</i> sp.	<i>Trichodina</i> spp.
	<i>Anabas testudineus</i>	<i>Dactylogyrus</i> sp.
	<i>Colisa fasciata</i>	Nematode sp.
Hali	<i>Xenotodon cancila</i>	Cestod sp.
	<i>Mastacembellus</i> sp.	<i>Trichodina</i> spp.
	<i>Anabas testudineus</i>	<i>Dactylogyrus</i> sp.
	<i>Colisa fasciata</i>	Nematode sp.
Hilna	<i>Xenotodon cancila</i>	Cestod sp.
	<i>Puntius gonionotus</i>	<i>Myxobolus koi</i>
	<i>Catla catla</i>	

from T sai and Ali (1997)

Table List of bacteria isolated from the Epizootic Ulcerative Syndrome (EUS) infected fish and water from the flood plains. Note that the list represents the bacteria isolated from fish/ water sampled from four floodplains.

<i>Fish Species and Water</i>	<i>Bacterial species</i>
Fish	
<i>Channa striatus</i>	<i>Aeromonas sobria</i>
<i>Channa punctatus</i>	<i>Pasturella</i> sp.
<i>Anabas testudineus</i>	<i>Pseudomonas fluorescence</i>
<i>Heteropneustes fossilis</i>	<i>Streptococcus</i> sp.
<i>Puntius</i> sp.	<i>Micrococcus</i> sp.
<i>Mystus</i> sp.	<i>Enterobacter</i> spp.
<i>Mastacembellus</i> sp.	Unidentified Gram -ves
<i>Lepidocephalus gantia</i>	Unidentified Gram +ves.
<i>Mystus vitatus</i>	
<i>Colisa fasciata</i>	
Water	<i>Aeromonas hydrophila</i>
	<i>Enterobacter</i> spp.
	<i>Pseudomonas</i> spp.

from Trai and Ali (1997)

Table 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%

from NERP (1994a)

Table 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.
PagliaBazar (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, kaikya, 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 Benua 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, kaikya, chanda etc	Nil	About 6/7 diseased fish were sorted out. About 85% decline compared with last year
Kharish River, BaraHaor	3; icha, guum	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; hoal, 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.

from NERP (1994a)

Table . Cyclone damage in Bangladesh

YEAR	MONTH AND DATE	AFFECTED AREA	NATURE OF PHENOMENA	APPROXIMATE DAMAGE
1822	May	Barisal	Most severe cyclone	40,000 people killed 1,00,000 cattle lost
1876	Oct.	Noakhali, Hatiya, Patuakhali, Chittagong	Severe storm surge Height 14m	4,00,000 lives and enormous properties lost
1897	Oct.	Chittagong, Kutubdia Island	Storm surges	1,75,000 lives lost
1960	Oct. 10-11	Noakhali, Hatiya, Char Jabbar	Cyclonic storm max. speed 129 km/hr Surge height 3m	6000 people killed
1963	May 28-29	Noakhali, Chittagong Cox's Bazar	Cyclonic storm max. speed 201 km/hr	11,520 people killed
1965	May 11-12	Khulna, Barisal, Noakhali, Chittagong	Cyclonic storm max. speed 161 km/hr Surge height 10m	19,270 lives lost
1970	Nov. 12-13	The entire belt from Khulna to Chittagong	Cyclonic storm max. speed 241 km/hr Surge height 10m	5,00,000 people and innumerable animals killed
1985	May 24-25	Noakhali, Hatiya, Char Jabbar, Sandwip Cox's Bazar, Chittagong	Cyclonic storm max. speed 154 km/hr Serge height 4m	11,069 lives lost 1,35,033 livestock lost
1988	Nov. 29	Khulna coast	Cyclonic storm max. speed 160 km/hr Surge height 5m	People killed 5,708 Deer killed 15,000 Royal bengal tiger killed 09
1991	April 29	Patuakhali, Barisal, Noakhali, Chittagong Cox's Bazar, Kutubdia	Cyclonic storm max. speed 193 km/hr Surge height 6m	1,50,000 people killed, homeless several million, destruction of property
1997	May 19	Chittagong, Cox's Bazar, Teknaff, St. Martin island	Cyclonic storm max. speed 160 km/hr Surge height 5m	200 people killed, homeless several million, destruction of property

APPENDIX E: PHOTOGRAPHS

(to be completed)

Second Aquaculture Project
hatchery for floodplain stocking, near Kishoreganj

Carp fingerlings at hatchery. Disease transmission and reduction of genetic diversity are potential impacts of floodplain stocking.



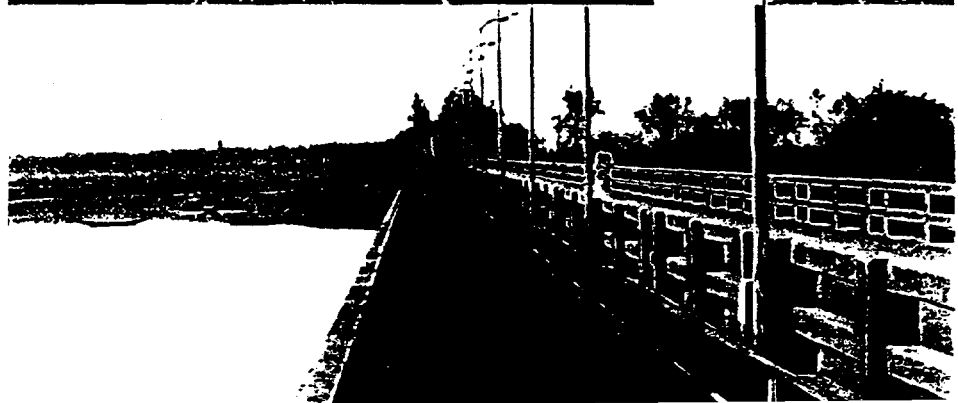
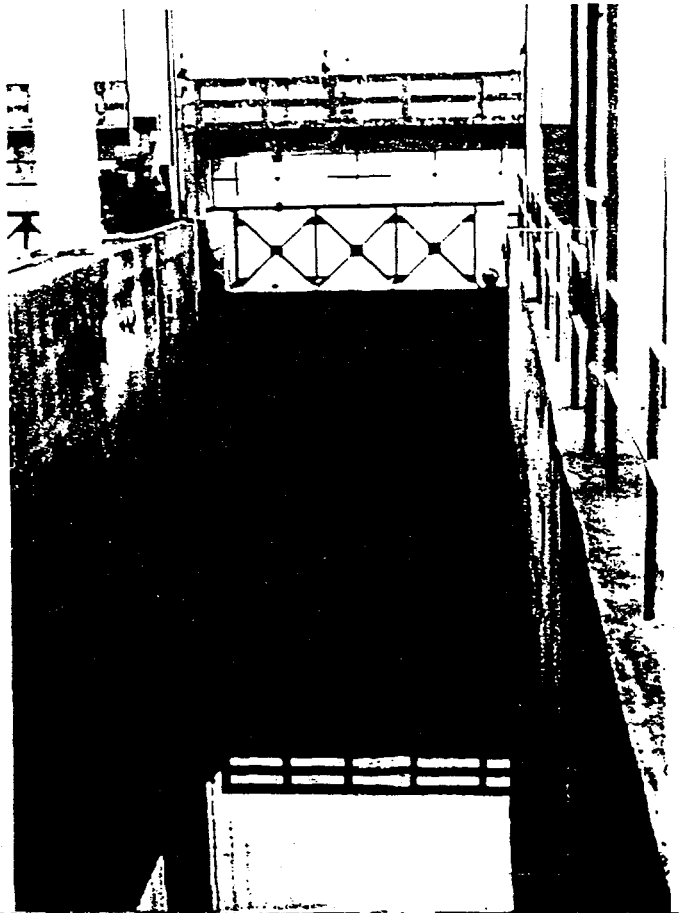
Re-excavated canal near Kuliachar.

Although canal re-excavation re-establishes a connection between river and beel, it also results in faster drainage of the beel during the monsoon, and can negatively impact beel production.

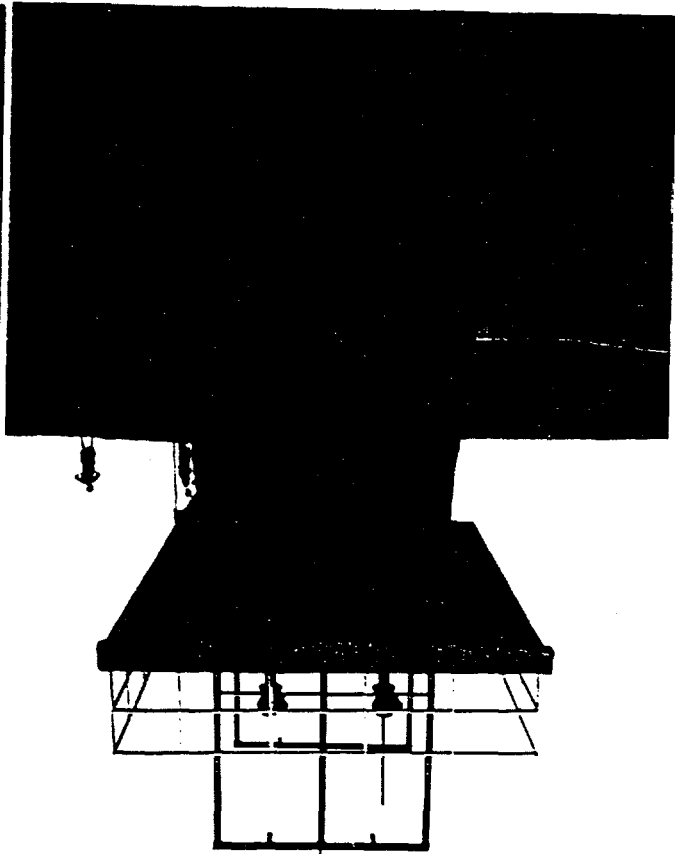
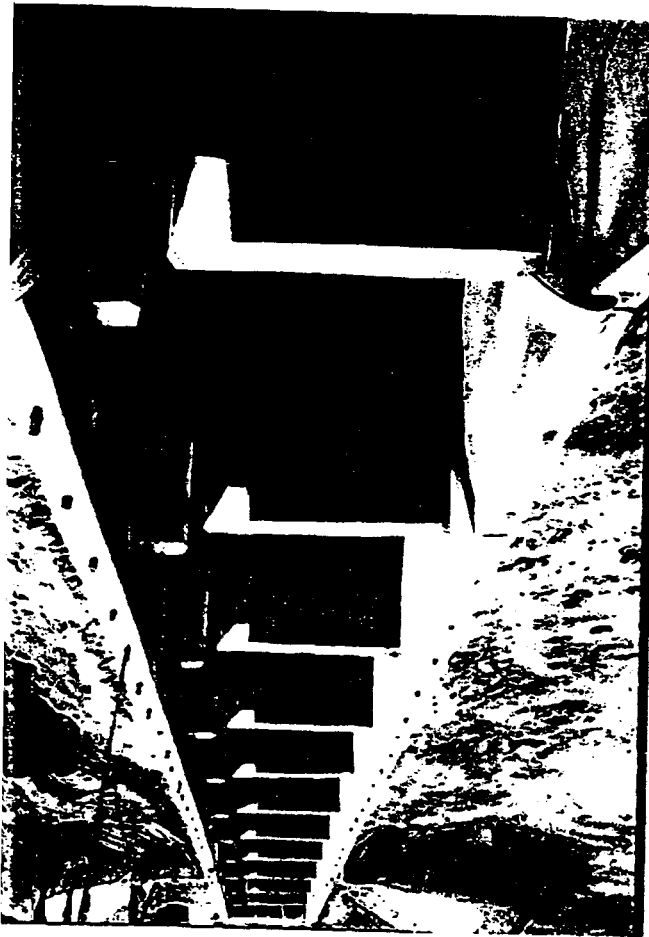
Fishing with a liftnet in re-excavated canal. Excessive fishing effort in re-excavated canals will result in less migrating fish reaching the beel.



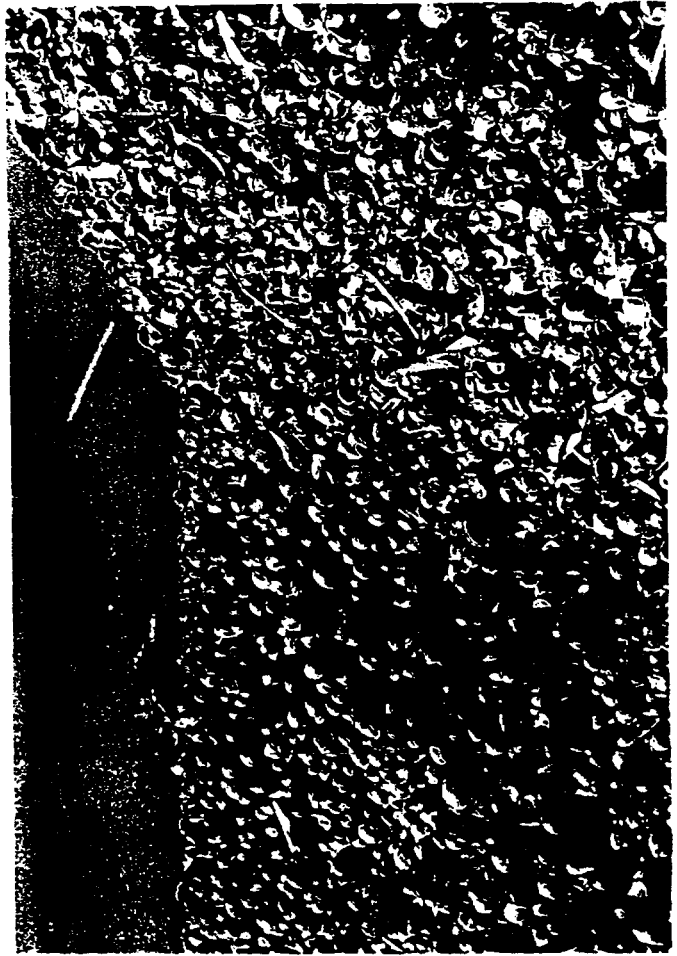
<p>Navigation lock at Chandpur FCDI project. Although some fish attempting to migrate from river to the inside of the project find their way through the lock, the intermittent operation of the lock is not optimal for fish traffic.</p>
<p>Trash racks of Chandpur FCDI project pumphouse at Char Bagadi keep water hyacinth out of the pumps. Small fish are however entrained and suffer high mortality.</p>
<p>Barrage of the Muhuri FCDI project across the Feni River. Brackishwater fish production has been seriously affected, especially the hilsa stock.</p>



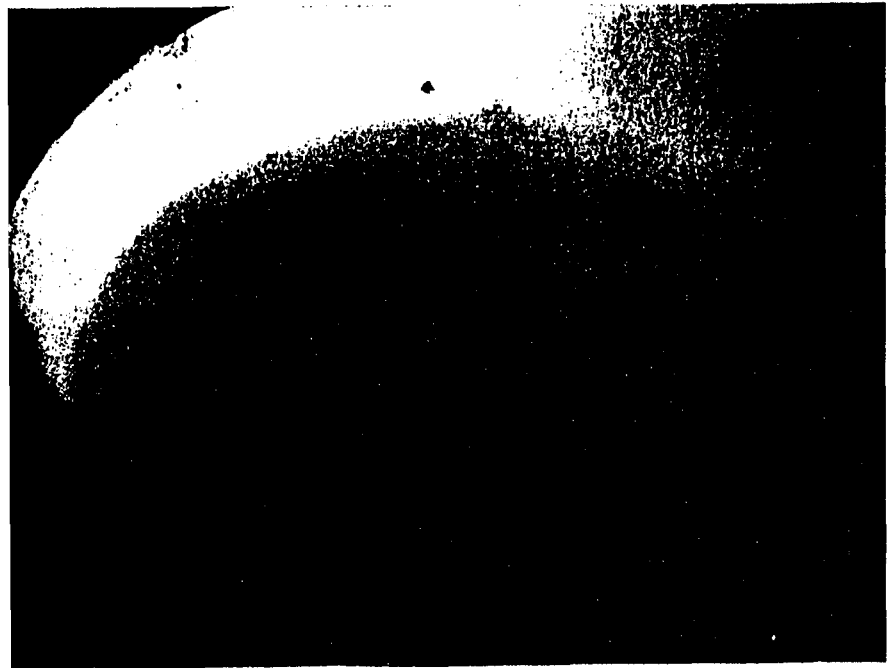
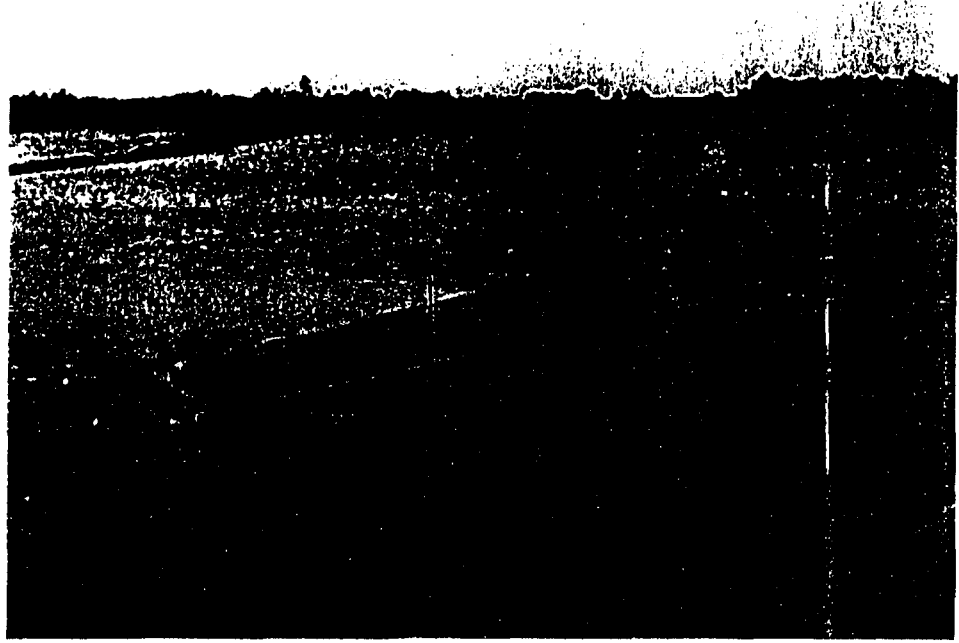
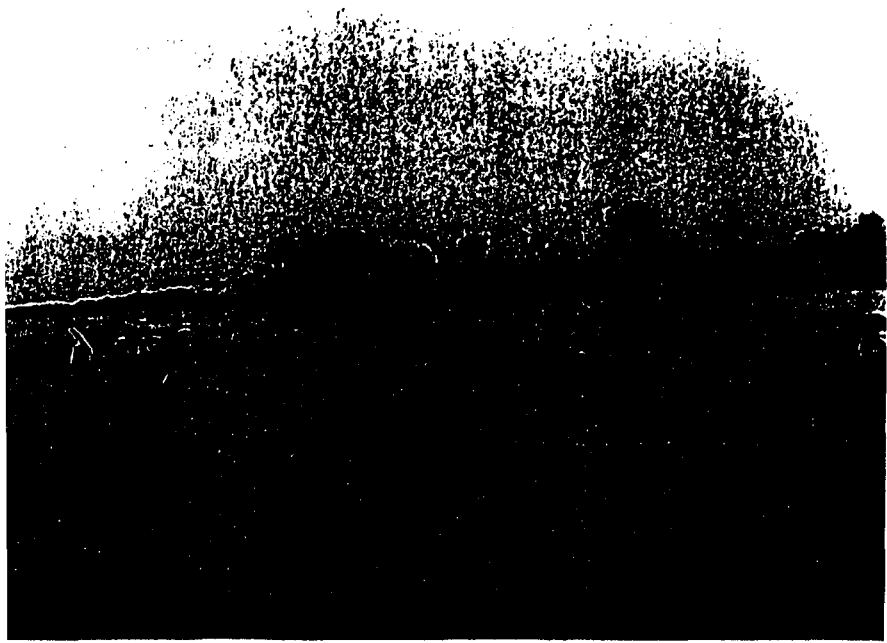
<p>Full flood control embankment of the Manu River FCDI project. The canal (Machuakhali) on the right has been cut of from the Kushiya River on the left, resulting in a serious decrease in fish production in Kawadighi Haor.</p>	
<p>The vertical slot fishpass at Kashimpur. This large structure is the first of its kind in Bangladesh. It has reopened a fish migration route between the Kushiya River and Kawadighi Haor, and allows fish to migrate across the embankment.</p>	<p>Inside view of the Kashimpur fishpass (while under construction). The slot extend the entire height of the pools. This allows fish to travel from pool to pool without having to jump (as in the conventional salmon type of fishpass).</p>



<p>Prawn ponds near Bagerhat. Freshwater prawn farming has fewer environmental impacts compared to brackishwater shrimp farming.</p>	<p>Subadult giant freshwater prawn (<i>golda chingri</i>).</p>
<p>Prawn feed balls made up from loose meal ingredients. Such feed is not efficiently utilised by prawns and fish and can pollute ponds and waters receiving discharge.</p>	<p>Empty snail shells. Large quantities of snails are harvested from natural sources for use as prawn feed. Overharvesting depresses snail populations, and has led to illegal imports from India.</p>



<p>Shrimp seed collection near Paikgaacha. Large numbers of small mesh nets filter the incoming and outgoing tides.</p>	<p>If seed collectors do not own a boat they stake their nets near the shore. The collected seed is sorted on the shore and the by-catch is dumped on the mud, resulting in massive mortality of finfish larvae, other shrimp species and zooplankton.</p>
<p>The dark long objects are shrimp (<u>P. monodon</u>) larvae.</p>	<p>Shrimp seed collected from a boat are sorted using a mussel shell. By-catch is not killed but either returned to the water or stocked in small ponds and allowed to grow out.</p>

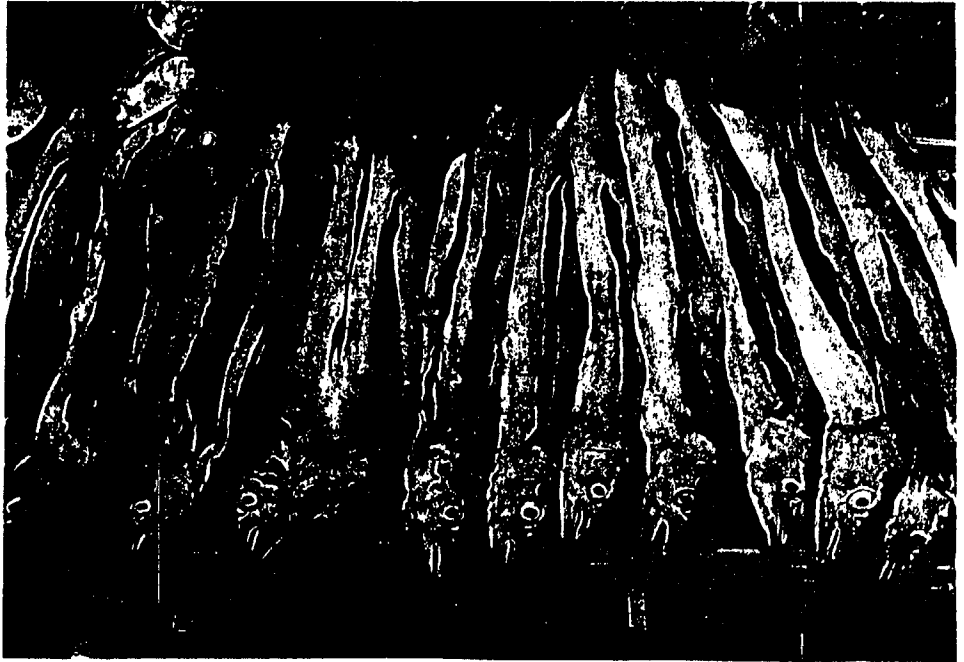
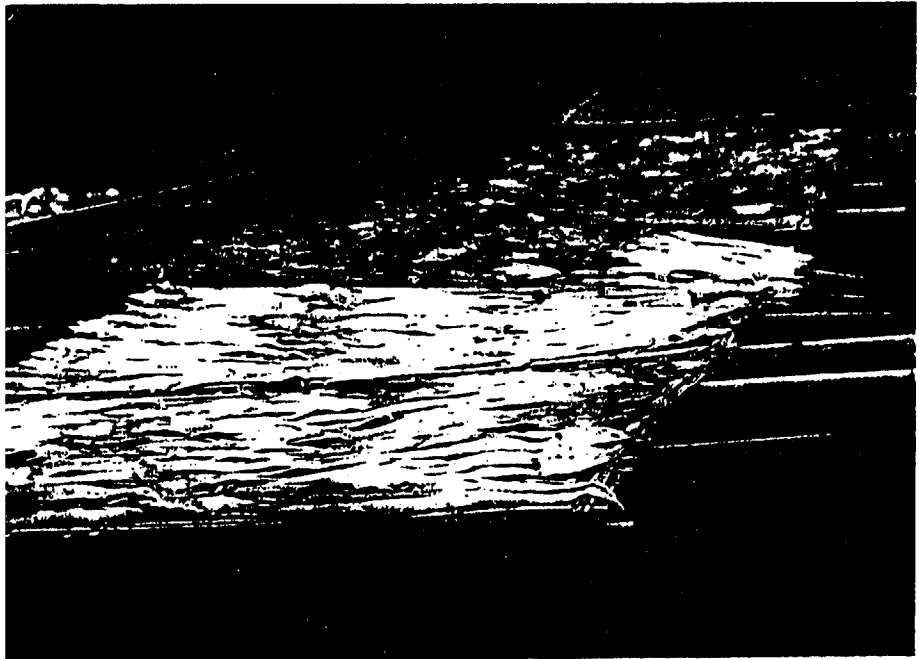


Bagnet fishing for finfish and shrimp in Naf River estuary, south of Teknaf.
Burma is in the background.

The catch from a bagnet is composed mainly of small shrimp species
and small and juvenile fish species.
Some fishermen complain that shrimp seed collectors
are negatively impacting fish stocks.



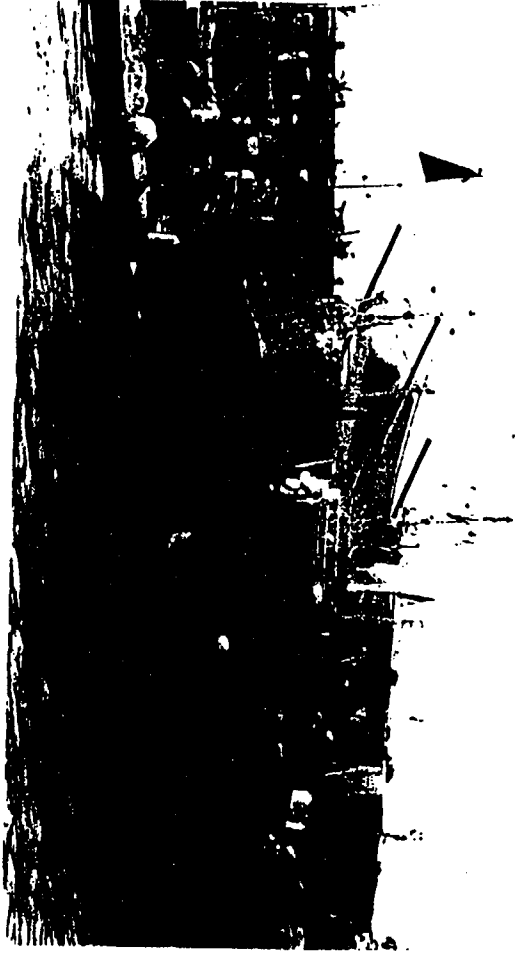
<p>The beach at St Martin's Island. No fish landing facilities exist, so fish are auctioned 'on-the-sand'.</p>	<p>No fish processing facilities exist, so fish are gutted 'on-the-sand' under unhygienic conditions.</p>
<p>Fish are sun-dried for export as no ice-making machines or cold stores exist on the island.</p>	<p>In an effort to control insect infestation, fish are routinely dipped in insecticide solutions, including DDT and other hazardous compounds smuggled into Bangladesh.</p>



The BFDC fish landing centre at Cox's Bazar.

Over 1,000 fishing boats use Cox's Bazar harbour.
This results in severe pollution of the harbour area, and heavy traffic congestion.

Solid waste management is a problem which needs to be dealt with soon..



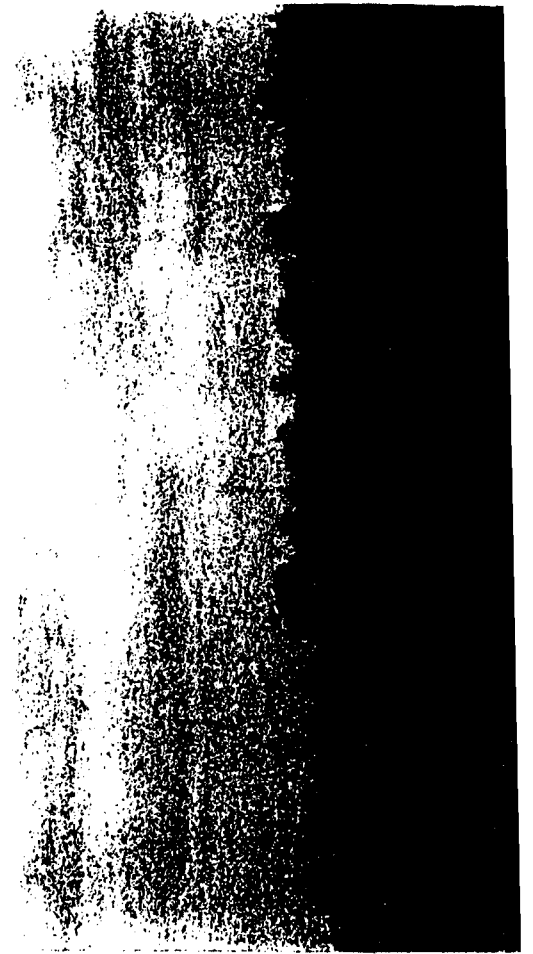
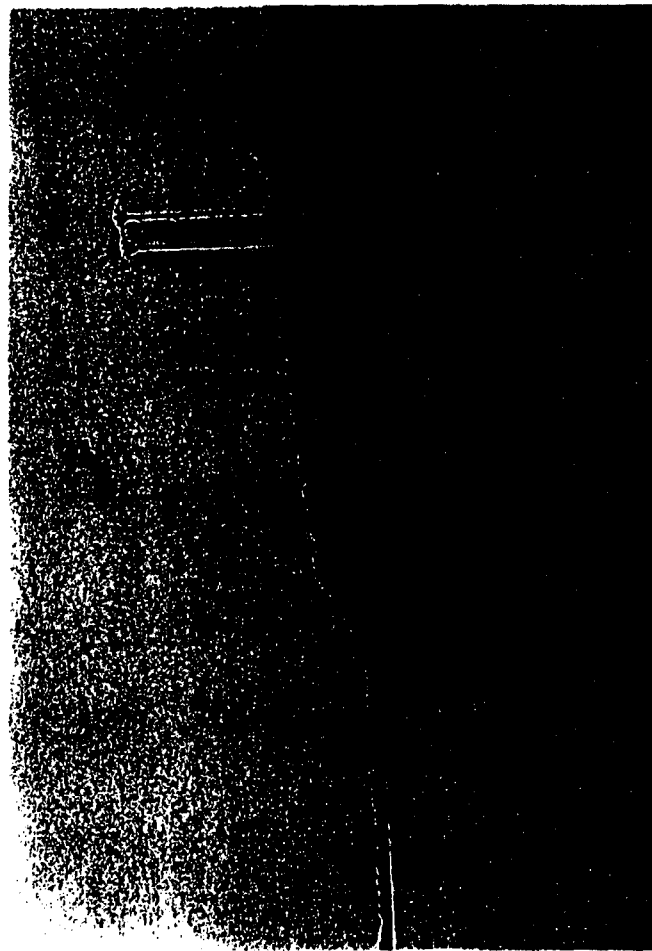
<p>The BFDC fish landing center at Cox's Bazar.</p> <p>In contrast to the depleted inland freshwater fisheries, the marine fisheries of Bangladesh are still quite productive.</p>	<p>Four sailfish were seen at the Cox's Bazar landing center during the visit of the EIA Team.</p> <p>The potential for a sport fishing charter business needs to be investigated. These two excellent game fish were sold for only Tk 700, but might have brought in hundreds or thousand of dollars in earning from charter.</p>
<p>Ice and shade help to slow deterioration of fish landed at Cox's Bazar.</p>	



Tall mangrove trees in the Sunderban, near Buri Goalini.
Protection of this important mangrove forest is a high priority.
Despite the importance that the mangrove area has for fish production, little is known about the fish resources of the Sunderban. The EIA Team was not even able to locate a checklist of fish species.

Most of the mangroves near Cox's Bazar have been severely depleted to make room for shrimp ponds. However, this stand on the river terrace between the polder embankment and the shoreline near the Niribili Shrimp farm is still relatively healthy, and illustrates good mangrove management practices. A dense band of mangroves should be left to grow undisturbed on the river terrace, to prevent erosion and provide a substrate for invertebrates.

A small species of mangrove (*keora*) near Cox's Bazar is suffering from leaf die-off.



Removal of mangroves from the river terrace in front of the Meghna Shrimp Farm near Cox's Bazar has resulted in erosion, necessitating construction of groins to try to prevent further encroachment of the polder embankment.

Loss of mangroves around Cox's Bazar has resulted in a serious decline in oyster abundance, as they no longer have a substrate to attach to.

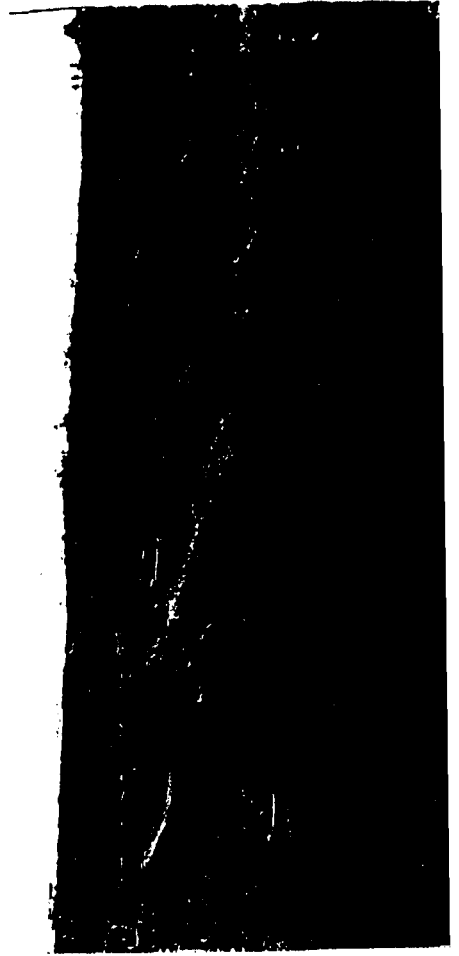
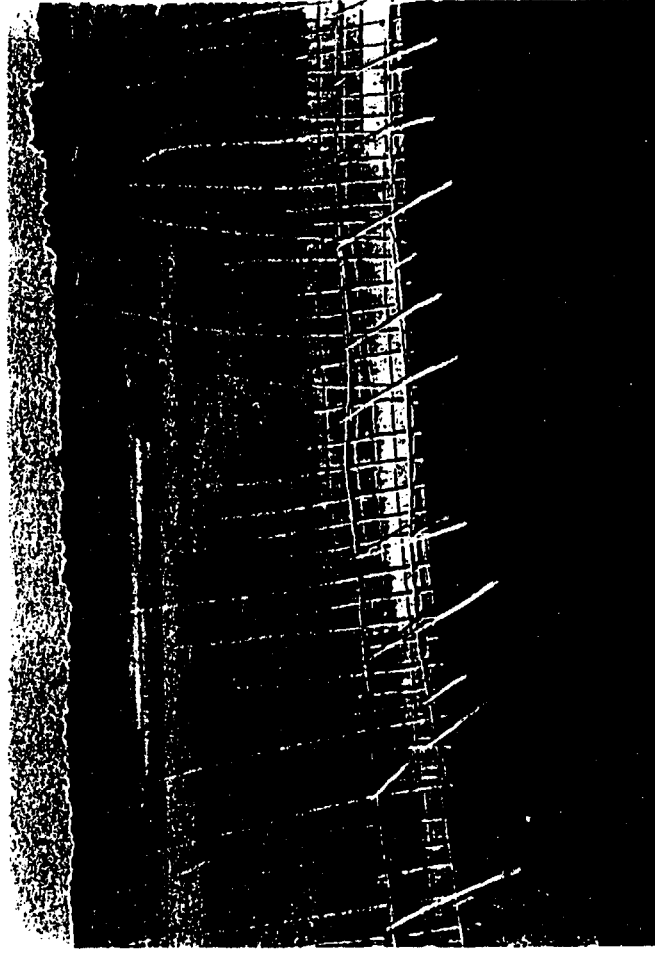
- This oyster colony is precariously living on a deteriorating jetty.



This species of acacia tree (*koi babla*) is planted along bunds and embankments in Dakatia Beel. It provides valuable habitat for birds, and yields a marketable product much in demand - branches used for fish production (katha).

Fencing keeps stocked carp fingerlings inside Baluhar Baor near Jessore, but could also prevent broodstock of large non-carp species from migrating into the baor to breed.

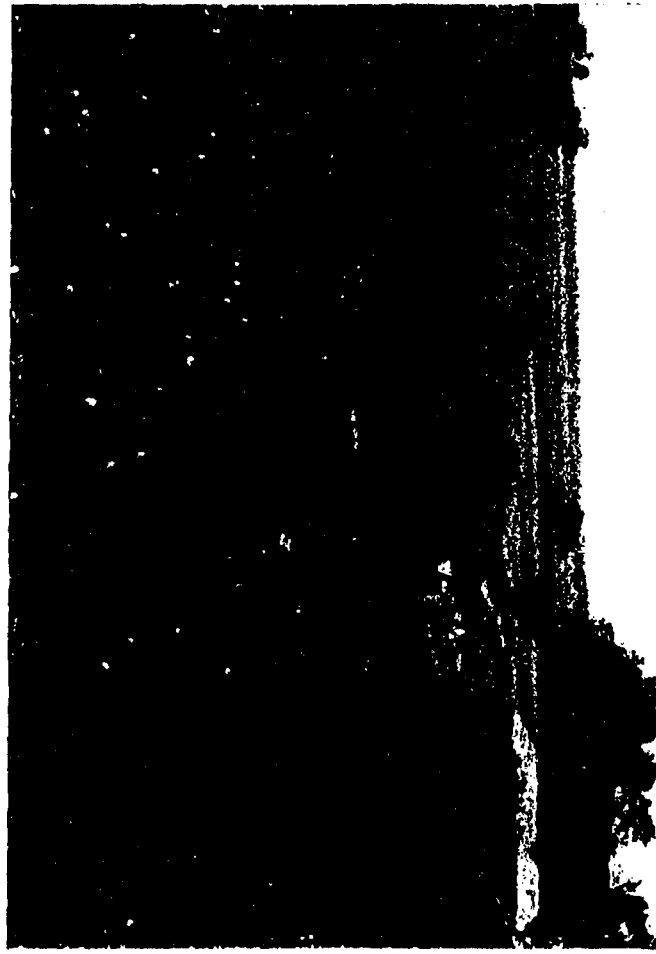
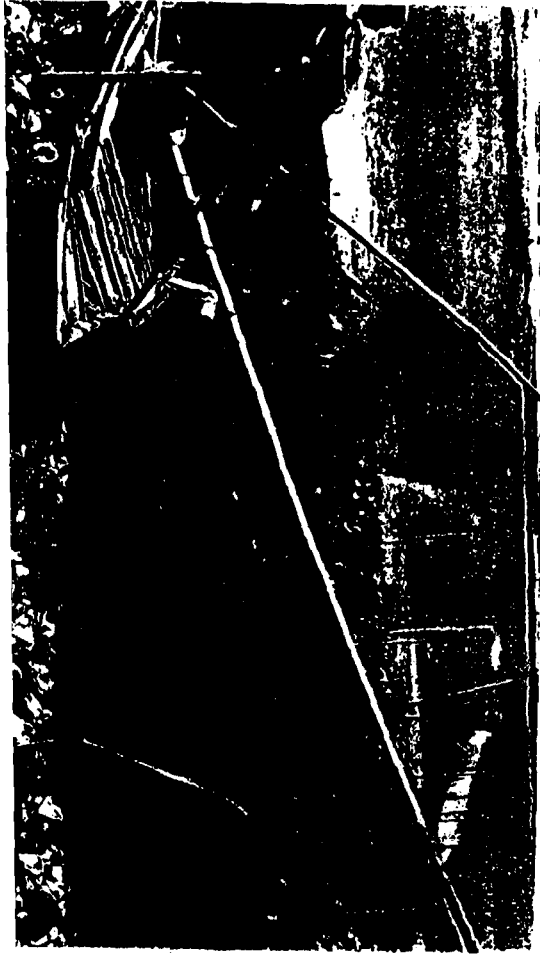
This fish fence across the Surma River near Kanairghat, presents a problem for navigation as it extends across the entire channel. Widespread introduction of fish pens could create similar problems for navigation.



Water hyacinth infestation in a large tank near Bagerhat.
Kachuri pana is a nuisance plant from South America which infests many water bodies in Bangladesh. It causes severe loss of water quality due to deoxygenation. Only air breathing fish can survive under such conditions.

Water hyacinth also interferes with navigation,
as in the Dakatia River near Chandpur.

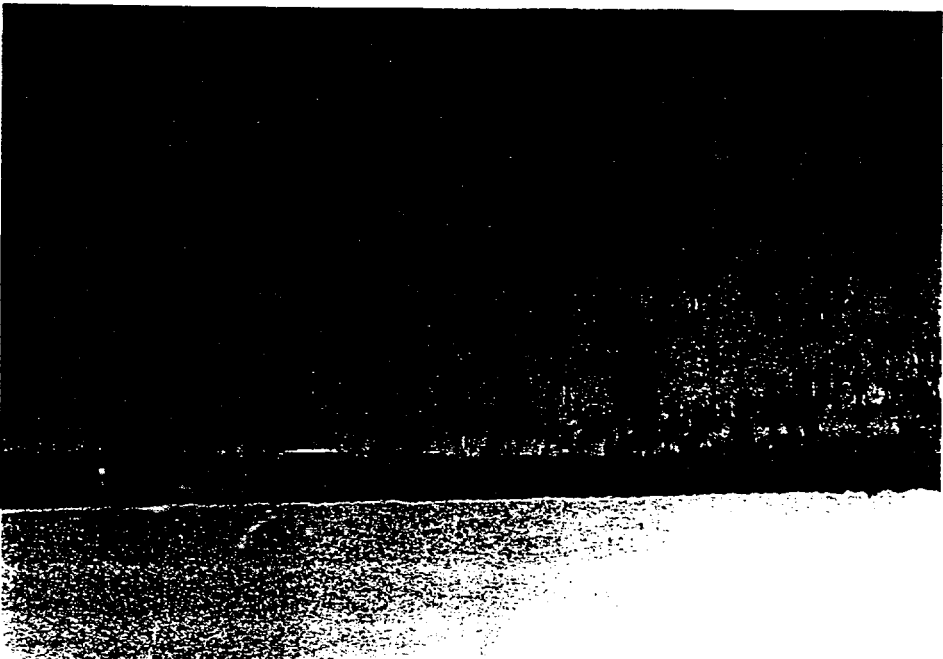
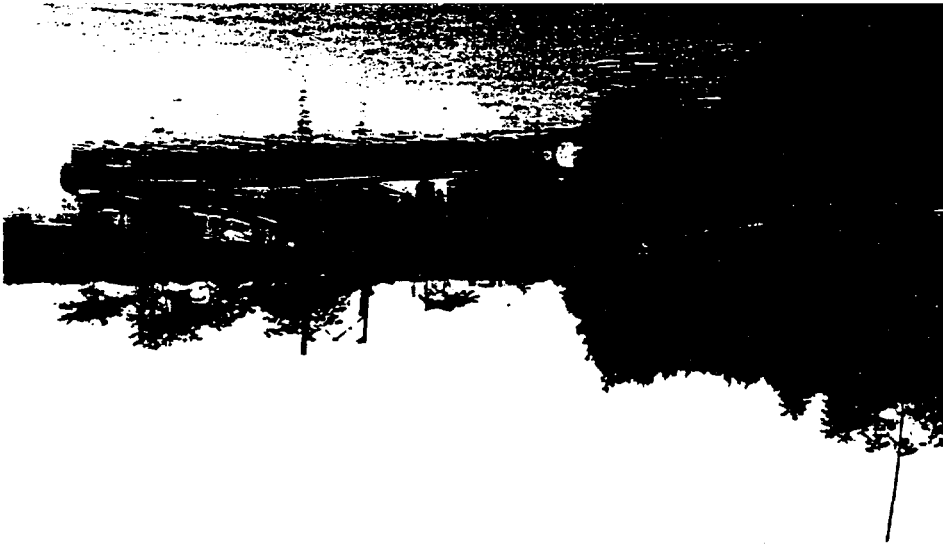
Operation of most fishing gears is hampered by water hyacinth infestation. This fisherman had to laboriously clear a small area in order to deploy a lift net. Even so, he catches few fish due to the poor water quality. under the mat.



Dakatia Beel is chronically waterlogged - in part due to badly conceived FCDI constructions, and in part due to general land subsidence in the region. Stocking of fish would help to relieve some of the suffering that waterlogging has caused the local population.

One of the silted up regulators.

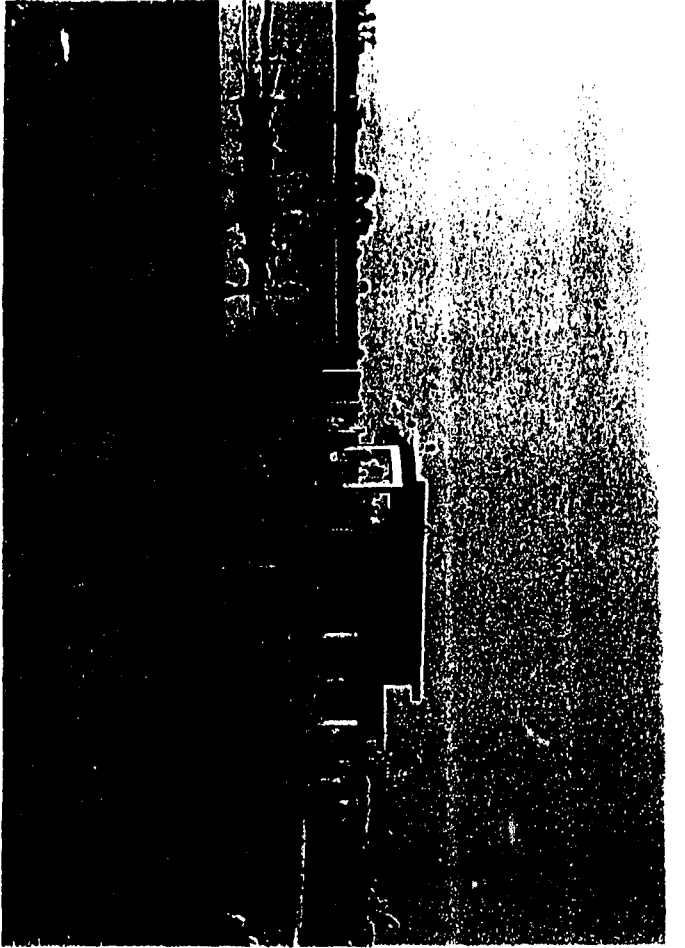
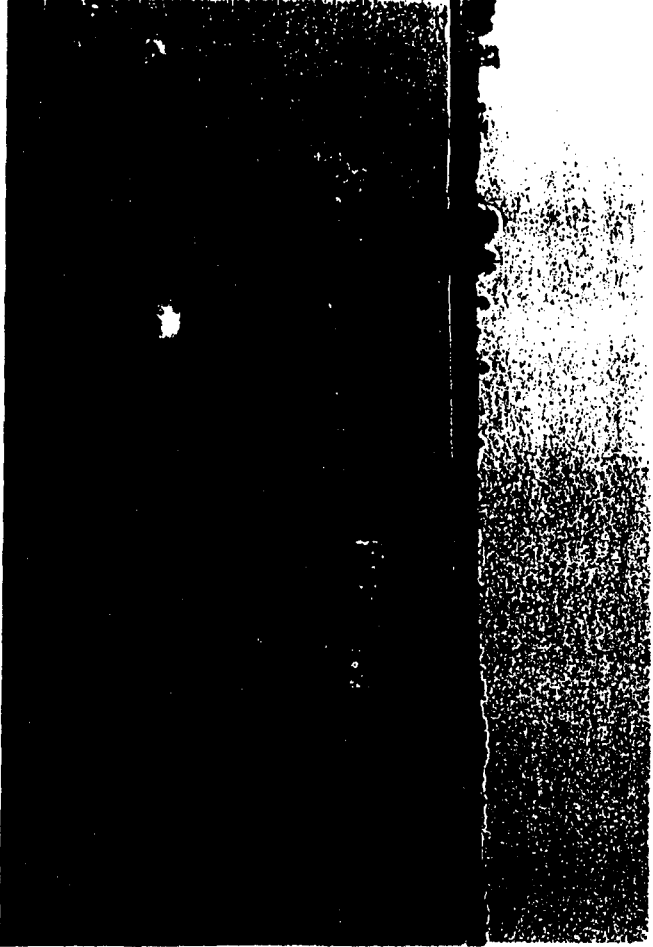
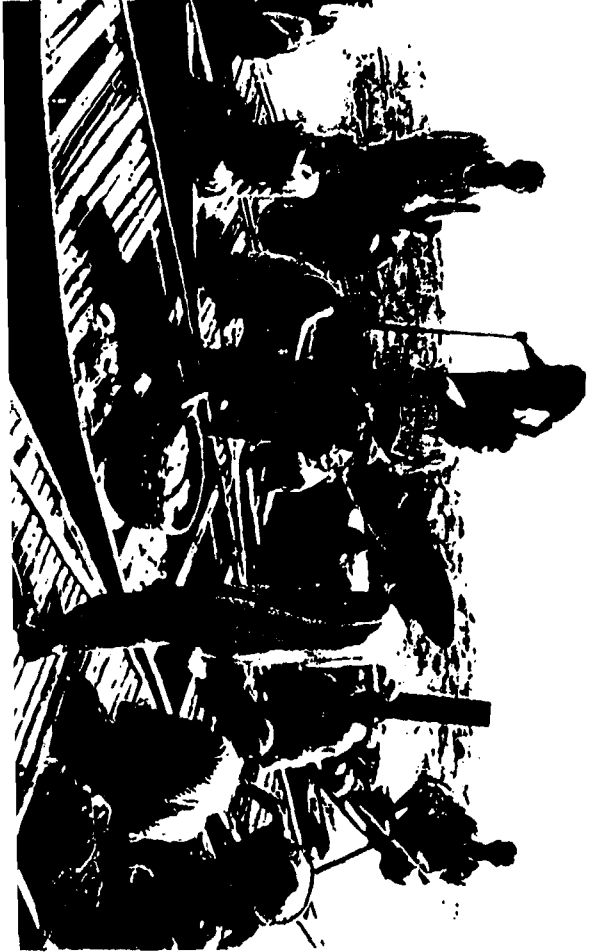
A dredger at work in the river outside of the embankment. Dredging of the river beds may relieve some of the waterlogging, but local people are asking for removal of the embankment and restoration of natural tidal flushing.



The benefits of community-based fisheries management are clearly visible at Nasti Baor. This group of fishermen own their own fish auctioning hall and office. They regularly stock the baor with carp fry.

Fish traders come to the landing center at a pre-arranged time. One hour before, paired teams of fishermen and boats go out to catch the fish using boat seines. This is an active method of fishing, and fishermen do not want a fish sanctuary in the baor, as the fish would become more difficult to catch at the appointed time.

In 1996, the fishermen of the baor produced an impressive yield of 1,820 kg per ha. As they have only a lease and do not own the baor or the fishery, they are now afraid that outsiders will try to take the fishery away from them as it has shown a high profit.



The jalmohal leasing system of GOB appears to create endless problems for the fisheries sector.

Here at a Third Fisheries Project shrimp polder, the water supply canal (to the right of the bund) has been leased for 99 years to a non-shrimp farmer. This individual now extorts large amounts of money from the hapless shrimp farmers in return for supplying water to their ponds.

Serious environmental degradation and indiscriminate overharvesting have affected other aquatic biota in Bangladesh. Few crocodiles are left in the wild. Crocodiles perform an essential ecological role in eliminating diseased fish and other animals. This semi-tamed crocodile survives in a tank near Bagerhat.

