ASSESSMENT OF ECOLOGICAL HEALTH STATUS IN SELECTED HAORS WITH DIFFERENT DEGREES OF INTERVENTIONS USING FISH INDICATORS

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Dedicated to my

BELOVED MOTHER AND HEAVENLY FATHER

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LIST O ABBREVIATIONS

BWDB	Bangladesh Water Development Board
CAS	Catch Assessment Survey
CEGIS	Centre for Geographic Information System
CPP	Compartmentalization Pilot Project
EIP	Early Implementation Project
EU	European Union
FAP	Flood Action Plan
FCBOs	Fishermen Community Based Organizations
FCD	Flood Control and Drainage
FCD/I	Flood control, Drainage and Irrigation
FGD	Focus group discussion
IECs	Important environmental components
IUCN	International Union for Conservation of Nature
NGOs	Non Government Organizations
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
RWMA	Rapid Water Management Appraisal
SRP	System Rehabilitation Project

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ABSTRACT

Haors are very important habitats for the unique and dynamic ecosystems, which have immense productive or ecological value. Importantly, haors provide suitable habitats for fisheries, a major component of the ecological resources. However, anthropogenic interferences, e.g. wetland encroachment and exploitation pressure, and water management infrastructures are causing decline of wetland habitats, especially during the dry season. Water management interventions bring about changes in natural systems of haors, and hence the impact of partial flood protection on the ecosystem of the haors is emerging as a significant concern.

The study examined the ecosystem of three selected haors subject to varying physical effects of water management infrastructure. Fish has been selected as an indicator for ecosystem as fishes are sensitive to many changes in natural water quality and habitat structure caused by anthropogenic or by natural causes. Based on a set of pre-determined criteria, a total of three haors were selected, which represented three distinct physical characteristics: a relatively undisturbed state (Chaptir haor), a moderately intervened state (Tangua haor), and an extensively intervened state (Baram haor). A range of Participatory Rural Appraisal (PRA) tools (e.g. resource mapping, FGDs) were used in the study to obtain data relating to the status of the physical system of the haors and the status of fisheries ecosystem.

The findings from the field surveys showed that migration routes and fish habitat areas have been impacted to different degrees in the three haors by water management infrastructures. Fish migration routes are better in Chaptir haor, followed by Tangua haor. Migration routes in Baram haor are the worst. Habitat depths, e.g. depths of the river, khals and beels are highest in Chaptir haor, followed by Tangua haor. Habitat depths in Baram haor are the lowest. The impact of water management interventions has also been reflected in the declines in fish catch compared to a period 10 years ago.

A scoring and ranking method was used for analyzing habitat wise fish composition data obtained from the field survey. This exercise yielded three species (Rui, Catla, and Boal) which are indicative of different status of ecosystem health in the haors.

Chapter One

Introduction

1.1 Background

Today most of the floodplains in the world are under increasing stress. Large-scale hydraulic dams and dykes, inappropriate agriculture and fishery uses, and other resources exploitation have resulted in a significant loss of floodplains and their proper functions and sustainable uses (Khan, 1997). The haor basin in the North-east region of Bangladesh also seems to be heading in that direction (CEGIS, 2006). Haors are the distinct feature of the region and consist of small circular internal drainage basins surrounded by rivers. The Haor basin in this region is a major reservoir of ecosystem constituting about 60% of the total standing water bodies in Bangladesh. These wetlands are very important habitats for the unique and dynamic ecosystems, which have immense productive or ecological value. Importantly, haors provide suitable habitats for fisheries, a major component of the ecological resources.

A large number of flood control drainage and irrigation (FCD/I) projects have been developed in the haor basin with the aim to protect boro crops from flash floods. These projects include embankment with sluice gates and closures. While the impact of full flood protection measures in Bangladesh on ecosystem (including fisheries) are well known and well documented, the impact of partial flood protection schemes in the haors is also emerging as a significant concern. Increasing anthropogenic interference poses a threat to the maintaining of the natural functions of the ecosystems (Shawinigan Lavalin Inc. and others, 1995). FCD/I projects significantly altered natural processes of Haors (Shawinigan Lavalin Inc. and others, 1994a).

A question is how the impacts of water management interventions on the haor ecosystems can be assessed. Different methods have been developed to assess the ecosystem condition of various water bodies. McLusky & Elliott (2004) indicate a range of methods. Bio-assessment methods are often preferred due to the possibility to evaluate the condition of the environment without having to capture the full complexity of the system. Assessing both short and long term effects in this way have been found to be relatively inexpensive and easy to perform. Fish has been the major species used in bio-assessment protocols (e.g. Deegan et al., 1997; Harrison et al., 2000; Hughes et al., 2002; Whitfield & Elliott, 2002; Coates et al., 2004; Harrison & Whitfield, 2004; Moy, 2004). An example of use of other indices includes aquatic vegetation (Dennison et al., 1993).

Ecological health includes concepts of biological community composition and function. The production of a system is directly related to the ecological health of that system. Fishes are important component of aquatic ecosystems through their role as consumers of other organisms and they can have a significant influence on the structure and function of these ecosystems (Pidgeon, 2003). Fish are sensitive to many changes in water quality and habitat structure caused by human activities and by natural causes. The responses of particular communities, especially fish, within aquatic ecosystems reflect the amount of degradation of that system (Wichert and Rapport, 1998 reported in Chakrabarty and Das, 2006) etc. Monitoring of fish communities can, therefore, provide a useful indicator of the ecological health of natural waters (Pidgeon, 2003).

As per European Union (EU) water policy fish as a biological quality element to be monitored as part of the assessment of ecological status of all water bodies except coasts (WFD, 2000). Uses of fish indices are becoming important bio-assessment tools in Europe. Application of fish as an indicator has already been found in many countries. Hossain (2003) used fish among a number of macro-benthos as an indicator of water pollution in the Karnafuli River-estuary in Bangladesh. Siligato and Bohmer (2001) report that fish populations and assemblages were investigated in a number of countries in order to document environmental pollutant effects on fish health as well as to assess the effects of human induced stream morphological alterations on an ecologically relevant level.

The impacts of fisheries ecosystem by water management interventions are related to the maintaining of fisheries habitats and life cycle. Flood and flooding are essential environmental factors required for completion of the life cycle of fish and hence important for the fisheries resources of floodplain (Paul, 1997). Larinier (2000) reported that migratory fish require different environments for the main phases of their life cycle which are reproduction, production of juveniles, growth and sexual maturation. However, water management interventions bring about significant changes in the natural flooding processes in haors. Haors are inundated and linked to rivers during the monsoon but are isolated during the dry season, to the rivers and floodplain, and vice versa. Structural interventions (embankments and regulators) on a river can disrupt fish migration to and from beels and haors, thus contributing to the decline and even the extinction of species. Migration is an important feature of the biology of many fish species, and the flood control measures reduction of water extent and duration in the floodplain in the recent years has affected migration adversely (ODA, 1994). This inevitably affects the open water fisheries sector as migratory routes and nursing grounds of many species of fish (Hunting Technical Services, 1992; Ali, 1990; Haggart, 1994; Hughes *et al.*, 1994).

Interventions in the haors have been principally in the form of partial flood protection with low submersible dykes (to save winter boro crop from early flash floods). Full flood protection have been there only a few haurs and have been known to have had negative impacts on floodplain capture fisheries because of imposed obstructions to the migration routes between floodplains and rivers and alteration of flooded area. Wetland extent with submersible embankments remains unchanged in the monsoon. However, reduction in production has also taken place, albeit to a lesser extent, in the haors with submersible embankment, mainly because of delay in migration to and from rivers in the pre-monsoon season (Shawinigan Lavalin Inc. and Others, 1994a; Hunting Technical Services, 1992; Sultana and Thompson, 1997).

Although the effect of submersible embankments on fisheries has been reported to be less compared to full-flood protection, it is important to recognize that the submersible embankment projects, if implemented in clusters, may have a cumulative effect on the flow hydrology in rivers and floodplains, and hence may have a cumulative effect on biological resources of the haors. Submersible embankments reduce floodplain discharges and increase in-channel discharges, especially during the pre-monsoon period. They tend to concentrate floodplain discharges and overbank spills into fewer locations and more specific spill points, often at locations where embankments are eroded and channel erosion/deposition problems are occurring. Shawinigan Lavalin Inc. and Others (1994b) observe that while water level and discharge effects may be negligible for individual submersible embankment projects, several such projects occurring together within a drainage system can produce significant cumulative effects on water levels and flows. The cumulative impacts of the numerous submersible embankment projects built in the northeast region, as Shawinigan Lavalin Inc. and Others (1994b) observe, have not been manifested as a result of frequent embankment breeches, wave damage, public cuts, and incomplete structures and embankments. However, if these projects became fully operational (as could happen if in the future they were rehabilitated), they would have significant impacts on pre-monsoon and in some cases monsoon water levels and flows.

In order to permit fish migration in rivers it is necessary to maintain conditions that help migrants reach their spawning grounds. To overcome obstacles, such as hydraulic structures, placed in the path of migrating fish, structures must be designed to assist the fish to pass them. The efficiency of such fish-passing structures depends to a large degree upon the ability of engineers to utilize knowledge of physiology, ecology and behavior of the migrating species (Pavlov, 1989).

Other than obstruction of fish migration routes, factors that have affected the fisheries resources of the haors are the reduction of the habitat area due to reduced depth of water in haors as a result of sedimentation (CEGIS, 2006). There is a tendency for complete or partial reclamation of the lower beel areas (often under public control) for paddy cultivation following improved drainage due to FCD projects. This has severely reduced the area of water available for fish during the dry season, and is claimed to have reduced the diversity and quantity of fish in the beels and haors; although other factors, including overfishing, pollution and fish disease, are also thought to contribute (Hughes et al., 1994).

There is no integrated water resource management plan for the haor basin. Presently, different development agencies working with natural resources undertake development work from their own perspective without any coordination among themselves. As a result the expected benefits are not realized. In many respects, the productivity of the haor basin is declining due to increasing flood damages and depletion of fishery resources and biodiversity. Therefore an integrated plan for sustainable socio-economic development of the entire haor basin is urgently needed (CEGIS, 2005).

1.2 Objectives

This study was carried out with a view to assessing the ecological health status in a number of selected haors using some fish indicators. The water management interventions in haors bring about changes in hydrologic settings (e.g. river/floodplain flow, sediment transport etc.) and consequently changes in the natural system of the haors. The hypothesis in this study was that the ecosystems of different haors have been impacted to different degrees due to water management interventions. Specific objectives of the study area were as follows:

- To assess ecological health in three selected haors under varying hydrological settings using some established health indicators
- To relate indicators with different hydrologic settings and water management interventions

The study was undertaken with the expectation that it would give a good understanding of the ecological (fish) health status in haors under varying hydrologic settings, which would provide insight on developing a better management system of ecological resources of haors.

1.3 Organization of the thesis

Chapter two provides the review of the previous literature. It includes the impact of partial or full flood protection embankment and migration pattern of fishes. Fish life cycle is also provided in this chapter. Chapter three presents the methodology of the thesis. First the chapter discusses the general description of the participatory rural appraisal (PRA) techniques. Then it describes the data collection procedure/method used in the study. Chapter four presents the selection process of the haors for the study. A detail description of the selection criteria is provided in this chapter. Chapter five presents a total description of the study area. The description includes physiography, interventions, water resource system, fish habitat area and the species diversity in the three selected haors. Results are presented in Chapter six along with some discussion of the results. Conclusions are presented in Chapter seven along with some recommendations.

Chapter Two

Literature Review

2.1 Introduction

The study focuses on the ecological health status of haors and tries to relate it with the water management interventions. A brief review is presented in this chapter on the haor system. Fish was selected as an indicator for the ecological health of haors different characteristics of fishes, including fish biodiversity, life cycle and migration patterns are reviewed in more details. These are some of the important characteristics that are likely to be disturbed by water management interventions. Water management interventions in the haor basin are briefly reviewed together with their impacts on fisheries.

2.2 Haors in the north-east region of Bangladesh

Haor is a large depression between two or more rivers. The depression is generally a bowl-shaped deeply flooded permanent freshwater wetland (which also serves as fish migration routes). Static water bodies, known as *beels,* are found at the centre of virtually every haor in the dry season. Haors receive surface runoff water by rivers and *khals*, and consequently, the haor basin becomes very extensive (a huge single wetland) water body in the monsoon and form a unique water system for fish habitation. The haors dry up mostly in the post-monsoon period. The haors are rich in biodiversity. Generally the wetland areas are the breeding and feeding places for most of the freshwater migratory fishes. Net production rate is higher than other aquatic system of the country (CEGIS, 2006). Fishermen fish in the perennial water bodies during dry season and in the flood water during monsoon. In Bangladesh haors are found mainly in greater Sylhet and greater Mymensingh regions (Table 2.1). The haor basin contains about 47 major haors and some 6300 beels of which about 3500 are permanent and 2800 are seasonal. These wetlands vary in size from as little as a few hectares to many thousands of hectares. The principal systems are as follows:

Table 2.1: Haor in the northeastern region of Bangladesh (Source: Khan, 1997)

District	Name of Haor	Area (ha)
Moulovibazar	Hail	24370
	Hakaluki	15000
	Kawadighi	22700
Sylhet	Pangar	19075
	Balai	2398
	Muria	5500
	Bara	32300
	Erali	1500
	Zilker	2800
	Hathkhola haor	7000
	Telir haor	-
	Maijjail & Dubriar	9600
	Muktarpur	7900
	Pokonaoir	9900
	Rautir	1400
	Salitigarr	3800
	Paterchuri	6060
Sunamgonj	Angurali	2592
	Baram	5500
	Bhanda	4000
	Chandra Sonarthal	4450
	Chaptir	4453
	Dhankunia	1780
	Gurmur	5360
	Halir	7325
	Joal Bhanga	4370
	Joydhona	1330
	Kalner	7120
	Karchar	7770
	Matian	6380
	Mohalia	1356
	Naluar	12141
	Panger	19075
	Shanghair	5000
	Shanir	7010
	Sonamoral	3725
	Tangua	5000
	Chairar	10100
	Chawkhaai	3000
	Dhekhar	30300
	Nainda	5300

- Baram, Banka, Habibpur, Maka and Makalkandi haors (which unite to form a single large water body during the rainy season), the Guldhuba haors, and Ranga and Baudha beels. These are located in the eastern and lowest part of the basin in Mymensingh.
- Tangua, Shanir, and Matian haors in the deep northern basin at the foot of the Meghalaya Hills. These form a single water body during the rainy season.
- Dekhar Haor, Pathar Chauli Haor, and Jhilkar and Jhinkar Haors, to the east of the Tangua system.
- The Jamaikata, Mahai, Nalua, and Parua haor system, on the eastern rim of the basin.
- Hakaluki, Chatal Bar, Haila, Kawadighi, Pagla and many smaller haors, in the central Sylhet lowlands.
- Hail Haor, between the Tarap and Banugach hill ranges in the southeast.
- Dingapota, Ganesher, Tolar, Anganer, Bara, and Humaipur Haors, in the south of the basin.
- Etna and Sania Haors, Kishorganj district.
- Khaliajuri Haor, east Mymensingh.

Most of haors are still in their natural state and some (about one tenth in number) have been enclosed by submersible embankments (CEGIS, 2006). In the dry season, the huge water drains out, leaving one or more shallow lakes (beels). The total drainage is towards southwest mainly via the Surma, Kushiyara, Baulai, and Kalni Rivers into the Meghna River and subsequently into the Bay of Bengal.

2.3 Fish biodiversity in haors

In addition to varieties of aquatic organisms, a total of 260 indigenous freshwater bony fish species suitable for human consumption, belonging to 145 genera and 55 families (Rahman, 1992). Cyprinids and catfishes dominate the ichthyofauna. Virtually all species are of some commercial importance in so far as they appear in retail markets. Major carps and large catfish are the most commercially valuable, but other group such as knifefish, "livefishes" (*koi, magur singi)*, and hering (*illish*) are also important. Miscellaneous species are the highest importance for subsistence and self- provisioning.

A widely used, popular approach groups fish species into two categories:

- *Boromaach,* or large fish. This includes major carp, large catfish, *Chital,* gangetic stingray, *Gazar*, *Shol* and *Ilish.* Most boromaach carry out longitudinal spawning migration.
- *Chotomaach,* or small fish. This includes the vast majority of species. Most *Chotomaach* do not carry out spawning migrations, or at most move short lateral distances into shallower water. The most common fishes that occur in this region are given in Table 2.2.

Table 2.2: Common fish species occur in the haor region (compiled from Shawinigan Lavalin Inc. and others, 1994a)

Category name	Species name	Occurrence	Spawning period
Major carps	*Rui* (Labeo rohita), *Mrigel* (Cirrhinus mrigala), *Kalibaus* (Labeo calbaus) *and Catla* (Catla catla)	Rivers, beels and khals	Spawning migration occur during the early monsoon
Large catfishes	*Boal* (Wallago attu), *Pangas* (Pangasius pangasius), *Air* (Aorichthys aor), *Guizza Air* (Aorichthys seenghala), *Baghair*(Bagarius bagarius) and *Rita*(Rita rita)	*Boal* inhabits lotic and lentic water bodies, *Air* and *Guizza Air* inhabit rivers and beels, *Pangas* lives in large deep rivers, *Rita* is found in muddy rivers and *Baghair* found in rivers	Spawning may take place from early April to end of the August
Minor carps	*Gonia* (Labeo gonius), *Lasu* (Cirrhinus reba), *Nanid*(Labeo nandina) *and Angrot*(Labeo angra)	Rivers, beels and khals	Breeds during the pre-monsoon floodplains
Small catfishes	*Magur (Clarias batrachus), Singi* (Heteropneustes fossilis), *Kani pabda* (Ompok bimaculatus), *Madhu pabda* (Ompok pabda), *Basa* (Eutropiichthys vacha), *Ghaura*(Clupisoma garua) and *Tengra (Batasio* and *Mystus)*	*Magur* is found in stagnant and muddy water, *Singi* lives in ponds, dithches and haors, *pabda* is found in all type of Inland waters from beels to rivers, *Ghaura* and *Basa* are found in rivers.	*Magur* breeds during the rainy season (April to August) in shallow water. *Singi,* spawning takes place during the monsoon months
Ilish	Hilsa ilisha	River and sea	Breeding, egg development

			and fry development take place in rivers
Snakeheads (Channa)	*Shol* (Channa striatus), *Gazar* (Channa marulius), *Tila shol* (Channa barca), *Taki* (Channa punctatus) and *cheng* (Channa orientalis)	Usually found in stagnant water including beels	Breeding take place during the pre-monsoon (March-April) in stagnant waters
Knifefishes (*boromaach*)	*Chital* (Notopterus chitala), *Foli* (Notopterus notopterus)	Inhabit beels as well as rivers, but prefer clear water	*Chital* breeding takes place in June-July, *Foli* breeding takes place in May-June
Stingray	*Shakush* (Himantura fluviatilis)	Kushiyara river	
Miscellaneous	Needle fishes: *Kaikka* (Xenentodon cuteutia),	Beels and flood lands	
	Minnows, Rasboras and Barbs: various small cyprinids such as *Punti, Chela, Mola* and *jaya. Important Sarpunti* (Puntius sarana) declined recent years.	Every type of aquatic habitat	
	Loaches: *Rani* (Botia dario), *Gutum* (Lepidocephalus guntea)	Surma and its tributaries around Sylhet, Chhatak and Sunamganj	
	Anchovies and Sardines: *Phasa* (Setipinna phasa), *Kachki* (Corica Soborna), *Goni chapila* (Gonialosa manminna) and *Chapila* (Gudusia chapra)	Beels ditches and floodlands	
	Spiny eels: *Baim* (Mastacembelus aculeatus),	Rivers beels and flood lands	
	Climbing perch: *Koi* (Anabus testudineus)	Stagnant water bodies	Breeding lasts from May to July
	Gobies: *Bailla* (Glossogobius giuris)	Rivers	
	Mud perches: *Bheda* (Nandus nandus)	Ditches and flood lands	
	Glassfishes: *Chanda* (chanda spp)	Beels	
Prawns	*Golda chingra* (Macrobrachium rosenbergi), *Icha*	Rivers and bels	

2.4 Declining fish biodiversity

Large amount of fish of various varieties as shown in Table 2.2 are still available in Panger Haor, Hail Haor and Zilkar Haor. Table 2.3 shows that the species availability, decline and extinct of the study area. The species declining and extinct are mainly due to squeezing of the fish habitat area, destruction of nursery fishing ground and fish migration restricted by intervention (Nishat and Bhuiyan, 1995).

Table 2.3: Species availability with decline and extinct (Source: Shawinigan Lavalin Inc. and others, 1994a)

Species availability	Availability decline	Extinct
Puti, Rui, Catla, Tengra, Khailsha, Veda/Meni, Taki, Koi, Shing, Chhoto Chingri, Baim (Tara, Shal, Guji), Gutum, Shol, Gajar, Magur, Gainna, Boaal, Mrigel, Mola, Batashi, Kakila, Foli etc.	*Koi. Shing, Magur, Shol, Goinna etc.*	*Pangas, Bacha, Pabda, Ghagat, Shal, Baim, Puta (Shor Puti), Rani, Chital, Kaliboush etc.*

2.5 Relationship between hydrologic cycle and fish life cycle in haors

The annual succession of pre-monsoon floods, monsoon floods, flood recession and dry season largely controls the events in the life histories in the floodplain fish species. Spawning migrations usually take place during the pre-monsoon and early monsoon floods. Major carps, *Chital*, *baghair*, *air*, *ilish* and some of the chotomaach species breed in the rivers. Other species (*boal*, *gonia* and most chotomaach) breed on the floodplains. Fingerling grows rapidly during the full flood phase. During the flood recession and dry season large boromaach generally move back into the deeper parts of the rivers while chotomaach and juvenile boromaach overwinter in the larger beels. There is some evidence that suggests that major carps possess a 'homing' ability similar to salmon which causes them to return to particular locations during the dry season. The principle carp breeding areas in the region are Tangua Haor, Pashur Haor, Companiganj area, Erali beel and Hakaluki Haor (Shawinigan Lavalin Inc. and others, 1994a). Major carps are known to spawn in rivers. However, some studies observe that they spawn in beels. Khan and Jhingran (1975) and Jhingran and Khan (1979) reported that *Rui* and *Mrigel* spawn in fields adjacent to rivers which are flooded after heavy showers, and in shallow marginal areas of bunds on flood fields.

It may mean that major carp broodstock does not necessarily have to migrate across embankments into rivers to spawn. Increasing beel water levels during the early monsoon may be sufficient stimulus to induce them to spawn in their overwintering beels or on the flooded haor. Broodstock which have overwintered in rivers might thus have two options for spawning migrations at the onset of the monsoon: 1) swim upstream to locate suitable spawning habitats (i.e. oxbow bends) in the river, or 2) remain in the vicinity of the overwintering ground, wait until the river bank is overtopped and then move laterally on to the floodplain to spawn.

Three species differ somewhat from the norms: 1) *pangus* spends its entire life in larger rivers and the coastal zone and does not appear to utilize the floodplain; 2) *illish* spawns in the rivers but juveniles drift downstream and mature in the sea; 3) *golda chingri* spawns in the sea and juveniles move into rivers to mature. Mother fisheries are an important component of the region's fisheries environment and resources. These are well delimited areas consisting of dense concentration of high quality fisheries habitats, including deep river duars, large beels, sediment-free khals, clear water, wetlands forest patches, reed beds, native shrubs and grasses. Mother fisheries support a high abundance of fish, both resident and seasonal migrants, and act as dispersal centers for the surrounding areas of the floodplain. Mother fisheries control fish abundance over large areas of the floodplain. There currently exist four mother fisheries in the region: Tangua Haor, Hakaluki Haor, Kaliajuri area and Companiganj area. Kawadighi Haor was also a mother fishery of great importance in the past, but its productivity was damaged by the Manu River FCDI project (Shawinigan Lavalin Inc. and others, 1994a).

Shawinigan Lavalin Inc. and others, (1994a) divided the fish year into four seasons:

1. Over wintering dry season **(December to March)**: Broodstock and juveniles approaching recruitment size are concentrated in river duars and beels. No migratory movements take place at this time. These habitats (especially beels) are fished heavily during this season, and whatever fish survive enter the next season.
2. Spawning migration season **(April to June)**: This season usually begins during the pre-monsoon flood phase of the hydrological year and can continue into the first part of the full monsoon flood phase. Fish generally moves from deeper

waters (such as duars) to shallower waters. Breeding takes place in shallower waters. Almost all fish species can be separated into two distinct groups:

- Species which breed in the rivers: Among *Boromaach* this includes the major carp *Rui, Mrigel, Catla* and *Kalibaus,* the knifefish *chital* and the large catfish *Baghair* and *Air*. Among *Chotomaach* this group includes *katchki, Batashi, Kajuli, Baim, Rani, Bailla,* and some others. *Chital* prefers submerged structures such as trees and artificial structures such as submerged canoes. Bypass structures of FCD/I project embankments need to allow this pattern.
- Species which breed on the floodplain: *Chotomaach* breed on the floodplains once inundation starts during pre-monsoon floods. There is also an evidence to breed in monsoon floods. Some *Boromaach* like *Boal* and *Ghonia* breed on the floodplains. The requirement for these species is that they need to be able to swim from rivers into beels and floodplains. Bypass structures of FCD/I project embankments need to allow this pattern.

3. Nursery/grazing season (**June to September**): The fish season corresponds to hydrological height of the monsoon flood season. The fingerlings of those fish which breed on the floodplain are already on the nursery grounds so they do not have an access problem. But the fingerlings hatched from river breeding species need to get up on to the floodplain, and this can only happen one of two ways: 1) passively swept on to the floodplain when the river overflows its banks or overtops a submersible embankment and 2) passively swept through a bypass structure such as a regulator when it is opened to effect controlled flooding. This is the season of rapid fish growth.
4. Flood recession season (**September to December**): A few species are able to aestivate (i.e. *Koi, Channa spp*), but the majority migrate to deeper water during flood recession. A fish moving from the floodplain out into a river will normally move along a khal. FCD/I embankment bypass structures need to allow this pattern to happen.

2.6 Fish migration patterns

In the haor regions there are some canals, khals and rivers which serve as fish migratory routes. Fish migrates to these beels and khals from rivers for their breeding, spawning and feeding and vice-versa. Migratory species comprised the highest share of the catch (approx. 54%) in the north east due to the greatest areas of open water occur which favour many migratory species. ODA (1994) reported names of 19 migratory species (riverine and floodplain), some of which are *Catla catla* (Catla), *Labeo rohita* (Rui), *Labeo calbasu* (Kalbaus), *Gudusia chapra* (Chapila), *Wallago attu* (Boal), *Cirrhinus mrigala* (Mrigel), *Eutropiichthys vacha* (Bacha), *Aorichthys aor* (Air) etc. Water management interventions interrupted migration of fish species. There are some water control structures and regulators in the haors, but most of them are fully or partially damaged while the connected khals are silted up. Normally, a haor is flooded by overtopping or breaching in the embankment during the month of May-June. CEGIS (2005) studies show that during May, big fishes spawn in the deeper part of the rivers/beels and small fishes spawn in the newly flooded shallow waters of the beel area. During flash floods/monsoon floods, the fingerlings of the species, which breed in the rivers, need to enter the haor area for feeding and growth (CEGIS, 2005). Fignre 2.1 shows the migration pattern of fish over the year. The spawning migration usually takes place from April to June in the early flood phase and the beginning of the deep phase. During the monsoon season (June to September), juveniles feed and grow in the shallow water with vegetation to avoid predation and then gradually move to open deep water area. During the flood receding period (September to December), with the decrease in water level, fish move to deep water areas of floodplain or to rivers for overwintering.

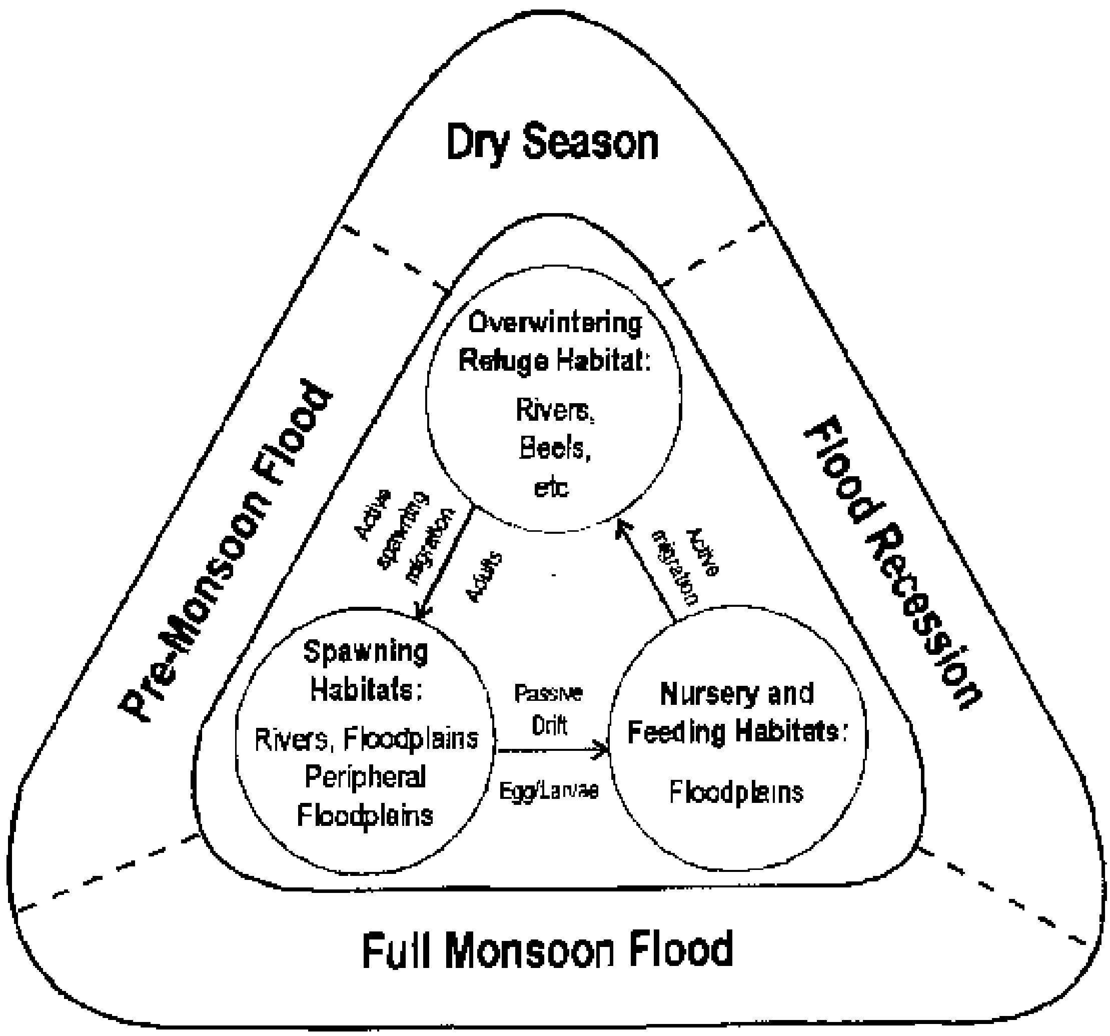


Figure 2.1: A general pattern of seasonal migration of fish in Bangladesh (Source: Nishat and Bhuiyan, 1995)

Except for major carp, *Pangas* and *Ilish*, most fish species breed more or less everywhere in the region. The species can be separated into two groups based on their preferred breeding habitat. Table 2.4 shows the identified breeders in each habitat of the region.

Floodplain and beel breeders: Breeding begins during the pre-monsoon flood. Depending on the rain and water volume in the river and floodplain, most of the catfish, live fish and other species (*Magur, Singhi, Koi, Tengra, Pabda, Air, Boal, Gazar, and Shoal*) start breeding at the end of March and early April.

River breeders: Reproductive patterns are more diverse among river breeders. *Air, Rita, Ghagot* and *Guizza* make pits in the shallower part of the river in April and May.

Table 2.4: Identified breeders in each habitat of the region (Source: Shawinigan Lavalin Inc. and others, 1994a)

Floodplain and beel breeders	River breeders
Boal, Ghonia, Sarputi, Singhi, Magur, Koi, Bheda, Puti, Icha, Chanda, Mola, Gulsha, Tengra, Laso, Kholisha, Along	*Chital, Ghagot, Kalibaus, Catla, Rui, Mrigel, Air, Rani, Pabda, Pangas, Basa, Garua, Shilon, Baspata, Kajuli.*

2.7 Types of intervention

There are two types of intervention in the North-east haor region viz., partial flood protection/submersible embankment and full flood protection embankment. Maximum haors are protected by the low height submersible embankment and very few are by regular embankment. The aim of the submersible embankment is to increase the crop production and to protect the early flash flood (Shawinigan Lavalin Inc. and others, 1994a).

2.7.1 Partial/submersible embankment

These projects typically consist of submersible embankments surrounding a haor including one or more hydrological regulators. The aim of these projects is to protect boro crop from early flash flood by delaying haor flooding until 16 May (Shawinigan Lavalin Inc. and others, 1994a). The Bangladesh Water Development Board (BWDB) added the technical dimension to this concept in 1960s and constructed a total of 1826 km submersible embankments in 46 projects to protect boro crop in 2, 89,911 ha area in six districts including a number of hydrological regulators and pipe sluices (CEGIS, 2006). The highest numbers of projects (24) were completed in the Sunamganj district, and the lowest number of projects (2) in Kishorganj district (CEGIS, 2006).

2.7.2 Full flood protection

Full flood protection in the haor basin has been very few. Shawinigan Lavalin Inc. and others (1994a) reported that full flood protection involved construction of embankment surrounding a haor or other flood prone area, with one or more hydrological regulators using paved roads as flood protection. The aim of these projects is to create conditions for double or triple cropping pattern by protecting *aus* and *aman* crop from monsoon flooding, as well as boro from pre-monsoon flooding (Shawinigan Lavalin Inc. and others, 1994a). Shawinigan Lavalin Inc. and others (1994a) showed that Zilkar haor and Damrir haor are the only haors with some full flood protection intervention. CEGIS (2005) studies show that Zilkar haor enjoys full protection in some parts and partial protection in some parts. Table 2.5 shows the reported impacts of full flood protection projects.

Table 2.5: Impact of full flood protection projects (Source: Shawinigan Lavalin Inc. and others, 1994a)

Project Name	FCD/I impact on fish production
Full flood protection (without pumped drainage)	
Zilkar haor	Mixed reports, No impact: according to one subsistence fishermen. Negative: reported 60-70% decline
Damrir haor	No impact

2.8 Impact of submersible embankment projects in the haors

Rapid rural appraisal (RRA) method was used in FAP-12 study for multi-disciplinary evaluation (including fisheries) of 17 FCD projects throughont Bangladesh (Hunting Technical Services, 1992). Sultana and Thompson (1997) reviewed the same 17 projects and observed that there is a growing concern of flood control and drainage (FCD) projects, as they have severely reduced fish stocks by reducing wetland areas and by blocking fish migration and dispersal routes. Snltana and Thompson (1997) reported that completion of 17 projects between 1970 and 1989 were consistent with this trend and show that projects with serious effects on fisheries may not be economically viable. However, a general decline in catches resulting from over fishing may also be a factor.

The investigation considered only two haors namely Zilkar haor and Halir haor with submersible embankment. The results obtained from the RRA findings for the two haors are summarized in Table 2.6. The study revealed that significant damage to fisheries took place in projects with full flood protection. The projects with submersible embankments also suffered damage, although to a lesser extent.

Table 2.6: FCD/I project impact on fisheries through RRA findings of FAP-12 (Source: Hunting Technical Services, 1992)

Project	Type	Capture fishery production			Culture fishery production		Overall impact	remarks
		Rivers	Beels	Floodplain	Fish ponds	Larger bodies		
Zilkar Haor	S	-1	-1	-1	0	+1	-1	Less damaging to fish stocks
Halir Haor	S	-1	-1	-1	0	0	-1	Less damaging to fish stocks

S=Submersible Embankment, -1=Decrease to some extent, 0=no change, +1=increased by some extent

Shawinigan Lavalin Inc. and others (1994a) observe that submersible embankment projects significantly altered natural processes of Haors. Such type of intervention causes many disturbances of natural processes of haors and changes the ecological setting which is harmful for species, particularly fish. Flood plain fish production in the region was found to be significantly impacted by at least seven factors of direct or indirect anthropogenic origin: FCDI projects, sedimentation, pesticides, fertilizers, sewage, industrial effluent and fish disease. In most cases several of these factors operated simultaneously. It was not possible to easily separate FCD/I impacts from non-FCD/I impacts (Shawinigan Lavalin Inc. and others, 1994a). Table 2.7 shows impacts of various types of flood protection projects on fisheries.

Table 2.7: Impact of partial flood protection project (Source: Shawinigan Lavalin Inc. and others, 1994a)

Project Name	FCD/I impact on fish production
Matian haor	Positive: higher water level for katha
Gurmar haor	Positive: higher water level for katha
Angurali haor	No impact
Sonamoral haor	Positive: higher water level for katha
Nawtana haor	Mixed impacts: Negative: reduced fish production, restricted fish Migration; Positive: prevents siltation.
Halir haor	Mixed impacts: No impact: according to one fishery group; negative reported 40-50% decline over last 10 years.
Joydhona haor	No impact
Karchar haor	Negative: severe reduction in fish production
Mahalia haor	No impact
Pangar haor	Negative: fish production has decreased
Chaptir haor	No impact
Shanghair haor	No impact
Tanguar haor	Mixed reports, No impact: according to one subsistence fishermen. Negative: affected fish migration.
Baram haor	Negligible impact.
Kalner haor	Negative: reported 70-75% decline over last 10-15 years.
Patherchuri haor	Positive: higher water level for katha, prevents siltation.
Hail haor	Negative: reported 75% decline over last 5 years.
Humaipur haor	No impact
Kushiyara-Bardal	Little impact

2.8.1 Impact on migration

Overall fish migration situation has been found by (CEGIS, 2006) as moderate to good in all the haors. Early (15 April-15 May) feeding and spawning migration rate of riverine and *beel* resident fishes is sometime possible through different open *khals* of the haors. But most of the connecting *khals* either remain mud sealed or closed by sluice gates in that season. Besides, riverine fishes migrate to the *beels* through overtopping or breaching of the existing embankment of the haor during flood months of *Jaistha-Ashar* (15 May-30 June). Successful vertical migration of different fishes, e.g. riverine carps, catfishes, etc. at their certain stages of life cycle for food and residence is only happening in *beels* those have sufficient depth. The canals towards the adjacent rivers are acting as the main fish migration routes of the haor. River connected *beels* are the main fish breeding area (CEGIS, 2006).

2.8.2 Decreasing fish habitat

Shrinkage of fish habitats (area and perennial *beels, khals* and adjacent rivers) is taking place due to rapid siltation, encroachment, etc (CEGIS, 2006). The main reasons for accelerated sedimentation are channel confinement that retains sedimentation in the haor and also aggravates sedimentation in the active river width. More sediment loads are coming from the upstream hill range due to deforestation and land slides. Significant flow reduction is taking place at the downstream section of the rivers thereby increasing sedimentation at the downstream river reaches (CEGIS, 2006).

Fish habitat destruction by the construction of roads and embankments, together with drainage, flood control and natural siltation, along with weak implementation of outdated policy measures by the government, have been commonly cited as causes for the deterioration of the country's fishery resources (Hossain et al., 2006).

2.8.3 Non FCDI related impacts of haors

Typically most non-FCD/I project fisheries are being impacted by several factors simultaneously. Remote effect from nearby and distant FCD/I projects also impact areas without FCD/I project, including destruction of carp stocks and channelization of migrating broodstock.

Bulk (60-70%) of the fish production is coming from the perennial *beels* of the haors during the dry season (February-March). Recent studies show that some of the major identical fish species are declining due to habitat change and indiscriminate fishing (CEGIS, 2006). The production trend is also declining slowly from the open water capture fisheries of the haor. Aquaculture is developing in suitable ponds of high land area of some haors.

Increased use of pesticides and fertilizers for producing high yielding varieties of food crops and rising industrial pollution are also contributing to the deterioration of the aquatic environment (Ali, 1997).

Hossain et al. (2006) reported that the situation has further been complicated by upstream damming in the major river systems that significantly reduces the water level and raises much of the river beds, thus dangerously modifying many of the aquatic habitats of the country.

2.9 Fisheries management issues and problems

The challenges for sustaining multiple uses of aquatic resources are evident globally. Until recently, traditional management of fisheries resources has commanded a low level of compliance with management measures (Alam and Thomson, 2001; Nielsen et al., 2004)

2.9.1 Decreasing stock abundance

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

2.9.2 Decreasing biodiversity

Fisheries biodiversity is decreasing due to several indiscriminate fishing e.g. use of harmful fishing gears, cathing of post larvae and brood fish, complete dewatering of leased water bodies for fishing, overexploitation, application of poison in beel for fishing, etc (CEGIS, 2006). Two major carp (Nanid and Angrot) and koral appear to have been extinct in the region. Populations of pangas, mohasol and sarputi have been seriously reduced. Several species are going extinct at the local level, e.g. bedha, taki, gagla, batch and chital.

2.9.3 Decreasing production

Fish production is decreasing due to habitat loss, change of existing aquatic ecological condition and poor fisheries management. Obstruction of early feeding and spawning migration due to inadequate migration routes (silted and sealed *khals*). (CEGIS, 2006)

2.10 Strategy for fisheries rehabilitation and sustainable development

2.10.1 Beel bypass

Under this FCD/I scheme, instead of locating the embankment along the periphery of the haor as is the usual practice, the embankment would built only the higher elevation agricultural land (haor), completely by-passing the beel cluster. This would leave beels freely connected by khals to rivers and allow unimpeded spawning migrations of fish (Shawinigan Lavalin Inc. and others, 1994a). However, there are costs of earthworks involved and a potential of encroachment and expropriation of agricultural plots.

2.10.2 Fish passes

Shawinigan Lavalin Inc. and others (1994a) showed that under this FCD/I mitigation scheme, fishpass would be constructed to allow migrating fish to cross over embankments. The vertical slot design is considered to be the most appropriate for FCD/I projects as it operates over a wide range of head and tail water elevations without adjustments. Hydraulic regulators, navigation gates and public embankment cuts also function to varying degrees as "fish bypass structures". Nishat and Bhuiyan (1995) showed that it is possible to mitigate the negative impacts of FCDI projects by alteration or modification of a number of flood control engineering structures. Fish passes or fish ladders have been devised to circumvent engineering structures that obstruct fish movement. BWDB has constructed three fish pass structures in Bangladesh (Kabir and Sharmin, 2002). These are Kashimpur Fish Pass at Moulvibazar, Fish Pass in Compartmentalization Pilot Project (CPP) at Tangail and Sariakandi Fish Pass at Bogra. Only one fish pass is situated in the north-east region. The Kashimpur Fish Pass provides a link between the Kushiyara River and Kawadighi Haor. Kabir and Sharmin (2002) reported that people were getting positive results when the structure was operated and maintained properly with the participation of all stakeholders. Therefore to make it sustainable pragmatic steps must be taken in operation, maintenance and management involving the user communities who form the majority of the command area. It was found difficult to assess the effectiveness of the structures due to lack of valid data on fish migration through fish pass. Kabir and Sharmin (2002), frem observation on the local communities (fishers, farmers and women), concluded that the fish pass functions better in terms of migration of fish from rivers to floodplains.

Husain (1998) studied that prevention and mitigation of fishery losses is not only important but also indispensable. Fish pass or fish friendly structure is very much important for fisheries resources. Husain (1998) extensively studied three existing fish pass structure functions and performance. Husain (1998) reported that people are getting benefit from fish friendly structure. Husain (1998) suggested that mitigation of fishery losses must be made modifying existing regulators and making them fish friendly.

Chapter Three

Methodology

3.1 Introduction

The research framework of the study is illustrated in Figure 3.1. The methodology adopted in the study can be categorized in three classes: selection of haor for investigation, application of participatory rural appraisal (PRA) tools to get understanding of the water resources systems and to collect fish catch and composition in the selected systems, and analysis of the information from PRA studies in the context of research objectives. The following section gives elaborations on the methods used.

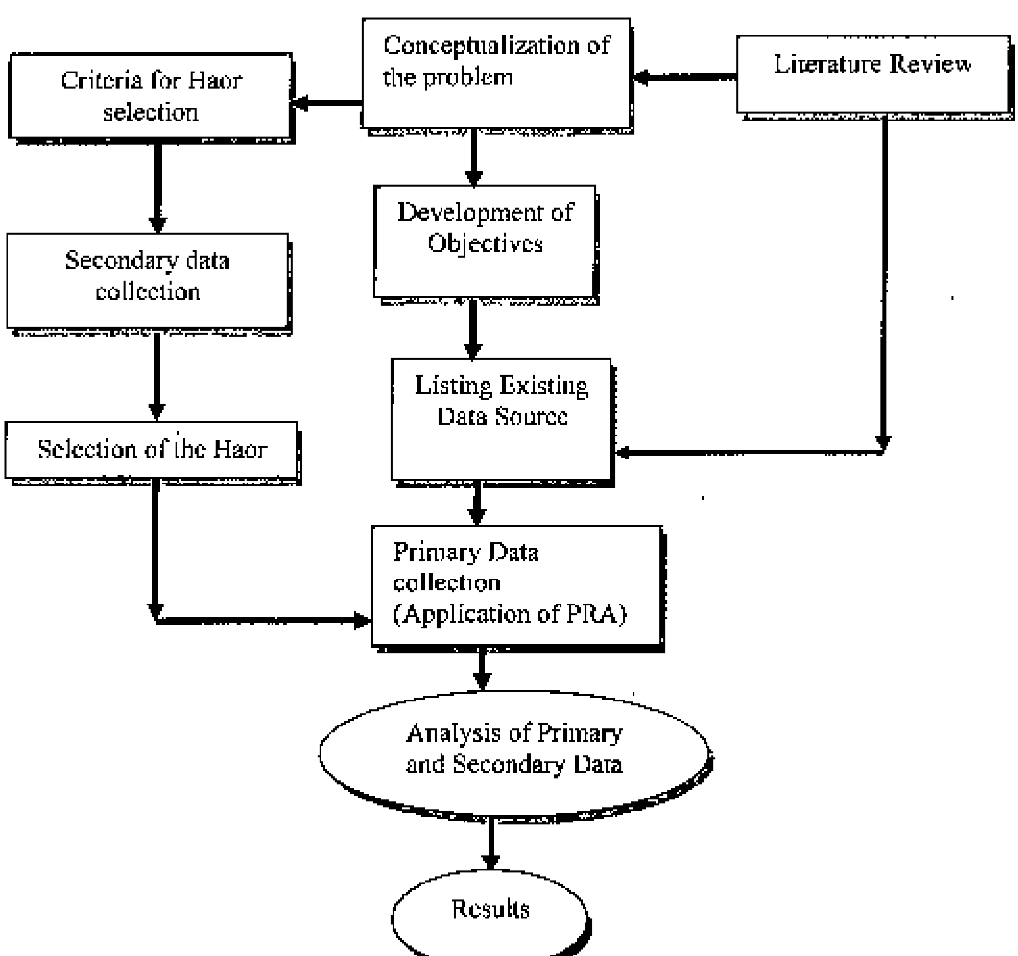


Figure 3.1: Research framework of the study

3.2 Haor selection criteria

One major component of the study was selection of a number of suitable haors in such a way that would serve the research objectives of the study. Haor selection was guided by a set of criteria devised in line with the objectives. The criteria included homogeneity in natural condition in pre-intervention state, type of management intervention, comparability in size, accessibility to the haors and availability of previous secondary data.

The target was to come up with a total of three haors with three distinct physical characteristics namely a) naturally undisturbed state, b) moderately intervened state and c) extensively intervened state. The selection process involved extensive review of secondary data and literature and expert consultation. Analysis of the different systems of haors in terms of hydrology, water management intervention and their status as reported in the previous studies and the impacts of management intervention on fisheries helped select three ecologically important haors in Sunamganj District out of 47 major ecologically important haors in the North-east region.

3.3 Application of participatory rural appraisal (PRA) techniques

Participatory Rural Appraisal (PRA) is a family of approaches and methods to enable rural people to share, enhance, and analyze their knowledge of life and conditions, to plan and to act (Chambers, 2002). Participatory Rural Appraisal is an intensive, systematic but semi-structured learning experience carried out in a community by a multi-disciplinary team, which includes community members. The PRA has different types of tools such as resource mapping, social mapping, focus group discussion (FGD); key informants, transect walk, timeline and seasonality.

The PRA is relatively a new method, fast becoming a very popular one because of its participatory, rapid, flexible, iterative, cost-effective and interdisciplinary nature. PRA tools are extensively used in socio-economic survey studies. Their application in bio-resource assessment is emerging in recent times. One example is the study by Metillo et al. (2004) who used PRA approach to address the crucial global issue of environmental degradation and loss of biodiversity in Mindanao, Phillipines. This comprehensive approach involved bottom-up, cross-sectoral and interdisciplinary efforts in addressing the complexity of problems associated with the loss of biodiversity. Nanyunja (2002) conducted a study focusing on human perception to biodiversity losses in Uganda. A number of PRA tools including Focus Group Discussions (FGDs), timelines, resonrce rankings and abundance scores were used in the study. Application of PRA in evaluating bio-resources, however, has been few in Bangladesh. One example is the application of the Rapid Rural Appraisal (RRA) method, an earlier form of PRA, in the evaluation of 17 FCD/I projects in FAP-12 study by Hunting Technical Services (1992), as mentioned in Chapter two. Mamun (2007) used a variety of PRA tools (semi structured interview, key informants, focus group discussions, resource mapping, seasonal calendars and transect walk) to study conservation and management of fresh water fish habitats in a number of beels in the north-central region of Bangladesh. Wester and Bron (1998) applied Rapid Water Management Appraisal (RWMA) technique, an adaptation of the RRA, to study water management systems in 27 FCD systems and two irrigation systems throughout Bangladesh. Their study involved, among others, the assessment of impacts of embankments on fisheries in the FCD systems, which included a number of haors.

The PRA is aimed to generate information on the biodiversity of the areas of concern and the various factors underlying the dynamics of the population-environment interactions. Acharya (2003) showed that Participatory Rural Appraisal (PRA) can be used for conserving bio-resources and improving livelihoods in Nepals. Forest biodiversity was assessed in the study by applying a range of PRA tools including transect walk and informal interviews.

3.4 Primary data collection

PRA approach was used for collection of primary data of fish composition and diversity. There are other possible means to collect data, such as catch assessment survey (CAS). However, these need longer period of time for data collection and are expensive, and hence were not considered in the present study. Out of suite of different PRA tools, Focus Group Discussions (FGDs) and Resource Mapping were selected and used for the collection of primary data.

3.4.1 Focus Group Discussions (FGDs)

FGD is an efficient and effective tool for colleting various information. Focus Group Discussion brings together a small and homogeneous group of 6-12 people who are the representative of a much larger sector of a society or of the community. The purpose is to create an informal situation in which the members of the gronp discuss the topic of concern among themselves with the help of a facilitator and in the presence of one or more observers.

The conventional way to perform FGDs is to do it in a group. The FGDs were conducted by the author himself. The author himself acted as the facilitator and observer simultaneously. For collecting information, six FGDs were conducted in the selected haors. Traditional fishermen groups were the main source of primary information collection. Each of the three haors selected in the study has two traditional fishermen villages. Visits were made to both the villages for collection of primary information. The names of the villages are Bhatidal and Nagergao in Tangua haor, Phutka and Nachni in Baram haor and Kochua and Chanpur in Chaptir haor. Two Focus Group Discussions were conducted in each haor (i.e. one in each village). Each FGD involved 10-12 people. Average age of the people was 35. All of them were male. All the FGDs were done in the open field of the villages.

3.4.2 Resource mapping

Resource mapping is a map to depict the resources, mostly natural water, vegetation etc available in the study area. Resource mapping normally covers the area of the entire study area along with some adjacent areas. Resource mapping is often used as a base map at the time of planning as it enlists and visualizes almost all resources. It also acts as a documentation of the situation in the study area during the time of planning.

Resource mapping activity was done in three villages: Bhatidol in Tangua haor, Nachni in Baram haor and Kochua in Chaptir haor. To draw the resource map, participants were provided with a brown paper and two colour pencils. One person from the groups of 6-10 people drew the map. In the case there was a mistake, it was immediately corrected by rest of the participants. The whole exercise took place in the open field of the villages except Nachni village because of absence of suitable open space (see Figure 3.2). At the time of mapping quantitative and qualitative fisheries related information were collected from the participants. Three resources mapping were done in three selected haors (one in each haor) following the same procedure as described above.

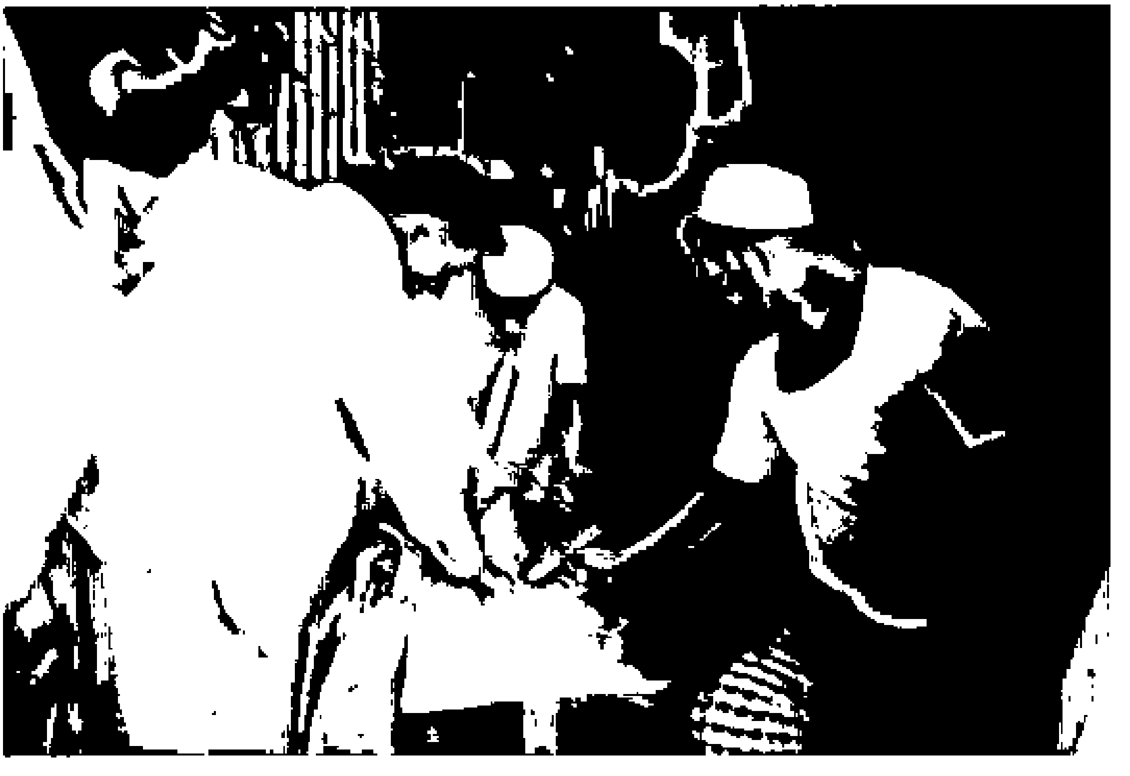


Figure 3.2: An exercise of resource mapping was done by the participants at Nachni village in Baram haor.

3.5 Secondary data collection

Secondary data were collected from various research related literature, government and non-government, published and unpublished reports, thesis papers etc. The secondary data were collected from the following government and non-government offices.

- Bangladesh Water Development Board (BWDB) System Rehabilitation Project (SRP) Report (1994).
- Centre for Geographic Information System (CEGIS) Haor Rehabilitation Project (2005, 2006).

- FAP-6, Fisheries Specialist Study (1994) and Specialist Study Report on Wetland Resources (1995).
- FAP-12, FAP-17 reports.

Chapter Four

Selection of Haors

4.1 Introduction

For the assessment of ecological health status of haors and to relate the ecosystem health to water management interventions, a total of three haors were to be selected, which would represent three distinct physical characteristics, are as follows:

- Naturally undisturbed state: there have been little changes in the physical process of the haor brought about by intervention causing no significant impact on ecological health status.
- Moderately intervened state: there have been moderate changes in the physical process of the haor brought about by intervention causing moderate impact on ecological health status.
- Extensively intervened state: there have been extensive changes in the physical process of the haor brought about by interventions, causing considerable impact on the ecological health status.

4.2 Selection criteria

It was decided that the three haors could be selected based on a number of criteria, including homogeneity in natural conditions in pre-intervention state, comparability in size, accessibility to the haors and availability of previous secondary data. The details descriptions of these criteria are given below.

4.2.1 Type of management intervention

To protect against floods and promote agricultural development, the Bangladesh Water Development Board (BWDB) has taken various intervention steps to the haor adjacent river between the mid-1960s and 1991 including over 490 kms of submersible embankments under 37 projects, 100 hydraulic structures (inclnding sluices, closures or regulators, drainage outlets and irrigation inlets) and the project sizes varies from 24370 hectare to 645 hectare (CEGIS, 2005). The interventions in the haors are illustrated in Table 4.1.

Although interventions have been made to the haors, their impacts have not been the same in all haors. The impacts on fisheries largely depend on to what extent the embankment with their sluices and regulators affected fish migration and fish habitat area.

Table 4.1: Interventions of the haor area (Source: CEGIS, 2006)

Name of haor	Area	Adjacent river	Adjacent haor	interventions	Embank-ment Length (km)	Project start and complete
Khai (sunamganj)	Project covers 4800 ha.	Mahasingh (surma), Betkhali, Dahuk	Shangair-W, Jamkhola-S, Dekhar-N	Submersible Embankment, Regulator (4 & 3 vent), pipe sluice	17.30	Start 91-92 & complete 94-95
Jamkhola (Sunamganj)	Project gross area 2000 ha.	Mahasingh (surma), Alda/Putia, Dahuk	Khai-N, Naluar-S	Submersible Embankment,	16.72	Start 99 & complete 2001
Naluar (Sunamganj)	Project gross area 12140 ha.	Kamarkhali (surma), Dahuk, Itakhola	Jamkhola-NW, Chaptir-N, Tangua-SW	Submersible Embankment (Polder 1 & 2), compartmental embankment, Regulator (5,4,1 vent)	52 (P1) and 24 (P2) CE-10.5	Start 91-92 & complete 94-95
Baram (Sunamganj)	Project gross area 5500 ha.	Kalni (Surma), Chamti, Darain, Mara chamti,	Chapter-NE, Chaptir and Tanguar-E, Bhanda-S, Udgal-NW	Submersible Embankment, compartmental embankment, Regulator, pipe sluice	28.4, CE-4.532 km	Start 87-88 & complete 92-93
Chandra sonar thal (Sunamganj)	Project gross area 5715 ha.	Kangsha, Dhanu and Konai	Dhankunia and Joydhona-NE, Pangar-E	Submersible Embankment, Regulator, pipe sluice	55.5	Constructed 74-78, Rehabilitated 94-97
Chaptir (Sunamganj)	Project gross area 4553 ha.	Mara Surma, Mara betkhali, Mahasingh, Kamarkhali, Era Chamti, Kalni.	Shanghair-N, Naluar-E, Tanguar-S	Submersible Embankment, compartmental embankment, Regulator, pipe sluice	42 km, CE-2 km	Start 95-96 & complete 97-98
Kushiyara-Bardal (Sylhet)	Project gross area 7500 ha.	Kushiyara and Bardal				Start 70-71 & complete 77-78
Nawtana (Netrokona)	3024 ha.	Dhanu, Balui and Chinnai		Submersible Embankment, compartmental embankment,	60 km	Started 1985-86 and completed

				Regulator,		1988-89
Shanghair (Sunamganj)	Project gross area 5000 ha.	Surma	Khai- E, Jamkhola and Chaptir-S, Kalikota and Panger-W	Submersible Embankment, compartmental embankment, Regulator,	24.40 km, CE-10km	Constructed 1982 to 1988
Sona moral (Sunamganj)	Project area 3275 ha.	Bauli, Someswari, Konai, Surma.	Gurmar and Halir-N, Panger-E, Joydhona, Dhankunia and Chandra sonarthal-S			
Tangua (Sunamganj)	Project gross area 5000 ha.	Kalni, Kamarkhali, Nachni, Kasta gang, Jalia and Kushiyara	Baram-NW, Chaptir-N, Naluar-NE	Submersible Embankment, compartmental embankment, Regulator, pipe sluice, Closer	29.20 km, CE-7.54 km	Implemented during 1991-92 to 1994-95
Dewghar (Kishoreganj)	Project gross area 1221 ha.	Daleswari and Dudda Gang		Submersible Embankment, compartmental embankment, Regulator, pipe sluice	15.40 km	Start 1991 & complete 1993
Shafique (Sylhet)	Project gross area 2380 ha	Surma and Kushiyara	Chatal haor			
Patharchuly (Sylhet)	Project gross area 5466 ha	Surma and piyain				
Kalikota (Sunamganj)	Project area 17610 ha	Mara surma, Kalni. Katagang, Piyain,		Submersible Embankment, compartmental embankment, Regulator, pipe sluice	77 km	Constructed 1994-95 to 1997-98
Udgal beel (Sunamganj)	Project gross area 5900 ha	Mara surma, kalni, Chamti, Darain and Bhela	Baram haor	Submersible Embankment, compartmental embankment, Regulator,	34 km, CE- 10.42 km	Constructed 1990-91 to 1994-95
Balali-padamsree (Netrokona)	2400 ha	Magra and Balali or Baloi River		Submersible Embankment, compartmental embankment, Regulator, and outlet		Implemented during 1984-85 and completed 1993-94
Bhanda beel (Sumanganj)	Project gross area 4000 ha.	Chamti, Kalni, Kushiyara, Darain	Baram-N, Tanguar-E	Submersible Embankment, compartmental embankment, Regulator, pipe sluice	32.08 km CE-14.54	Start 1987-88 & complete 1992-93

Dhankunia (Sunamganj)	Project gross area 1692 ha.	Surma, Someswari, Baulai	Chandro sonar thal-SW, Pangar-E, Sonamoral-N	Submersible Embankment, compartmental embankment, Regulator,	20.50 km CE- length 6 km	
Gurmer (Sunamganj)	Project gross area 5360 ha.	Someswari, Baulai and Mara ganga	Tanguar-N, Halir-SE, Mahalia-E	Submersible Embankment, compartmental embankment, Regulator,	60 km, CE- Length 14 km	Start 1985-86 & complete 1989-90
Kawadighi (Moulivibazar)	Project gross area 22672 ha.	Kushiyara and Manu				
Joydhona (Sunamganj)	Project gross area 355 ha.	Konni, Surma, Someswari	Sona moral-EW,	Submersible embankment	12.50 km,	Constructed in 1962-69

4.2.2 Homogeneity in natural condition

Homogeneity in natural condition means the haors would have derived from the same river system in the pre-intervened state. In such cases, the impacts of the water management interventions on ecosystem could be isolated from other factors.

4.2.3 Comparable size

Comparable size was one of the important haor selection criteria. It was important because the selected haors differ significantly in size it would be difficult to compare their impacts. The impact may very well vary between a small and large haor. The impact on ecosystem health may get obscured or complex because of the presence of other exogenous factors. The degree of intervention and coverage area would be different for two different (such as large and small) sizes of haors.

4.2.4 Accessibility

Accessibility to the haors was another criteria. There are quite a number of haors which lie in remote areas and it takes considerable time and difficult ride (by boat and van) to reach them. Conducting field studies in such areas is also expensive. In consideration of this, haors were to be selected that were relatively easily accessible.

4.2.5 Availability of previous data

Availability of previous data was another pre-condition criteria for haor selection. Not all the haors have been extensively studied in previous studies. So haors for which considerable data are available on water management interventions, functions of the infrastructures and the impacts on different aspects of fisheries were considered for the study.

4.3 Selection of Haors

On the basis of the above discussed criteria a number of haors were narrowed down for selection. Fish migration, fish biodiversity and fish habitat of each haor were then analyzed and compared. One important assumption in haor selection was that other exogenous factors, including the fishing practice in the haors were more or less similar (which was validated to some extent during field evaluation).

Following the selection criteria as mentioned above, a preliminary screening was done from secondary literature and maps, and a number of haors were initially considered. These mainly fall into two river systems, one is Surma-Baulai river system and another one is Surma-Kalni-Kushiyara river system. Sonamoral (3275 ha), Dhankunia (1692 ha) and Gurmer (5360 ha) haors are falling under the Surma-Baulai river system. Chaptir (4553 ha), Tangua (5000 ha), Baram (5500 ha), Udgal Beel haor (5900 ha), Bhanda beel haor (4000 ha) and Khai (4800 ha) haors are falling under the Surma-Kalni-Kushiyara river system. Sonamoral (3275 ha), Dhankunia (1692 ha) and Gurmer (5360 ha) could be three possible choices for the study. But these haors were eliminated due to their poor accessibility. These haors are situated in remote areas where field visits would be difficult, time consuming and expensive. The other three choices might be those in the Surma-Kalni-Kushiyara river system: Chaptir, Tangua, Baram, Udgal Beel haor, Bhanda beel haor and Khai. These haors are comparable in size. There is not much information available for Khai haor. Some fisheries related information about the remaining haors were then analyzed and compared.

The impacts on fisheries of important environmental components (IECs) were analyzed by CEGIS (2006), which is presented in Table 4.2. There are clear differences in the fish diversity and habitat area in terms of water depth. Fish migration was considered in the study for the entire season. The table shows that in most of the haors fish migration is good except Chandra sonarthal, Kushiyara bardal and Joydhona. The baseline fish biodiversity is good in a few haors, moderate in most haors and poor in a few haors. The baseline aquatic environment is found good in all the haors.

Based on the information given in Table 4.2, three candidate haors are selected for the present study: Chaptir haor, Tangua haor, and Baram haor. The locations of the three haors are shown in Figure 4.1. While fish migration (round-the-year) and aquatic environment in baseline conditions are found good in the CEGIS study in all three haors, there is a difference in baseline fish biodiversity; the biodiversity is good in Chaptir haor, moderate in Tangua haor and poor in Baram haor. Although the intensity of interventions appear to be similar in the three haors, different fish biodiversity may indicate different levels of functioning of the different components of the haor systems (e.g. status of migration possibilities in the 'pre-monsoon' season, connectedness of the open khals to river channels, repair and maintenance of the infrastructures, etc). These were some of the aspects to be investigated in the present study.

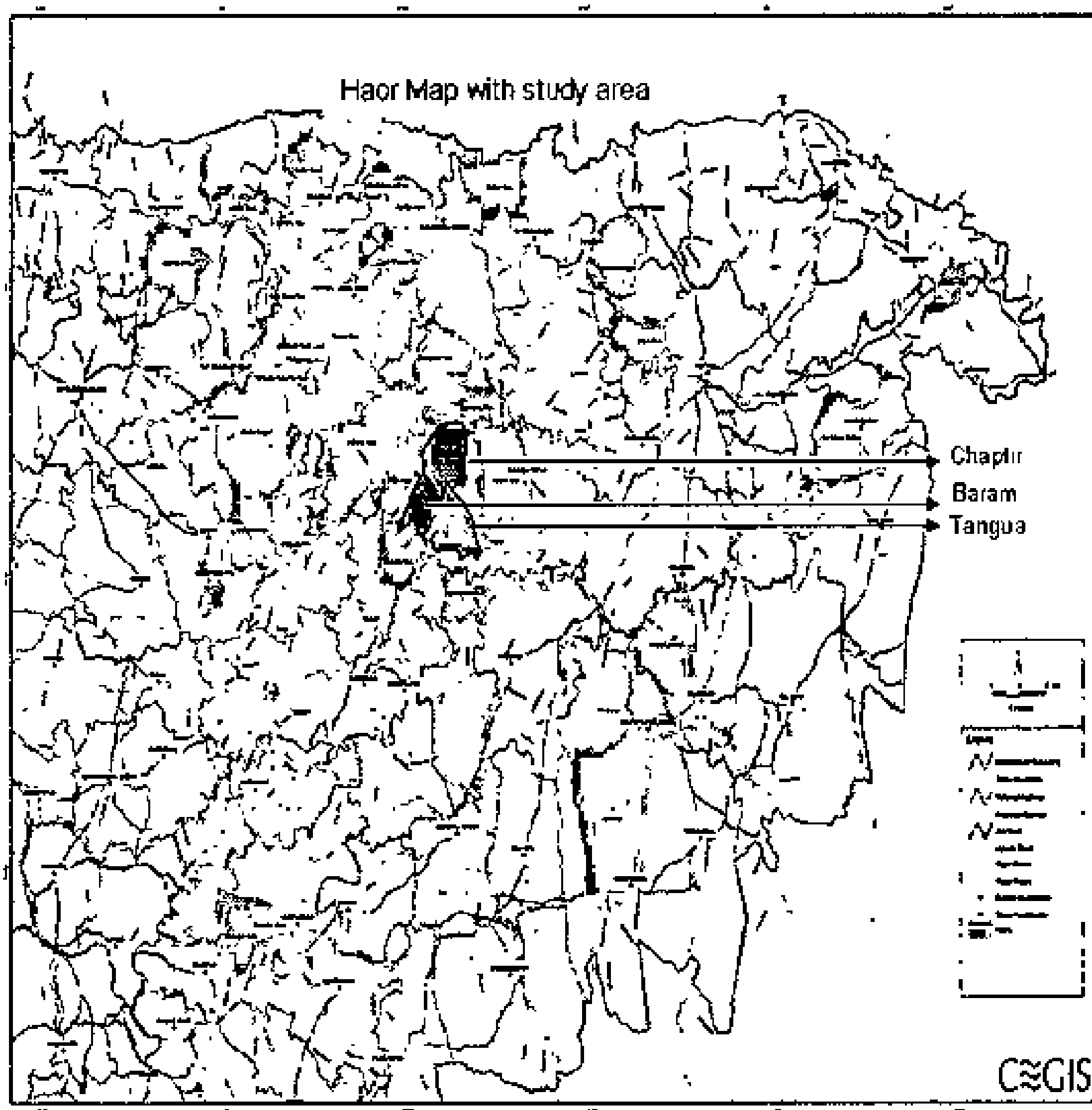


Figure 4.1: Location map of the study area (Source: CEGIS, 2006)

Table 4.2: Impact of important environmental components (IECs) on fisheries Resources (Source: CEGIS, 2006)

Haor	Important Environmental Components (IECs)					
	Fish habitat area	**Fish migration**	**Fish biodiversity**	**Water depth of beels**	**Aquatic environment**	**Fish production (tons) capture**
	Baseline (ha)	**Baseline**	**Baseline**	**Baseline**	**Baseline**	**Baseline**
Khai	135	Good	Moderate	2.4-3	Good	220
Jamkhola	130	Good	Moderate	2.1-2.4	Good	208
Naluar	1440	Good	Moderate	1.8-2.1	Good	1875
Updakhali	840	Good	Moderate	2.1-2.4	Good	1275
Baram	61	Good	Poor	1.2-1.5	Good	130
Chandra sonarthal	233	Moderate	Good	2.4-3.0	Good	350
Chaptir	162	Good	Good	2.1-2.4	Good	350
Kushiyara bardal	130	Poor	Poor	0.9-1.2	Poor	143
Nawtana	362	Good	Moderate	1.5-1.8	Good	545
Shanghair	130	Good	Moderate	0.9-1.2	Good	160
Sonamoral	370	Good	Moderate	1.2-1.5	Good	650
Tangua	114	Good	Moderate	2.1-2.5	Good	295
Dewghar	48		Moderate	0.9-1.2	Good	150
Shafique	160		Moderate	*****	Good	240
Patherchuli	50		Poorer	*****	*****	120
Kalikota	670	Good	Moderate	1.8-2.1		1600
Udgal beel	180		Good	1.2-1.5-1.8		750
Balali padmsree	40		Poor	1.2-1.5	Good	45
Bhanda	110		Poor	1.2-1.5, 2.1-2.4, 3.0-4.5	Good	130
Dhankunia	170	Good	Decreasing	1-2-3	Good	80
Gurmer	510	Good	Moderate	1.5-1.8	Good	850
Kawadighi	400	Good	Moderate			1000
Joydhona	20	Poor	Poor	1.5-1.8		30

Chapter Five

Study Area

5.1 Introduction

This chapter presents descriptions of the three selected haors, Chaptir haor, Tangua haor and Baram haor, based on secondary data and information. The water resources systems and flow hydrology in the three haors are discussed. Discussions on water management interventions, different aspects of fisheries ecosystem and existing fisheries resources management are also presented. Comprehensive descriptions of haors are rarely available in literatures. The descriptions of the three haors presented here draw significantly from the Haor rehabilitation report of CEGIS (2006) which gives a fairly detailed description of a large number of haors.

5.2 Descriptions of selected haors

5.2.1 Location

Chaptir haor. This haor is located in between $24^{0}44'0$ and $24^{0}50'0$ north latitude and between $91^{0}22'0$ and $91^{0}26'0$ east longitude in Derai under Sunamganj District. There are four haors located around the Chaptir haor. Shanghair haor is located further north of Chaptir haor. Naluar haor is located at further east. Tanguar haor is located just south and Baram haor is located the west side of Chaptir haor. The project has a gross area of 4553 ha and net area of 3642 ha. Water resource system of Chaptir haor consists of a number of rivers, khals and beels. The haor is surrounded by Mara Surma River in the north and west and all other rivers such as Mara Betkhali River, Mahasingh River (part) in the north Dauka River (part) or Kamarkhali River in the east, Era chamti River and Kalni River in the south and west. There are a number of khals and perennial beels spreading over the project area. Figure 5.1 shows the water resources system with existing interventions in the Chapir haor.

Figure 5.1: Water resource system with existing interventions in the Chaptir haor (Source: CEGIS, 2006)

Tangua Haor. This haor is located in between 24^{0}42'0 and 24^{0}46'0 north latitude and between 91^{0}22'0 and 91^{0}28'0 east longitude under Derai upazila and partially under Jagannathpur upazila of Sunamganj District. Locally this haor is called Tangni haor. The project has a gross area of 5000 ha and net area is about 4500 ha. The Tangua haor project is surrounded by Kamarkhali river and Chaptir haor in the north, Kamarkhali river (part), Nachni river, Kasta Gang, Jalia river and Naluar haor in the east while Kushiara in the south and Kalni river as well as Bhanda and Baram haor project in the west. There are three types of land characteristics such as medium low land, low land and very low land. Water resource system is mainly dependent on surrounding rivers, khals and beels spreading over the project area. The southwest to north of the haor is bounded by Kalni River and Kamarkhali River, which are connected with each other. At the east part, some rivers e.g. Kamarkhali River, Nachni River, Kasta Gang and Jalia River border the project while Kushiyara River river flows along the southern boundary up to the place named Markuli at the west where Kalni-Kushiyara cross dam is located. Figure 5.2 shows the water resonrces system with existing interventions in the Tangua haor.

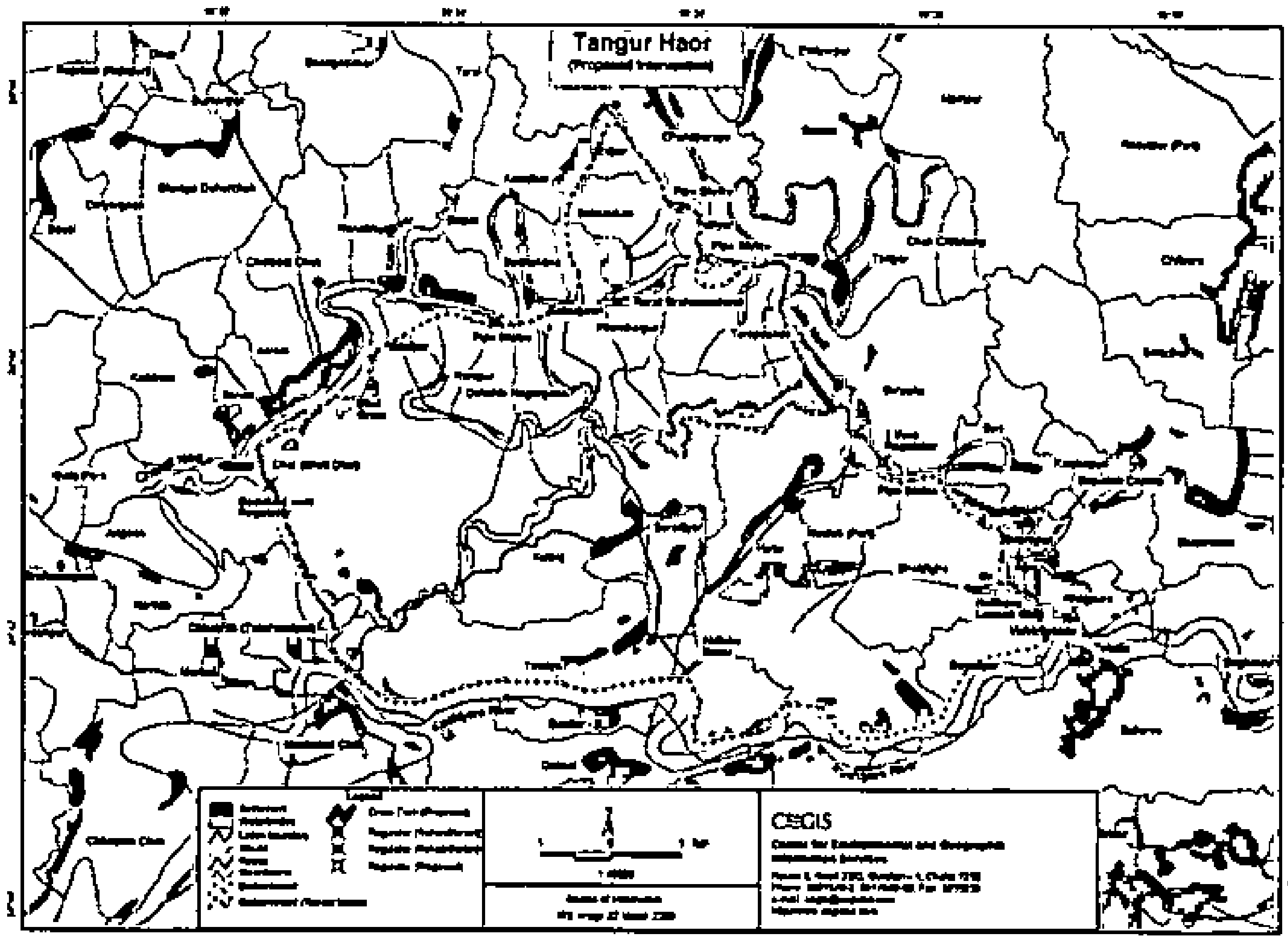


Figure 5.2: Water resource system with existing interventions in Tangua haor (Source: CEGIS, 2006)

Baram haor. The haor is located in between $24^{0}42'0$ and $24^{0}48'0$ north latitude and between $91^{0}18'0$ and $91^{0}24'0$ east longitude mainly in two upazillas Dirai and Shalla of Sunamganj District. There are four haors adjacent to this haor. These are Chaptir haor in north-east, Tanguar haor in east, Bhanda haor in south and Udgal haor in north-west. The project has a gross area of 5500 ha and net area of 4800 ha. Water resource system is mainly dependent on surrounding rivers, khals and beels spreading over the project area. The haor is clockwise bordered by Kalni River, Chamti River, Darain River and Mara Chamti River. Kalni River is the main upstream source of water, which originates from Surma River at Sunamganj district. Figure 5.3 shows the water resources system with existing interventions in the Baram haor.

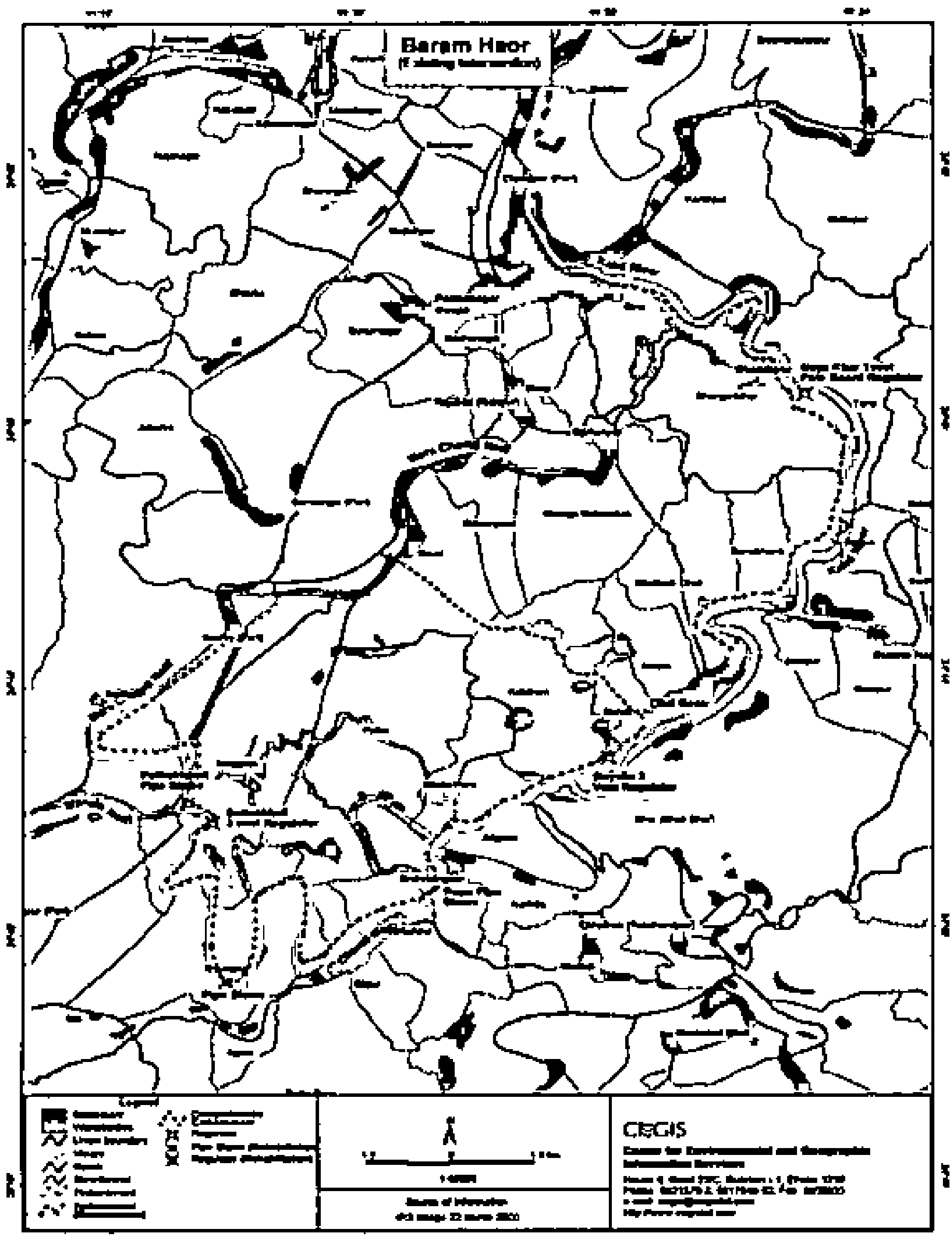


Figure 5.3: Water resource system with existing intervention in Baram haor (Source: CEGIS, 2006)

5.2.2 Hydrology

The main source of flooding is Surma -Mara Surma- Kalni river system. Chaptir and Tangua haors receive excessive flood water from Surma -Mara Surma- Kalni river system which hits the submersible embankments during the middle of April, while Baram haor receives the excessive upstream water from Surma-Mara Surma-Kalni-Chamti-Darain river system which hits the submersible embankment during the middle of April. Most of the years, flood hits all the three haors during the second or third week of April. The reported reasons for flash flood in all three haors are:

- Excessive rainfall, runoff and inflow from upstream.
- Weak flood protection embankment.
- Heavy silted up river beds and water level rises rapidly.
- River erosion and minimum setback distance from river.
- Changing flow direction of Kalni-Kushiyara.

5.2.3 Water management intervention

Chaptir haor project was constructed in 1995-96 and completed in 1997-98 under System Rehabilitation Project (SRP) of Bangladesh Water Development Board (BWDB). Tangua Haor project was implemented during the period 1991-'92 to 1994-'95 under the financial support of Early Implementation Project (EIP) of BWDB. Baram Haor project was started in 1987-88 and completed in 1992-93 under EIP funding of BWDB. The intervention structure and reported performance are summarized in Table 5.1. Table 5.1 shows that the embankment height is lower than the design level in all three selected haors. Chaptir haor compartmental embankment performance is reported to be good. Tangua haor compartmental embankment performance is not that good. Baram haor compartmental embankment performance is not reported. Physical conditions of regulator in all three haors are reported to be not functioning properly.

Table 5.1: Water management interventions in three selected haors and their performance (Source: CEGIS, 2006)

Haor	Submersible Embankment		Compartmental Embankment		Regulator		Pipe Sluices	
	Length (km)	Performance	Length (km)	Performance	No	Performance	No	Performance
Chaptir	42	Height of embankment is lower than design level due to rapid siltation	2	Embankment condition is reported to be good	2	Physical condition is not good, not functioning properly, linked up khal has been silted up	5	Physical condition is not good
Tangua	29.20	Height of embankment is lower than design level due to rapid siltation	7.5	Not suitable for irrigation water reserving, height is lower than design level due to rapid siltation	2	Physical condition is not good, not functioning properly, linked up khal has been silted up		
Baram	28.4	Height of embankment is lower than design level due to rapid siltation	4.5	-	3	Physical condition is not good, not functioning properly		

5.2.4 Fisheries ecosystem

Chaptir haor is rich in fish resources. Fish habitats are in good condition and rich in biodiversity. Tangua haor has considerable area of fish habitats and open migration routes. Fish biodiversity is moderately rich in Tangua haor. Fisheries activities are major income earning source of the most of the people of Tangua haor. Fisheries of Baram haor are mainly confined at the perennial and semi-perennial small sized *beels*. Status of fish biodiversity is very poor in Baram haor. The common fisheries related issues and problems so far identified in all three haors are as follows:

- Fish production is decreasing due to habitat loss, change of existing aquatic ecological condition and poor fisheries management.
- Fisheries biodiversity is declining due to inadequate migration routes and indiscriminate fishing e.g. use of harmful fishing gears, catching of post larvae and brood fish, completely dewatering of leased water bodies for fishing, etc.

- Loss of fish habitats (both area and depth of perennial *beels, Khals* and adjacent rivers) due to rapid siltation.

5.2.5 Fish habitat description

The siltation rate is increasing gradually and squeezing the fish habitat area of all three haors. Most of these *beels* are silting up gradually. Entire floodplain inundates up to 96% of the haor during full monsoon in all three haors. The fish habitat area, habitat depth, siltation rate and production are summarized in Table 5.2. Fish habitat area and depth are comparable in Chaptir and Tangua haors, while they are much lower in Baram haor.

Table 5.2: Fish habitat area of three selected haors with their production (Source: CEGIS, 2006)

Haor	**Habitat area (hectare)**	**Average fish habitat depth in meter**			**Siltation rate inch/year**	**Fish production (capture)**
		River	Khal	Beel		
Chaptir	162 (4% of the haor)	9.1-12.0	4.5-6.0	2.1-2.4	4	Declining
Tangua	114 (3% of the haor)	10-12	6-8	2.1-2.4	3	Declining
Baram	61 (1.5 % of the haor)	4.6-4.8	1.5-1.8	1.2-1.5	4	Declining

5.2.6 Fish migration

Most of the connecting *khals* either remain mud sealed or closed by sluice gates at that season of all three haors. Besides most of the riverine fishes migrate to the *beels* by overtopping or breaching of the existing embankment of all the three haors during flood months of *jaistha-Ashar* (15 May- 30 June). In Chaptir haor, early (15 April- 15 May) feeding and spawning migration rate of riverine and *beels* resident fishes are sometimes possible through different open *khals* of the haor. In Tangua haor, the same is possible due to some old rivers inside the haors. In Baram haor, early feeding and spawning migration rate of riverine and *beels* resident fishes are not possible due to mud sealed or closed sluice gates at the entrance of connecting *khals* of the haor. In Chaptir haor, vertical migration of different fish species e.g. riverine carps, catfishes, etc as a part of their lifecycle for food and residence is happening due to sufficient depth. In Tangua haor, vertical migration of different fish species is causing carp species to be available in deeper parts of the beels. In Baram haor, vertical migration of different fishes at certain stages of lifecycle is hindered due to lower depths of the beels (average 1.2-1.5 m). The canals toward the adjacent rivers are acting as the main fish migration routes of all the three haors. River connected *beels* are the main fish breeding area of all three haors.

5.2.7 Fish species diversity

Chaptir Haor. This haor is rich in fish biodiversity because of the higher depths of the *beels* and presence of good migration routes during breeding monsoon. But fish biodiversity is declining rapidly due to habitat loss. The CEGIS study found a total of twenty six species. Out of this twenty six species, three are riverine species, ten are floodplain species and the remaining thirteen are both riverine and floodplain species. List of the fishes of different habitats of the haor is given the Table 5.3.

Table 5.3: Species diversity of different fish habitats of the Chaptir Haor (source: CEGIS, 2006)

Guild	Scientific Name	Local Name	Habitat Type			
			River	Khal	Beel	Culture
Carp	*Labeo gonius*	Gonia	P	A	A	A
Eel	*Macrognathus pancalus*	Guchi Biam	A	A	P	A
Large catfish	*Wallagu attu*	Boal	P	A	A	A
Carplet	*Amblypharyngodon mola*	Mola	P	P	A	A
Small catfish	*Mystus vittatus*	Tengra	P	P	P	A
Glass fish	*Parambassis baculis*	Chanda	P	P	P	A
Gobies	*Glossogobius giurus*	Baila	P	P	P	A
Bronze Featherback	*Notopterus notopterus*	Foli	P	P	P	A
Leaffish	*Nandus nandus*	Meni	P	P	P	A
Loach	*Lepidocephalus guntea*	Guttum	A	P	P	A
Catfish	*Mystus punctatus*	Taki	P	A	P	A
Garfish	*Xenentodon cancila*	Kakila	P	P	P	A
Carp	*Labeo ruhita*	Rui	P	A	P	P
Snakehead	*Channa sriatus*	Shol	A	P	P	A
Snakehead	*Channa marulius*	Gozar	A	P	P	A
Clupeid	*Gudusia chapra*	Chapila	P	A	A	A
Barb	*Puntius chola*	Puti	P	P	P	A
Snakehead	*Channa punctatus*	Taki	A	P	P	A
Carp	*Labeo kalbasu*	Kal baous	P	A	P	A
Prawn	*Prawn sp.*	Chingri	P	P	P	A
Carp	*Hypophthalmichthys*	Silver carp	A	A	A	P
Carp	*Ctenopharyngodon idellus*	Grass carp	A	A	A	P
Carp	*Cyprinus carpio*	Mirror carp	A	A	A	P
Catfish	*Pangasias suchii*	Thai pangas	A	A	A	P
Barb	*Puntias sarana*	Thai puti	A	A	A	P
carp	*Catla catla*	catal	A	A	A	P

Note: A=Absent and P=Present

Tangua haor. This haor is moderately rich in fish biodiversity. But the trend is declining significantly. This is mostly due to habitat loss. The CEGIS study found a total of nineteen species. Out of this nineteen species, four are riverine species, three are floodplain species and the remaining twelve are both riverine and floodplain species. List of the fishes of different habitats of the haor is given in the Table 5.4.

Table 5.4: Species diversity of different fish habitats of the Tangua Haor (source: CEGIS, 2006)

Guild	Scientific Name	Local Name	Habitat Type			
			River	Khal	Beel	Culture
River catfish	*Mystus aor*	Ayre	P	A	A	A
Carp	Labeo gonius	Gonia	P	A	A	A
Eel	*Macrognathus pancalus*	Guchi Biam	A	A	P	A
Large catfish	*Wallagu attu*	Boal	P	A	A	A
Carplet	*Amblypharyngodon mola*	Mola	P	P	A	A
Small catfish	*Mystus vittatus*	Tengra	P	P	P	A
Glass fish	*Parambassis baculis*	Chanda	P	P	P	A
Gobies	*Glossogobius giurus*	Baila	P	P	P	A
Carp	*Labeo ruhita*	Ruhi	P	A	P	A
Snakehead	*Channa sriatus*	Shol	A	P	P	A
Snakehead	*Channa marulius*	Gozar	A	P	P	A
Clupeid	*Gudusia chapra*	Chapila	P	A	A	A
Barb	*Puntius chola*	Puti	P	P	P	A
Snakehead	*Channa punctatus*	Taki	A	P	P	A
Carp	*Labeo kalbasu*	Kal baous	P	A	P	A
Prawn	*Prawn sp.*	Chingri	P	P	P	A
Carp	*Hypophthalmichthys*	Silver carp	A	A	A	P
Catfish	*Pangasius suchii*	Thai pangas	A	A	A	P
Cyprinidae	*Catla catla*	Catal	P	P	P	P

Note: A=Absent and P=Present

Baram haor. This haor is poor in fish biodiversity. It is declining even more rapidly due to habitat loss, poor fisheries management, and indiscriminate fishing (e.g. harmful fishing gears). The CEGIS study found a total of twenty species. Out of this twenty species, three are riverine species, nine are floodplain species and the remaining eight are both riverine and floodplain species. List of the fishes of different habitats of the haor is given in the Table 5.5.

Table 5.5: Species diversity of different fish habitats of the Baram Haor (source: CEGIS, 2006)

Guild	Scientific Name	Local Name	Habitat Type			
			River	Khal	Beel	Culture
Carp	*Labeo gonius*	Gonia	P	A	A	A
Eel	*Macrognathus pancalus*	Guchi Biam	A	A	P	A
Large catfish	***Wallagu attu***	Boal	P	A	A	A
Small catfish	*Mystus vittatus*	Tengra	P	P	P	A
Glass fish	*Parambassis baculis*	Chanda	P	P	P	A
Gobies	*Glossogobius giurus*	Baila	P	P	P	A
Leaffish	*Nandus nandus*	Meni	P	P	P	A
Loach	*Lepidocephalus guntea*	Gutum	A	P	P	A
Carp	*Labeo ruhita*	Rui	P	A	P	P
Snakehead	*Channa sriatus*	Shol	A	P	P	A
Snakehead	*Channa marulius*	Gozar	A	P	P	A
Clupeid	*Gudusia chapra*	Chapila	P	A	A	A
Barb	*Puntius chola*	Puti	P	P	P	A
Snakehead	*Channa punctatus*	Taki	A	P	P	A
Prawn	*Prawn sp.*	Chingri	P	P	P	A
Carp	*Hypophthalmichthys*	Silver carp	A	A	A	P
Carp	*Ctenopharyngodon idellus*	Grass carp	A	A	A	P
Catfish	*Pangasias suchii*	Thai pangas	A	A	A	P
Barb	*Puntias sarana*	Thai puti	A	A	A	P
carp	*Catla catla*	catal	A	A	A	P

Note: A=Absent and P=Present

5.2.8 Species of conservation significance

CEGIS (2006) found that *Labeo nandina, Pangasius pangasius, Chitala chitala* and *M. rosenbergii* are unavailable in all the three selected haors. *Heteropneustes fossilis* and *Amblyceps mangois* are rare in appearance in all three selected haors. List of fish varieties those are locally unavailable (for last five years) or have become rare in appearance in the three haors are given in the Tables 5.6-5.8.

Table 5.6: List of species of conservation significance in Chaptir haor (source: CEGIS, 2006)

Scientific Name	Local Name	Local status	
		Rare	Unavailable
Ompok pabda	Pabda	√	×
Macrognathus aculeatus	Boro Baim	√	×
Heteropneustes fossilis	Shing	√	×
Amblyceps mangois	Magur	√	×
Catla catla	Catla	√	×
Eutropiichthys vacha	Bacha	√	×
Botia dario	Rani	√	×
Anabus testudineus	Koi	√	×
Puntius sarana	Shar puti	×	√
Chitala chitala	Chital	×	√
M. rosenbergii	Boro chingri	×	√
Anguilla bengalensis	Bamosh	×	√
Labeo nandina	Nanid	×	√
Pangasius pangasius	Riverine pangus	×	√

Table 5.7: List of species of conservation significance in Tangua haor (source: CEGIS, 2006)

Scientific Name	Local Name	Local status	
		Rare	Unavailable
Ompok pabda	Pabda	√	×
Cirrhinus mrigala	Mrigel	√	×
Labeo ruhita	Ruhi	√	×
Macrognathus aculeatus	Boro Baim	√	×
Heteropneustes fossilis	Shing	√	×
Amblyceps mangois	Magur	√	×
Anabus testudineus	Koi	√	×
Notopterus notopterus	Foli	√	×
Puntius sarana	Shar puti	×	√
Chitala chitala	Chital	×	√
M. rosenbergii	Boro chingri	×	√
Eutropiichthys vacha	Bacha	×	√
Botia dario	Rani	×	√
Labeo nandina	Nanid	×	√
Pangasius pangasius	Riverine pangus	×	√

Table 5.8: List of species of conservation significance in Baram haor (source: CEGIS, 2006)

Scientific Name	Local Name	Local status	
		Rare	Unavailable
Ompok pabda	pabda	√	×
Heteropneustes fossilis	Shing	√	×
Amblyceps mangois	Magur	√	×
Catla catla	Catla	√	×
Anabus testudineus	Koi	√	×
Chitala chitala	Chital	×	√
M. rosenbergii	Boro chingri	×	√
Anguilla bengalensis	Bamosh	×	√
Silonia silondia	Silong	×	√
Labeo nandina	Nanid	×	√
Pangasius pangasius	Riverine pangus	×	√

5.2.9 Existing fisheries management

There are three Fishermen Community Based Organizations (FCBOs) formed by local fishermen in all the three haors. But they have a very limited opportunity to bring positive changes in the traditional fisheries management system. Fishing rights on existing fish habitats have already been established on behalf of the lessee, as most of the perennial water bodies are generally given on lease for three years. Enforcement of fisheries regulation is very week. Department of fisheries have very limited activities on fisheries resource conservation and management. In Chaptir haor and Baram haor, some NGOs are working, but their activities are limited to micro credit. In Tangua haor, no other fisheries management practices (either govt. or NGO) are can be found.

Chapter Six

Results and Discussion

6.1 Introduction

This chapter presents the results of the application of participatory rural appraisals (PRA) tools (e.g. resource mapping, FGDs) in three selected haors. A comparison with findings from the previous study is sometimes made. Analysis of the data provided a number of indicator fish species, which are examined with the water resources systems of the three haors.

6.2 Findings from field investigations

6.2.1 Chaptir haor

There are two traditional fishermen villages named Chanpur and Kochua in Chaptir haor. Average families of the traditional fishermen are 70 in each village. There are lots of non-traditional fishermen villages also involved in the fishing activities.

6.2.1.1 Water resources mapping

Resource mapping was done in Kochua village by the local people. The hand drawn map is presented in Figure 6.1. This map shows a number of important beels which are suitable for fish habitat viz, Chatal beel, Kochua beel, Kasma beel and Khaima khowli beel. However, a number of other beels were mentioned by the local people, which are not shown in the map because they do not fall into Kochua village. These beels also have ecological importance namely Atarai beel, Terajani beel, Juldoba beel. Hingra beel and Gujir mar beel etc. The respondents also mentioned the names of various khals which are used as important migration routes for fish, e.g. Nimaikhali Khal, Kaliboi khal, Atarai khal, Chatoler khal, Kashitala khal and Demkhalir khal, some of which are shown in Figure 6.1. The respondents opined that due to the embankment these khals and beels are silted up gradually and if the conditions do not change these khals and beels will lose the immense ecological resources.

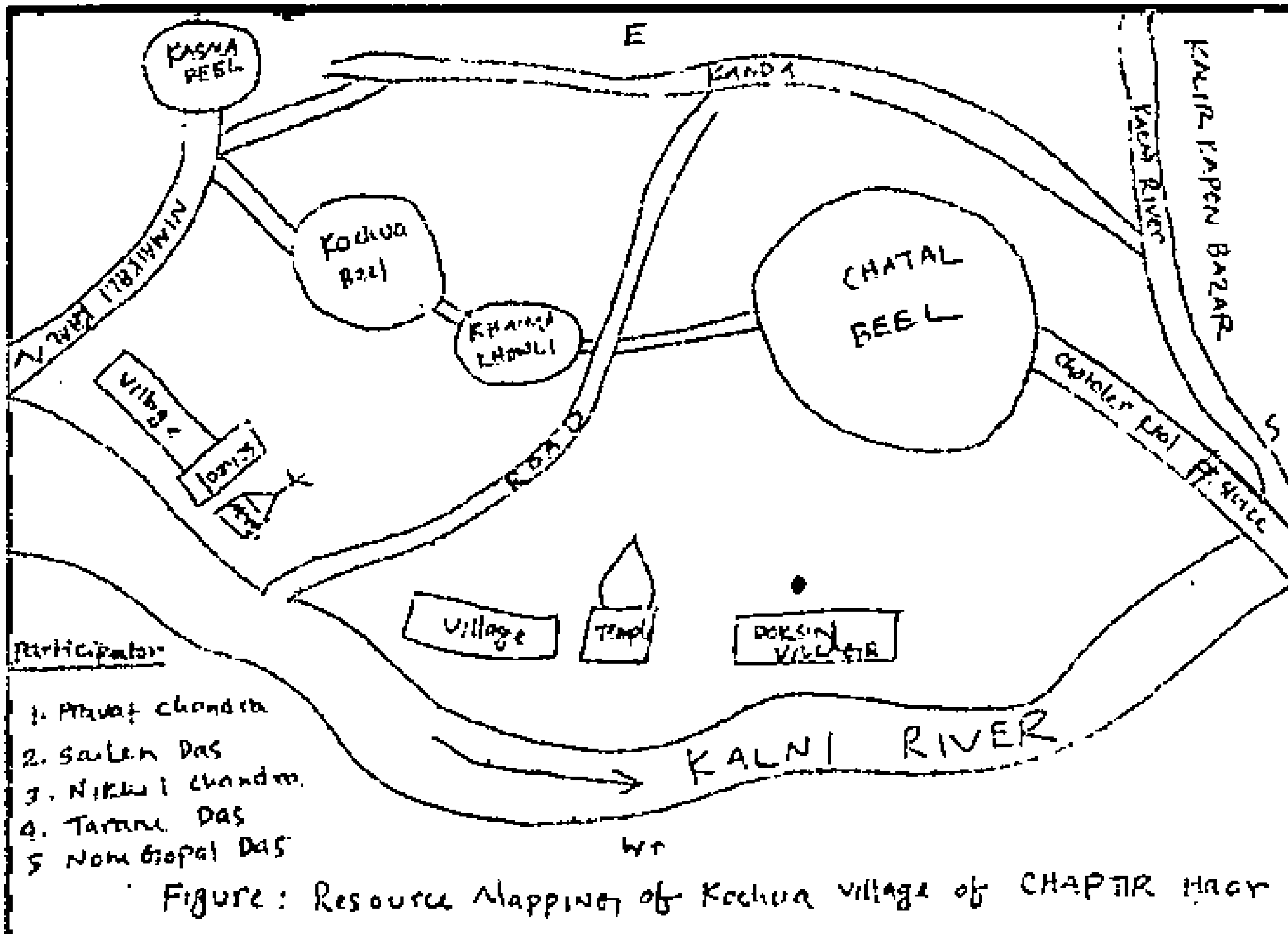


Figure 6.1: Resource mapping with water resource system in Chaptir haor (Source: Field survey)

Local people reported that the average depth of Kalni River at present is 9.1 to 13.7 meters (data provided by the respondents were in feet which were later converted to meters). The average depth of the beels and khals at present are 4.5 to 5.5 meters and 6.4 to 7 meters, respectively. The depth of the khals and beels has slightly decreased compared to ten years ago. The people of the study area said that the average depth of the adjacent rivers has slightly decreased due to siltation. They also reported that siltation is squeezing the fish habitat area by destructing the weeding and bushy trees which are suitable place for fish.

6.2.1.2 Fisheries related problems and issues

From focus group discussions (FGD's) in Chaptir haor, the following were found to be the issues related to fisheries.

- Obstruction of fish migration due to embankment
- Reducing depth of beels, khals and adjacent river water due to siltation.
- Indiscriminate fishing such as Capturing of barried and juvenile fish, complete dewatering of beels, uses of destructive gears (e.g. *kona Jaal and Current Jaal*) etc.
- Encroachment of beels for cultivation of rice or paddy during Hemanto (November-December).
- Increase of fishing effort- No. of fishermen, nets, boats, etc.
- Access of traditional fishermen into beels is not ensured in the present leasing system.

6.2.1.3 Fish species diversity

Fish biodiversity in Chaptir haor was found to be rich during field survey. However, as local people stated, the fish diversity was even richer before. The fish biodiversity, in the opinion of local people, decreased rapidly due to siltation of the adjacent rivers, fish habitat loss and poor fisheries management. Fish species found during field survey are presented in Table 6.1. Out of total eighteen species, four are riverine species and six are floodplain species. Rest eight species are both riverine and floodplain species.

Table 6.1: Species diversity of different fish habitats of the Chaptir haor (Source: Field survey)

Scientific Name	Local Name	Habitat Type			
		River	Khal	Beel	Floodplain
Puntius chola	Puti	A	P	P	P
Mystus vittatus	Tengra	P	P	P	P
Ompok pabda	Pabda	P	P	P	P
Mystus punctatus	Ghagoat	P	P	P	P
Wallagu attu	Boal	P	P	P	P
Colisa fasciatus	Khaila	P	P	P	P
Channa marulius	Gozar	A	P	P	P
Heteropneustes fossilis	Sing	A	P	P	A
Cirrhinus mrigala	Mrigel	A	P	P	P
Punctius sarana	Shar puti	A	A	P	A
Labeo ruhita	Rui	P	P	P	P
Catla catla	Catla	P	P	P	P
Chitala chitala	Chital	P	A	A	A
Gudusia chapra	Chapila	P	A	A	P
Notopterus notopterus	Foli	A	A	A	P
Macrognathus aculeatus	Baim	P	A	A	A
Prawn sp.	Itcha	P	A	A	A
Boro chingri	Boro itcha	P	A	A	A

Note: A=Absent and P=Present

6.2.1.4 Decreasing fish catch

Although the respondents could identify a large number of species that are presently available in the Chaptir haor, they could compare the catch composition of only a few species between present and ten years ago. This is shown in Table 6.2. While the catch of all reported species went down compared to those ten years ago, the species sing suffered the most declines. Catch of four species Puti, Tengra, Khaila and Gozar, declined by about three-quarters.

Table 6.2: Fish catch of Chaptir haor at present situation compared with last 10 years (Source: Field survey)

Guild	Scientific name	Local name	Present (%)
Small catfish	*Ompok pabda*	Pabda	50
Large catfish	*Wallagu attu*	Boal	40
Catfish	*Mystus punctatus*	Ghagoat	40
Small catfish	*Mystus vittatus*	Tengra	25
Barb	*Puntius chola*	Puti	25
Perch	*Colisa fasciatus*	Khaila	25
Snakehead	*Channa marulius*	Gozar	25
Small catfishes	*Heteropneustes fossilis*	Sing	01

6.2.1.5 Species of conservation significance

The list of species of conservation significance is shown in Table 6.3. The five species namely *Amblyceps mangois* (Magnr), *Eutropiichthys vacha* (Bacha), *Botia dario* (Rani), *Labeo nandina* (Nanid) and *Pangasius pangasius* (Pangas) are already unavailable in Chaptir haor. The local people reported that they had found the species *Labeo nandina* and *Pangasius pangasius* 20-25 years ago. The other six species are rare in appearance in Chaptir haor. The rare and unavailable species in Chaptir haor are compared with the list of threatened species prepared by IUCN (2000). More than half of the threatened species in Chaptir haor are also listed as threatened overall in Bangladesh.

Table 6.3: Species of conservation significance list of Chaptir haor (Source: Field survey)

Scientific name	Local name	Local status (10 years)		Threatened species (IUCN, 2000)
		Rare	unavailable	
Punctius sarana	Sharputi	√	x	Critically endangered
Heteropneustes fossilis	Sing	√	x	-
Chitala chitala	Chital	√	x	Endangered
Macrognathus aculeatus	Baim	√	x	-
Prawn sp.	Itcha	√	x	-
Boro chingri	Boro itcha	√	x	-
Amblyceps mangois	Magur	x	√	-
Eutropiichthys vacha	Bacha	x	√	Critically endangered
Botia dario	Rani	x	√	Endangered
Labeo nandina	Nanid	x	√	Critically endangered
Pangasius pangasius	Pangas	x	√	Critically endangered

6.2.1.6 Scoring and ranking of relative abundance

Habitat wise percentage composition of fish species in different habitats (river, khals, beels and floodplain) is shown in Table 6.4. The local people are not familiar with percentage data. The collected data was in the form of locally used terminology 'Ana'. The collected data was transformed into the percentage value. For example, out of total 100% in the river habitat the species *Mystus vittatus* (Tengra) got 7%. In this way, percentage values of the other species were also obtained. As shown in Table 6.4, in the river type habitat the highest percentage value (25%) was *Gudusia chapra* (Chapila). After adding percentage value of all species it must be equal to 100 for each habitat.

Table 6.4 also shows the scoring and ranking of species of different fish habitats of Chaptir haor. Scoring and ranking is a common method associated with PRA tools used in biodiversity evaluation studies (e.g. Nanyunja, 2002). There exist various forms of scoring and ranking methods. In the present analysis, the species were ranked according to their relative abundance and then scores were assigned for each species weighted by the total number of species in the three haors. This is illustrated below.

The highest percentage composition got the highest rank of 1 and accordingly the lowest got the lowest rank. The highest ranked species was given a score equal to the total number of species. The total species common and uncommon in all three haors altogether is 29. So the highest ranked species was given the score 29. The species which did not get any percentage value was given the score 0 (zero). Ranking and scoring was done in the same way for each habitat type (such as beels, khals and floodplains). Finally scores for all the habitat types were added which yielded the total score. As for example, the total score of species *Wallagu attu* was calculated as: 27 (River) + 25 (Beels) + 26 (Khals) + 27 (floodplains) =105 (from Table 6.4 the bold color shows the score of each Habitat types).

As seen in Table 6.5, the highest ranked species in river type habitat is *Gudusia chapra* (Chapila). Some of the species that got the lowest rank in the river habitat of Chaptir haor include *Channa marulius* (Gozar), *Heteropneustes fossilis* (Sing), *Amblyceps mangois* (Magur) etc. The species *Puntius chola* (Punti) is the highest ranked species in khals, beels and floodplains habitat. Some of the species that got lower ranks in all four habitats include *Amblyceps mangois* (Magur), Labeo *nandina* (Nanid), *Pangasius pangasius* (Pangas), *Eutropiichthys vacha* (Bacha). *Botia dario* (Rani) etc. The highest scored species in Chaptir haor is *Mystus vittatus* (Tengra). Out of total twenty nine species, eleven species got the lowest score of 0 (zero) in Chaptir haor.

Table 6.4: Scoring and ranking of fish species found in different habitats of Chaptir haor (Source: Field survey)

Serial No.	Scientific Name	Local Name	Habitat Types catch composition												
			River (%)	Rank	Score	Khal (%)	Rank	Score	Beel (%)	Rank	Score	Flood-plain (%)	Rank	Score	Total score
1	*Gudusia chapra*	Chapila	25	1	29	0	6	0	0	7	0	3	4	26	55
2	*Ompok pabda*	Pabda	12	2	28	7	5	25	7	4	26	7	3	27	106
3	*Mystus punctatus*	Ghagoat	12	2	28	0	6	0	7	4	26	7	3	27	81
4	*Colisa fasciatus*	Khaila	12	2	28	7	5	25	7	4	26	12	2	28	107
5	*Mystus vittatus*	Tengra	7	3	27	12	2	28	12	2	28	12	2	28	111
6	*Wallagu attu*	Boal	7	3	27	7	5	25	7	4	26	7	3	27	105
7	*Labeo rohita*	Rui	7	3	27	8	4	26	5	5	25	7	3	27	105
8	*Catla catla*	Catla	7	3	27	7	5	25	3	6	24	7	3	27	103
9	*Chitala chitala*	Chital	7	3	27	0	6	0	0	7	0	0	5	0	27
10	*Macragnathus aculeatus*	Baim	2	4	26	0	6	0	0	7	0	0	5	0	26
11	*Prawn sp.*	Choto chingri	1	5	25	0	6	0	0	7	0	0	5	0	25
12	*M rosenbergii*	Boro Chingri	1	5	25	0	6	0	0	7	0	0	5	0	25
13	*Puntius chola*	Puti	0	6	0	25	1	29	25	1	29	25	1	29	87
14	*Channa marulius*	Gozar	0	6	0	10	3	27	7	4	26	3	4	26	79
15	*Heteropneustes fossilis*	Sing	0	6	0	7	5	25	10	3	27	0	5	0	52
16	*Amblyceps mangois*	Magur	0	6	0	0	6	0	0	7	0	0	5	0	0
17	*Cirrhinus mrigala*	Mrigel	0	6	0	10	3	27	3	6	24	3	4	26	77
18	*Punctius sarana*	Shar puti	0	6	0	0	6	0	7	4	26	0	5	0	26
19	*Labeo nandina*	Nanid	0	6	0	0	6	0	0	7	0	0	5	0	0
20	*Pungasius pangasius*	Pangas	0	6	0	0	6	0	0	7	0	0	5	0	0
21	*Eutropiichthys vacha*	Bacha	0	6	0	0	6	0	0	7	0	0	5	0	0
22	*Botia dario*	Rani	0	6	0	0	6	0	0	7	0	0	5	0	0
23	*Notopterus notopterus*	Foli	0	6	0	0	6	0	0	7	0	7	3	27	27
24	*Anabus testudineus*	Koi	0	6	0	0	6	0	0	7	0	0	5	0	0
25	*Labeo kalbasu*	Kalibaus	0	6	0	0	6	0	0	7	0	0	5	0	0
26	*Macrognathus pancalus*	Gucchi	0	6	0	0	6	0	0	7	0	0	5	0	0
27	*Labeo gonius*	Gonia	0	6	0	0	6	0	0	7	0	0	5	0	0
28	*Coric soborna*	kachki	0	6	0	0	6	0	0	7	0	0	5	0	0
29	*Cirrhinus reba*	Laso	0	6	0	0	6	0	0	7	0	0	5	0	0

6.2.2 Tangua haor (Locally called Tangi)

Four traditional fishermen villages are present in Tangua haor with 60 families on average in each village. There are lots of non traditional fishermen. During dry season the people dewater the beels for cultivation. This is how the people are removing the grasses and other weeding trees, which snpport as nursery fishing gronnds during flooding.

6.2.2.1 Water resources mapping

Resource mapping was done in Bhatidol village by the local people. The hand drawn map is presented in Figure 6.2. This map shows a number of important beels which are suitable for fish habitat viz. Jobduba beel, Badali beel, Hawa beel, Kunjuri beel, and a number of Khals which are used as important fish migration routes viz. Haowa khal, Gujar khal, Jalia nadi and Kheya Ghater khal. The local people reported that they catch more fish in the Jobduba beel, Jalia nadi and Banna nadi. But day by day these fish habitat area is squeezing due to gradual siltation and the present condition is very much worsening. The local people also mentioned some important khals which are not shown in the map because they do not fall into Bhatidol village.

Kalni River and Kushiara River are both important for this haor as they bring the upstream water into the haor as well as drain out the flood water. Kalni river flows divert into the Chamti River at its south-west direction after the construction of Kalni-Kushiara cross dam at Markuli. Khals and beels serve a number of functions of water resource system including accumulation of upstream flood water while a number of khals serve the purpose of drainage through the rivers surrounding the projects. The average depths of the beels and khals at present are 1.3 to 2.4 meters and 2.7 to 5.0 meters, respectively. The average depth of the adjacent river at present is 5.4 to 9.0 meters. Local people reported that rapid siltation took place in this haor. The depths of the adjacent khals and beels have decreased dramatically over the last few years. The rapid siltation rate is squeezing the fish habitat area.

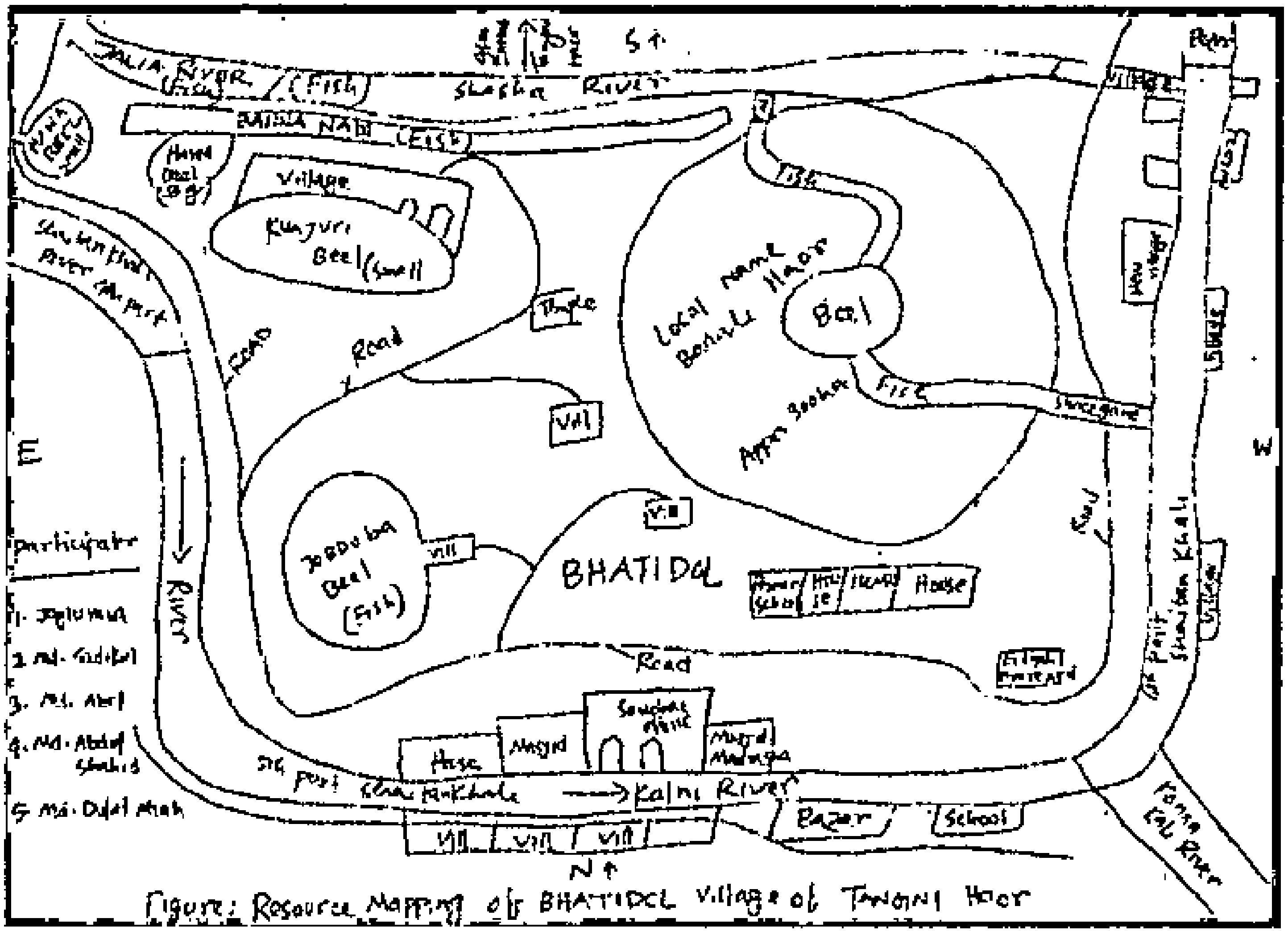


Figure 6.2: Resource mapping with water resource system in Tangua haor (Source: Field survey).

6.2.2.2 Fisheries related problems and issues

From focus group discussions (FGDs) in Tangua haor the following were found to be the issues related to fisheries.

- Obstruction of fish migration due to embankment.
- Reducing depth of water (such as river, beels and khals) due to siltation.
- Encroachment of beels for cultivation of rice or paddy during hemanto (November-December).
- Indiscriminate fishing such as Capturing of barried and juvenile fish, complete dewatering of beels, use of destructive gears (e.g. *kona Jaal and Current Jaal*) etc.
- Use of chemical fertilizer (e.g. pesticides).
- Increase of fishing effort- No. of fishermen, nets, boats, etc.
- Access of traditional fishermen into beels is not ensured in the present leasing system.

6.2.2.3 Fish species diversity

Fish diversity in Tangua haor was found moderately rich in the field survey. Fish biodiversity has decreased dramatically in recent years. This is mainly due to habitat loss, overexploitation of fisheries resources and unplanned fisheries management as reported by the respondents. Fish species found during field survey are presented in Table 6.5. Out of total seventeen species, one is riverine species and three are floodplain species. Rest thirteen species are both riverine and floodplain species.

Table 6.5: Species diversity of different fish habitats of the Tangua haor (Source: Field Survey)

Scientific Name	Local Name	Habitat Type			
		River	Khal	Beel	Floodplain
Mystus vittatus	Tengra	P	P	P	P
Colisa fasciatus	Khaila	P	P	P	P
Ompok pabda	Pabda	P	P	P	P
Wallagu attu	Boal	P	P	P	P
Puntius chola	Puti	P	P	P	P
Channa marulius	Gozar	A	P	P	P
Labeo ruhita	Rui	P	P	P	P
Eutropiichthys vacha	Bacha	P	A	A	A
Mystus punctus	Ghagot	P	P	P	P
Catla catla	Catla	A	A	A	P
Prawn sp.	Choto Chingri	P	P	P	P
Coric soborna	Kachki	P	A	A	P
Gudusia chapra	Chapila	P	A	P	P
Cirrhinus reba	Laso	P	P	P	P
Cirrhinus mrigala	Mrigel	P	P	P	P
Labeo gonius	Gonia	P	P	P	P
Botia dario	Rani	A	A	A	P

Note: A=Absent and P=Present

6.2.2.4 Decreasing fish catch

Similar to Chaptir haor, the respondents in Tangua haor could identify a large number of species that are presently available. They could compare the catch composition of only a few species between present and ten years ago. This is shown in Table 6.6. All the species reported by the respondents suffered significant declines. The species Rui suffered the most followed by Khaila and Boal.

Table 6.6 Fish catch of Tangua (locally tangni) haor at present situation compared with last 10 years (Source: Field survey)

Guild	Scientific name	Local name	Present (%)
Small catfish	*Mystus vittatus*	Tengra	25
Small catfish	*Ompok pabda*	Pabda	25
Small catfish	*Ailia coila*	Kazoli	25
Large catfish	*Wallagu attu*	Boal	25
Carp	*Labeo gonius*	Gonia	25
Clupeid	*Gudusia chapra*	Chapila	25
Clupeid	*Corica soborna*	Kachki	25
Snakehead	*Channa marulius*	Gozar	19
Barb	*Puntius chola*	Puti	10
Perch	*Colisa fasciatus*	Khaila	10
Carp	*Labeo ruhita*	Rui	05

6.2.2.5 Species of conservation significance

Table 6.7 shows the list of the species of conservation significance. The local people mentioned that they did not find the species of *Heteropneustes fossilis* (Sing) and *Amblyceps mangois* (Magur) in the last 10-15 years. The species *Punctius sarana* (Shar puti), *Labeo nandina* (Nanid) and *Pangasius pangasius* (Pangas) were not found since last 20 years according to the local people. They also reported that *Anabas testudineus* (Koi) and *Chitala chitala* (Chital) were not found between last 5-8 years. The other three species *Eutropiichthys vacha* (Bacha), *Botia dario* (Rani) and *Catla catla* (Catla) are rare in appearance. The rare and unavailable species in Tangua haor are compared with the list of threatened species prepared by IUCN (2000). More than half of the threatened species in Tangua haor are also listed as threatened overall in Bangladesh.

Table 6.7: Conservation significance list of fish species of Tangua haor (Source: Field Survey)

Scientific name	Local name	Local status (last 10 years)		Threatened species (IUCN, 2000)
		Rare	unavailable	
Eutropiichthys vacha	Bacha	√	x	Critically endangered
Botia dario	Rani	√	x	Endangered
Catla catla	Catla	√	x	-
Punctius sarana	Shar puti	x	√	Critically endangered
Labeo nandina	Nanid	x	√	Critically endangered
Pangasius pangasius	Pangas	x	√	Critically endangered
Anabas testudineus	Koi	x	√	-
Heteropneustes fossilis	Sing	x	√	-
Amblyceps mangois	Magur	x	√	-
Chitala chitala	Chital	x	√	Endangered

6.2.2.6 Scoring and ranking of relative abundance

Habitat wise percentage composition in Tangua haor is shown in Table 6.8. The table also shows the scoring and ranking of species for different fish habitats of Tangua haor. From the table, it is seen that the highest ranked species in river type habitat is *Coric soborna* (Kachki). Some of the species that got the lowest rank in the river habitat of Tangua haor include *Channa marulius* (Gozar), *Heteropneustes fossilis* (Sing), *Amblyceps mangois* (Magur) etc. The species *Mystus vittatus* (Tengra) is the highest ranked species in khals, beels and floodplains habitat. Some of the species with the lowest rank in all four habitats are *Amblyceps mangois* (Magur), Labeo *nandina* (Nanid), *Pungasius pangasius* (Pangas), *Chitala chitala* (Chital), *Punctius sarana* (Shar punti) etc. The highest scored species in Tangua haor is *Mystus vittatus* (Tengra). Out of total twenty nine species, twelve species got the lowest score of 0 (zero) in Tangua haor.

Table 6.8: Scoring and ranking of fish species found in different habitats of Tangua haor (Source: Field survey)

Serial No.	Scientific Name	Local Name	Habitat Types catch composition												
			River (%)	Rank	Score	Khal (%)	Rank	Score	Beel (%)	Rank	Score	Flood plain (%)	Rank	Score	Total score
1	*Coric soborna*	Kachki	25	1	29	0	10	0	0	11	0	6	5	25	54
2	*Mystus vittatus*	Tengra	22	2	28	35	1	29	30	1	29	26	1	29	115
3	*Mystus punctus*	Ghagot	9	3	27	2	8	22	9	4	26	8	3	27	102
4	*Gudusia chapra*	Chapila	9	3	27	0	10	0	2	9	21	7	4	26	74
5	*Wallagu attu*	Boal	9	3	27	7	6	24	8	5	25	4	7	23	99
6	*Colisa fasciatus*	Khaila	8	4	26	12	3	27	12	3	27	5	6	24	94
7	*Labeo gonius*	Gonia	3	4	26	9	5	25	6	7	23	1	8	22	96
8	*Cirrhinus reba*	Laso	4	5	25	2	7	23	3	8	22	6	5	25	95
9	*Ompok pabda*	Pabda	2	6	24	1	9	21	1	10	20	1	8	22	87
10	*Puntius chola*	Puti	2	6	24	17	2	28	16	2	28	23	2	28	108
11	*Eutropiichthys vacha*	Bacha	2	6	24	0	10	0	0	11	0	0	9	0	24
12	*Prawn sp.*	Choto Chingri	2	6	24	10	4	26	7	6	24	5	6	24	98
13	*Cirrhinus mrigala*	Mrigel	2	6	24	1	9	21	1	10	20	1	8	22	87
14	*Labeo ruhita*	Rui	1	7	23	1	9	21	4	6	24	1	8	22	90
15	*Channa marulius*	Gozar	0	8	0	3	7	23	1	10	20	1	8	22	65
16	*Amblyceps mangois*	Magur	0	8	0	0	10	0	0	11	0	0	9	0	0
17	*Heteropneustes fossilis*	Sing	0	8	0	0	10	0	0	11	0	0	9	0	0
18	*Anabas testudineus*	Koi	0	8	0	0	10	0	0	11	0	0	9	0	0
19	*Punctius sarana*	Shar puti	0	8	0	0	10	0	0	11	0	0	9	0	0
20	*Labeo nandina*	Nanid	0	8	0	0	10	0	0	11	0	0	9	0	0
21	*Pangasius pangasius*	Pangas	0	8	0	0	10	0	0	11	0	0	9	0	0
22	*Chitala chitala*	Chital	0	8	0	0	10	0	0	11	0	0	9	0	0
23	*Catla catla*	Catla	0	8	0	0	10	0	0	11	0	4	7	23	23
24	*Botia dario*	Rani	0	8	0	0	10	0	0	11	0	1	8	22	22
25	*M. rosenbergii*	Boro chingri	0	8	0	0	10	0	0	11	0	0	9	0	0
26	*Notopterus notopterus*	Foli	0	8	0	0	10	0	0	11	0	0	9	0	0
27	*Macrognathus aculeatus*	Baim	0	8	0	0	10	0	0	11	0	0	9	0	0
28	*Labeo kalbasu*	Kalibaus	0	8	0	0	10	0	0	11	0	0	9	0	0
29	*Macrognathus pancalus*	Gucchi	0	8	0	0	10	0	0	11	0	0	9	0	0

6.2.3 Baram haor

Two traditional fishermen villages named Nachni and Phutka are there in Baram haor. Lots of non-fishermen are also involved in the fishing activities. Average families of the traditional fishermen villages are 80 in each village. This haor is more heavily affected by the dry season cultivation compared to the other haors. This dry season cultivation directly affected nursery fishing ground during flood months due to the sweeping of the grasses and weeds.

6.2.3.1 Water resources mapping

Kalni River is main upstream source of water, which originates from Surma River at sunamganj district. The main stream of Kalni meets with Kushiara River at Markuli bazaar. But, during 1970s, a cross dam was constructed over Kalni river just upstream of Kalni-Kushiara river confluence at Markuli. After construction of this dam, Kalni flows towards Chamti River at its south-west direction. A number of small beels plays an important role in the project area. Resource mapping was done in Nachni village by the local people. The hand drawn map is presented in Figure 6.3. This map shows a number of important beels viz, Singhair beel, Kaita beel, Jaulla jaor beel and khals, which are suitable habitats for fish and are used as migration routes. The people reported that Jaulla jaor beel is the most important fish habitat area. They showed the pata kowri sluice gate which is now lost under soil. They also showed the Katal khali sluice which is connected to the Janulla jaor beel through khals. In the west, Mara Chamti River is situated in Baram haor which is fully dead or silted up.

The average depth of the adjacent rivers has decreased significantly compared to the last ten years. The average depth of the adjacent river at present is 4.5 to 4.8 meters. Average depth of the adjacent *khals* and *beels* decreased due to very rapid siltation and cultivation of agriculture. The average depths of *khals* and *beels* at present are 1.8-2.0 meters and 1.2-1.3 meters, respectively. Local people reported that rapid siltation rate is squeezing the fish habitat area.

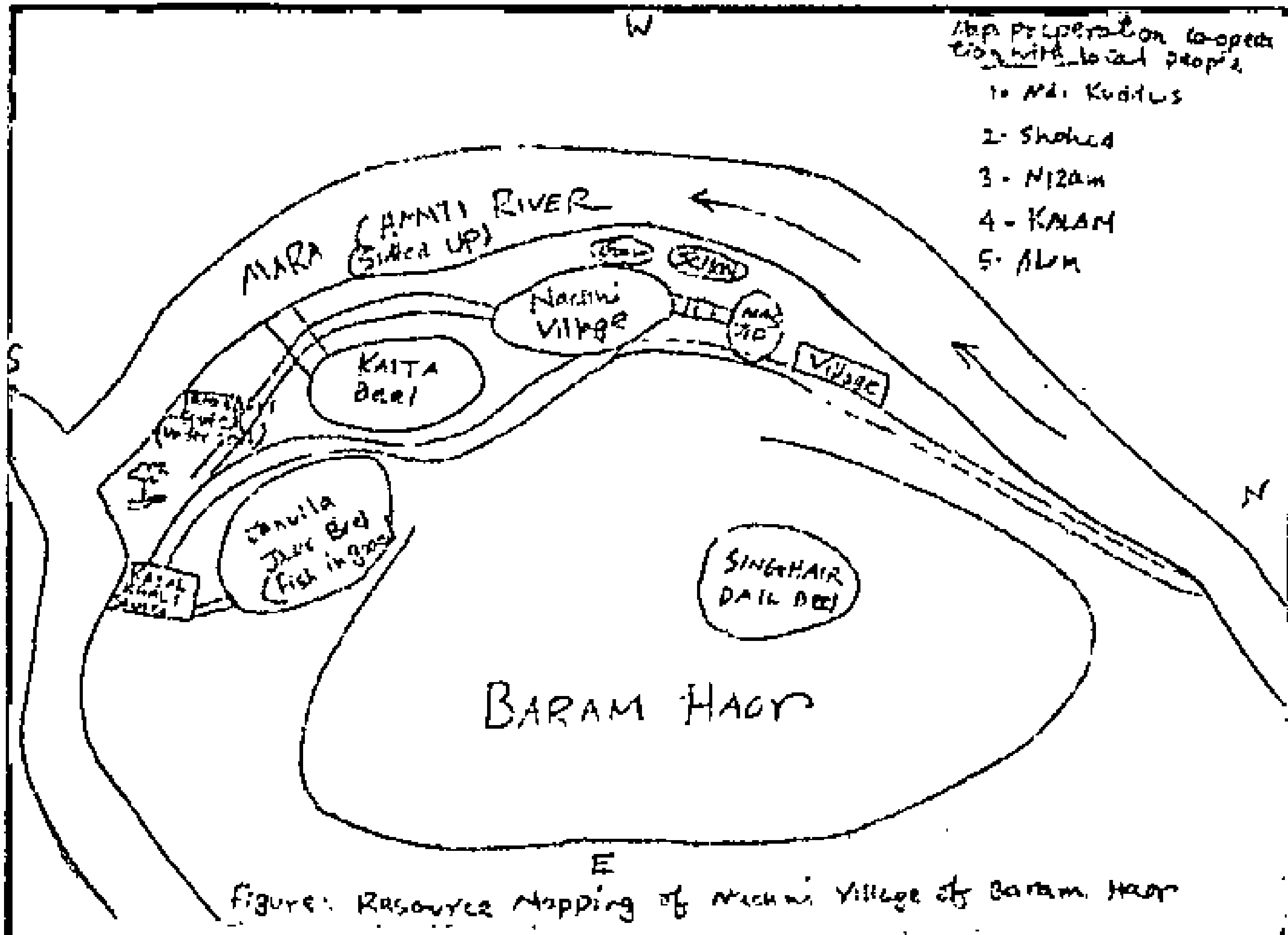


Figure 6.3: Resource mapping with water resource system in Baram haor (Source: Field survey)

6.2.3.2 Fisheries related problems and issues

From focus group discussions (FGDs) in Tangua haor the following were found to be the issues related to fisheries.

- Obstruction of fish migration due to embankment
- Reducing depth of water (such as river, beels and khals) due to siltation.
- Indiscriminate fishing such as Capturing of barried and juvenile fish, complete dewatering of beels, use of destructive gears (e.g. *kona Jaal and Current Jaal*) etc.
- Encroachment of beels for cultivation of rice or paddy during Hemanto (November-December).
- Increase of fishing effort- No. of fishermen, nets, boats, etc.
- Access of traditional fishermen into beels is not ensured in the present leasing system.

6.2.3.3 Fish species diversity

The fish species diversity in Baram haor was found very poor in the field survey. Fish diversity has declined rapidly due to habitat loss, poor fisheries management indiscriminate fishing e.g. harmful fishing gears. The fish species found during the field survey are presented in Table 6.9. Out of total twelve species, two are riverine species and one is floodplain species. Rest ten species are both riverine and floodplain species.

Table 6.9: Species diversity of different fish habitats of the Baram haor (Source: Field Survey)

Scientific Name	Local Name	Habitat Type			
		River	Khal	Beel	Floodplain
Mystus vittatus	Tengra	P	P	P	P
Colisa fasciatus	Khaila	P	P	P	P
Wallagu attu	Boal	P	A	A	A
Puntius chola	Puti	P	P	P	P
Channa marulius	Gozar	P	P	P	P
Ompok pabda	Pabda	P	P	P	P
Mystus punctatus	Ghagoat	P	P	P	A
Cirrhinus mrigala	Mrigel	A	P	A	P
Punctius sarana	Shar puti	P	P	P	A
Botia dario	Rani	P	P	A	P
Labeo kalbasu	Kalibaus	P	A	A	A
Macrognathus pancalus	Gucchi	P	A	P	P

Note: A=Absent and P=Present

6.2.3.4 Decreasing fish catch

Although the respondents could identify a large number of species that are presently available in the Baram haor, they could compare the catch composition of only a few species between present and ten years ago. This is shown in Table 6.10. All the species reported by the respondents suffered significant declines. The species, Mrigel, Ghagoat, Puti and Gozar suffered the most followed by Khaila and Pabda.

Table 6.10 Fish catch of Baram haor at present situation compared with last 10 years (Source: Field survey)

Guild	Scientific name	Species name (local)	Present (%)
Small catfish	*Mystus vittatus*	Tengra	25
Large catfish	*Wallagu attu*	Boal	19
Small catfish	*Ompok pabda*	Pabda	12
Perch	*Colisa fasciatus*	Khaila	10
Catfish	*Mystus punctatus*	Ghagoat	05
Barb	*Puntius chola*	Puti	05
Snakehead	*Channa marulius*	Gozar	05
Carp	*Cirrhinus mrigala*	Mrigel	03

6.2.3.5 Species of conservation significance

Table 6.11 shows the conservation list of the species in Baram haor. The three species namely *Labeo nandina* (Nanid), *Amblyceps mangois* (Magur) and *Pangasius pangasius* (Pangas) have already been unavailable in Baram haor, similar to Tangua and Chaptir haors. The local people mentioned that they did not find the species of *Heteropneustes fossilis* (Sing) and *Amblyceps mangois* (Magur) in the last 5-10 years. The other six species are rare in appearance. The rare and unavailable species in Baram haor are compared with the list of threatened species prepared by IUCN (2000). One third of the threatened species in Baram haor are also listed as threatened overall in Bangladesh.

Table 6.11: Conservation significance list of fish species of Baram haor (Source: Field Survey)

Scientific name	Local name	Local status (10 years)		Threatened species (IUCN, 2000)
		Rare	unavailable	
Punctius sarana	Shar puti	√	x	Critically endangered
Mystus punctatus	Ghagoat	√	x	-
Botia dario	Rani	√	x	Endangered
Labeo kalbasu	Kalibaus	√	x	Endangered
Macrognathus puncalus	Gucchi	√	x	-
Wallago attu	Boal	√	x	-
Labeo nandina	Nanid	x	√	Critically endangered
Pungasius pangasius	Pangas	x	√	Critically endangered
M. rosenbergii	Boro chingri	x	√	-
Chitala chitala	Chital	x	√	Endangered
Labeo ruhita	Rui	x	√	-
Catla catla	Catla	x	√	-
Anabus testudineus	Koi	x	√	-
Heteropneustes fossilis	Sing	x	√	-
Amblyceps mangois	Magur	x	√	-

6.2.3.6 Scoring and ranking of relative abundance

Habitat wise percentage composition in Baram haor is shown in Table 6.12. The table also shows the scoring and ranking of species for different fish habitats of Baram haor. From the table, it is seen that the highest ranked species in river type habitat is *Puntius chola* (Punti). Some of the species that got the lowest rank in the river habitat of Baram haor are *Cirrhinus mrigala* (Mrigel), *Heteropneustes fossilis* (Sing), *Amblyceps mangois* (Magur) etc. The species *Puntius chola* (Punti) is the highest ranked species in all four habitats such as river, khals, beels and floodplains. Some of the species that got the lowest ranks in all four habitats include *Amblyceps mangois* (Magur), Labeo *nandina* (Nanid), *Pungasius pangasius* (Pangas), *Chitala chitala* (Chital) etc. The highest scored species in Baram haor is *Puntius chola* (Punti). Out of total twenty nine species, seventeen species got the lowest score of 0 (zero) in Baram haor.

Table 6.12: Scoring and ranking of fish species found in different habitats of Baram haor (Source: Field Survey)

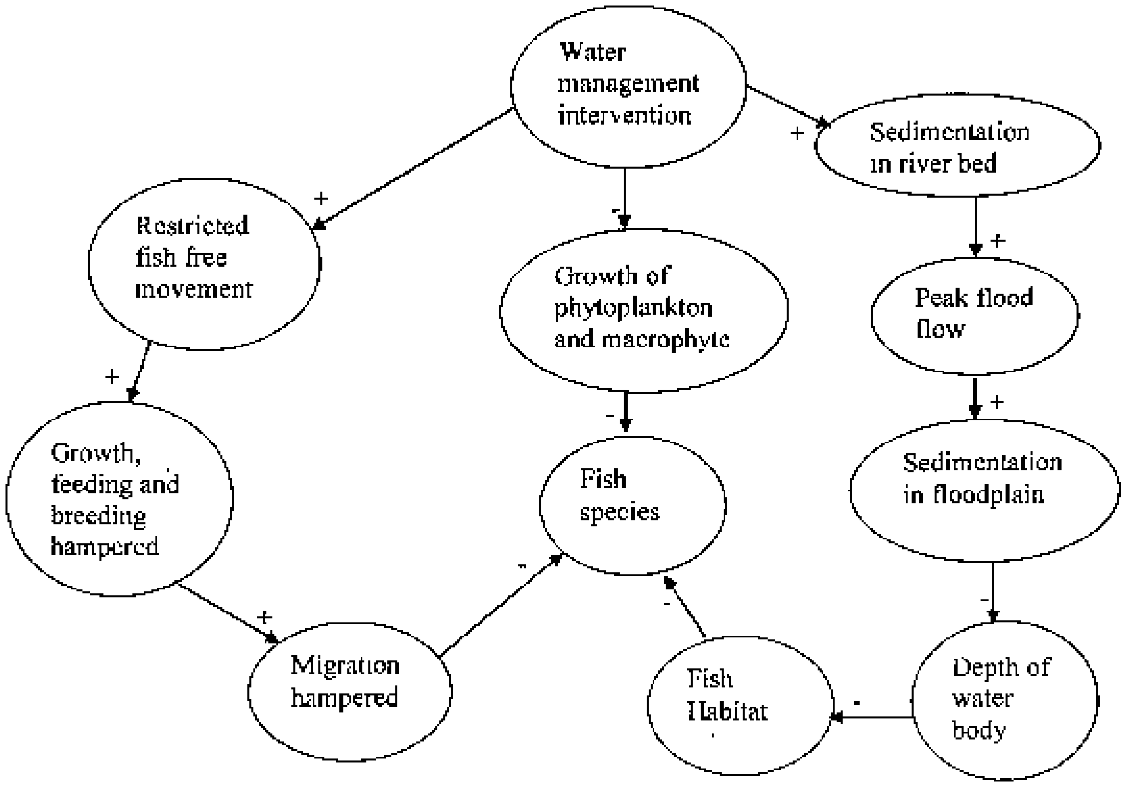
Serial No.	Scientific Name	Local Name	Habitat Type catch composition												
			River (%)	Rank	Score	Khal (%)	Rank	Score	Beel (%)	Rank	Score	Flood-plain (%)	Rank	Score	Total score
1	*Puntius chola*	Puti	25	1	29	38	1	29	30	1	29	50	1	29	116
2	*Wallagu attu*	Boal	13	2	28	0	8	0	0	7	0	0	8	0	28
3	*Mystus vittatus*	Tengra	12	3	27	13	2	28	15	2	28	12	2	28	111
4	*Colisa fasciatus*	Khaila	12	3	27	12	3	27	12	3	27	6	5	25	106
5	*Ompok pabda*	Pabda	7	4	26	6	6	24	12	3	27	10	3	27	104
6	*Macrognathus pancalus*	Gucchi	7	4	26	0	8	0	10	4	26	2	7	23	75
7	*Mystus punctatus*	Ghagoat	6	5	25	3	7	23	3	6	24	0	8	0	72
8	*Punctius sarana*	Shar puti	6	5	25	10	4	26	12	3	27	0	8	0	78
9	*Botia dario*	Rani	6	5	25	6	6	24	0	7	0	5	6	24	73
10	*Channa marulius*	Gozar	3	6	24	9	5	25	6	5	25	9	4	26	100
11	*Labeo kalbasu*	Kalibaus	3	6	24	0	8	0	0	7	0	0	8	0	24
12	*Heteropneustes fossilis*	Sing	0	7	0	0	8	0	0	7	0	0	8	0	0
13	*Amblyceps mangois*	Magur	0	7	0	0	8	0	0	7	0	0	8	0	0
14	*Cirrhinus mrigala*	Mrigel	0	7	0	3	7	23	0	7	0	6	5	25	48
15	*Labeo nandina*	Nanid	0	7	0	0	8	0	0	7	0	0	8	0	0
16	*Pungasius pangasius*	Pangas	0	7	0	0	8	0	0	7	0	0	8	0	0
17	*Anabus testudineus*	Koi	0	7	0	0	8	0	0	7	0	0	8	0	0
18	*M. rosenbergii*	Boro chingri	0	7	0	0	8	0	0	7	0	0	8	0	0
19	*Chitala chitala*	Chital	0	7	0	0	8	0	0	7	0	0	8	0	0
20	*Labeo ruhita*	Rui	0	7	0	0	8	0	0	7	0	0	8	0	0
21	*Catla catla*	Catla	0	7	0	0	8	0	0	7	0	0	8	0	0
22	*Labeo gonius*	Gonia	0	7	0	0	8	0	0	7	0	0	8	0	0
23	*Cirrhinus reba*	Laso	0	7	0	0	8	0	0	7	0	0	8	0	0
24	*Coric soborna*	Kachki	0	7	0	0	8	0	0	7	0	0	8	0	0
25	*Gudusia chapra*	Chapila	0	7	0	0	8	0	0	7	0	0	8	0	0
26	*Notopterus notopterus*	Foli	0	7	0	0	8	0	0	7	0	0	8	0	0
27	*Macrognathus aculeatus*	Baim	0	7	0	0	8	0	0	7	0	0	8	0	0
28	*Eutropiichthys vacha*	Bacha	0	7	0	0	8	0	0	7	0	0	8	0	0
29	*Prawn sp.*	Choto chingri	0	7	0	0	8	0	0	7	0	0	8	0	0

6.3 Conceptual cause effect relationship between fisheries and interventions

Figure 6.4 shows a conceptual relationship between fisheries and water management intervention. Embankments and regulators restrict the free movement of fish from rivers to beels and haors and vice versa. Haor are inundated and linked to rivers during the monsoon but are isolated during the dry season. Restricted fish free movement hampers migration of fish species that severely affects fish growth and breeding, which is sign of species declination.

With the construction of haor projects, floodplain areas have became gradually less. This has confined the flood water as well as sediments within the river system. The confinement of rivers has led to raised riverbeds, resulting in an increase in peak flood level. Increased inundation during monsoon brings more sediment into the floodplain, including beels, haors and khals. The habitat area available for fish is thus reduced during pre-monsoon and early-monsoon period.

During the dry season, there is an accumulation of animal droppings and rotting vegetation in the form of plant nutrients These nutrients are dissolved rapidly during the early stage of flooding and, combined with river-borne silts, result in profuse growth of phytoplankton and macrophytes, which offers ideal conditions for growth, feeding and breeding of many fish species which migrate to the floodplain with the rising water (Welcomme, 1979). Submersible embankment prohibits the early stage of flooding to save boro crops from early flooding. As a result, the accumulations of plant nutrients are not likely to dissolve properly. That's why the shortage of nutrients in the aquatic body is a possibility which would indicate decrease in fish species.



('+' sign indicates increase and '–'sign indicates decrease)

Figure 6.4: Cause effect relationship between fisheries and interventions

6.4 Comparison of fisheries ecosystem among three haors

The findings of the field investigation reveal that the fisheries ecosystem of Chaptir haor has been less affected, and thus the haor represents a relatively undisturbed state. The ecosystem of Tangua haor has been moderately affected, and thus the haor represents a moderately disturbed state. The fisheries ecosystem of Baram haor is most heavily affected, and thus the haor represents a heavily disturbed state. The findings with the Chaptir haor are similar to the findings of Wester and Bron (1998), who found the impact of embankments on the fisheries of Chaptir haor to be low. Although the ecosystem of Chaptir haor did also suffer, it is relatively less disturbed compared to the other two haors. Fish diversity in Chaptir haor is richest among the three haors. Fish diversity in Tangua haor is found moderately good while the same in Baram haor very poor. The number of species of conservation significance under threat is highest in Baram haor indicating the worst fish ecosystem of the three. In the context of the same parameter, the fish health is better in Tangua haor and best in

Chaptir haor. When the differences in fish catch between present and 10 years ago are compared among the three haors (see Table 6.13 and Figure 6.5), it is clearly seen that while all haors have suffered declines in fish catch over last 10 years, the fish catch in Baram haor has gone down the most, followed by Tangua haor.

Table 6.13: Changes of fish catch among three selected haors over last 10 years (Source: Field survey)

Scientific name	Species name (local)	Present (%)		
		Chaptir	Tangua	Baram
Ompok pabda	Pabda	50	25	12
Wallagu attu	Boal	40	25	19
Mystus punctatus	Ghagoat	40	-	05
Mystus vittatus	Tengra	25	25	25
Colisa fasciatus	Khaila	25	10	10
Puntius chola	Puti	25	10	5
Channa marulius	Gozar	25	19	5
Heteropneustes fossilis	Sing	01	-	-
Cirrhinus mrigala	Mrigel	-	-	03
Labeo gonius	Gonia	-	25	-
Corica soborna	Kachki	-	25	-
Ailia coila	Kazoli	-	25	-
Gudusia chapra	Chapila	-	25	-
Labeo ruhita	Rui	-	05	-

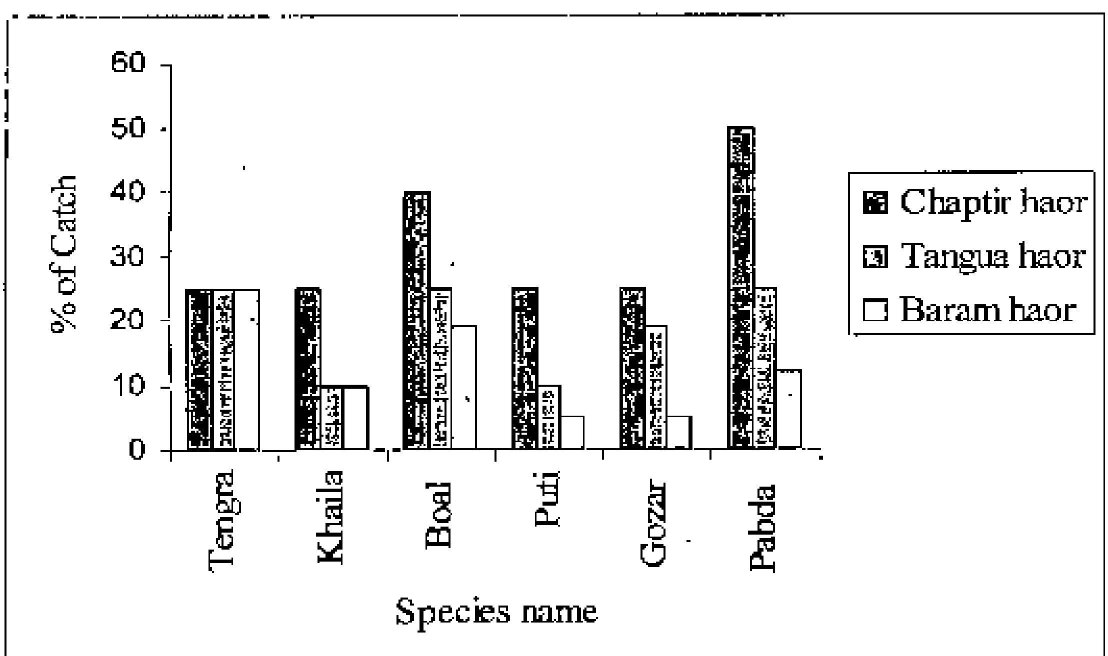


Figure 6.5: Changes in fish catch of the three haors over last 10 years (Source: Field survey)

If the degrees of interventions of the three haors are compared from information given in Chapter Four, it is seen that they are similar in all the three haors. The question obviously arises why, in spite of similar intensity of water management interventions the three haors would exhibit different degrees of impacts in the ecosystem. This is explained below.

As discussed in previous sections, a number of factors have been suggested by the participants in field survey as possible reasons for the degradation of ecosystem. It appeared from field survey that the extent of some factors, e.g. indiscriminate fishing, increase of fishing effort etc. were not too different among the three haors. The differences in fish ecosystem can then be attributed to the changes in the physical system (e.g. loss of fish habitat, impacted fish migration routes) due to water management interventions. A general overview of the status of fish migration routes were given by the participants in field survey indicating better fish migration opportunities in Chaptir haor, moderate opportunities in Tangua haor and poor opportunities in Baram haor. Some primary observations of the systems also supported their views. The regulators/sluices visited by the investigator were found to be mud-sealed in all the haors. However, some open khals were seen in the Chaptir haor, not obstructed by embankment and/or sluices or regulators. These should help relatively good fish migration. In Tangua haor, there are some old rivers, such as Jalia nadi and Banna nadi (explained in section 6.2.2.1), which are connected to the beels. These allow for some migration routes. However, during field survey, no such open khals or old rivers were found in Baram haor. Hence, the fish migration routes are poor in this haor. So, the water management interventions, although similar in intensity, affected the fish migration routes to different degrees, and hence brought different degrees of changes in fish ecosystem.

Another affect on fish ecosystem on the haors has been the sedimentation that has taken place in different habitats of the haors. The impacts of water management intervention on the habitat area and hence on fish ecosystem could be ascertained from the views of the local people, summarized in Table 6.14.

Table 6.14: Comparison of depth of different fish habitat (Source: Field survey and CEGIS, 2006)

Chaptir Haor	2007-08 study
Beel average depth (m)	4.5-5.5
Khals average depth (m)	6.4-7
River average depth (m)	9.1-13.7
Area shrinkage	Decreased
Tangua haor	2007-08 study
Beel average depth (m)	1.3-2.4
Khals average depth (m)	2.7-5.0
River average depth (m)	5.4-9.0
Area shrinkage	Decreased
Baram Haor	2007-08 study
Beels average depth (m)	1.2-1.3
Khals average depth (m)	1.8-2.0
River average depth (m)	4.5-4.8
Area shrinkage	Decreased

The depths of the adjacent rivers and beels are higher in Chaptir haor than those in the Tangua haor. In the Baram haor fish habitat area squeezing due to the siltation and dry season cultivation affected nursery fishing ground. In Tangua haor fish habitat area are squeezing due to the rapid siltation of adjacent rivers, khals and beels. The problem of sedimentation has been more severe in Baram haor as it is located at downstream. Suspended sediment load concentration in a river is generally more at downstream stretches and hence siltation is likely to be more in inundated floodplains. The depths of khals, which are potentially important migration routes, are more affected in Tangua haor and most heavily affected in Baram haor (Table 6.14).

6.5 Indicator of fish ecosystem

The total scores of individual species in each haor established in previous sections are summarized in Table 6.15. As seen in Table 6.15, the number of species with highest scores is greatest in Chaptir haor (10 species), followed by Tangua haor (9 species) and Baram haor (6 species). Four species got the score of zero (0) in all three haors. Comparing the scores of the three haors, three species can be selected, which can explain the ecosystem status of the three haors. They are separately presented in Table 6.16. The species are *Wallago attu* (Boal), *Labeo ruhita* (Rui) and *Catla catla* (Catla).

It is clear that very low availability of Rui, Catla and Boal (especially Rui and Catla) is an indicator of heavily disturbed ecosystem, while moderate availability indicates moderately disturbed and good availability indicates relatively (naturally) undisturbed ecosystem. It is noted here that no indicator species specific to any haors could be obtained. It would have required seasonal plus long term (e.g. two years) direct sampling of fish followed by extensive statistical analysis. It was not possible in the present study due to constraints of time and funds.

Table 6.15: Score of Individual species in each haor

Guild	Scientific Name	Local Name	Score		
			Chaptir Haor	Tangua Haor	Baram Haor
Small catfish	*Mystus vittatus*	Tengra	111	115	111
Perch	*Colisa fasciatus*	Khaila	107	94	106
Small catfish	*Ompok pabda*	Pabda	106	87	104
Large catfish	*Wallagu attu*	Boal	105	99	28
Major carp	*Labeo ruhita*	Rui	105	90	0
Major carp	*Catla catla*	Catla	103	23	0
Barb	*Puntius chola*	Puti	87	108	116
Catfish	*Mystus punctatus*	Ghagoat	81	102	72
Snakehead	*Channa marulius*	Gozar	79	65	100
Major carp	*Cirrhinus mrigala*	Mrigel	77	87	48
Clupeid	*Gudusia chapra*	Chapila	55	74	0
Small catfish	*Heteropneustes fossilis*	Sing	52	0	0
Knifefish	*Chitala chitala*	Chital	27	0	0
Knifefish	*Notopterus notopterus*	Foli	27	0	0
Barb	*Punctius sarana*	Shar puti	26	0	78
Prawn	*Prawn sp.*	Choto Chingri	25	98	0
Prawn	*M rosenbergii*	Boro chingri	25	0	0
Eel	*Macrognathus aculeatus*	Baim	25	0	0
Small catfish	*Amblyceps mangois*	Magur	0	0	0
Minor carp	*Labeo nandina*	Nanid	0	0	0
Large catfish	*Pungasius pangasius*	Pangas	0	0	0
Small catfish	*Eutropiichthys vacha*	Bacha	0	24	0
Perch	*Anabus testudineus*	Koi	0	0	0
Loach	*Botia dario*	Rani	0	22	73
Major carp	*Labeo kalbasu*	Kalibaus	0	0	24
Eel	*Macrognathus pancalus*	Guchi	0	0	75
Minor carp	*Labeo gonius*	Gonia	0	96	0
Clupeid	*Coric soborna*	Kachki	0	54	0
Minor carp	*Cirrhinus reba*	Laso	0	95	0

Table 6.16: Indicator species for fish ecosystem

Guild	Local name	Scientific name	Haor name		
			Score of species		
			Undisturbed Haor (Chaptir)	Moderately Intervened Haor (Tangua)	Extensively Intervened Haor (Baram)
Cat fish	*Wallagu attu*	Boal	105	99	28
Carp	*Labeo ruhita*	Rui	105	90	0
Carp	*Catla catla*	Catla	103	23	0

6.6 Life cycle of the fish species

Before examining the life cycle of the three indicator species, a discussion is made here about the fish life cycle in general to have a good understanding of the relationship between water management infrastructure and the indicator species. The fish life cycle is divided in four stages. Figure 6.6 shows the overall life cycle of fish. Species generally prefer to spawn at the time of rising water. At this time, the species spawn and migrate to the floodplain in search for their food and secure for suitable climatic condition. After recession of water, fish then migrate back to the river from floodplains.

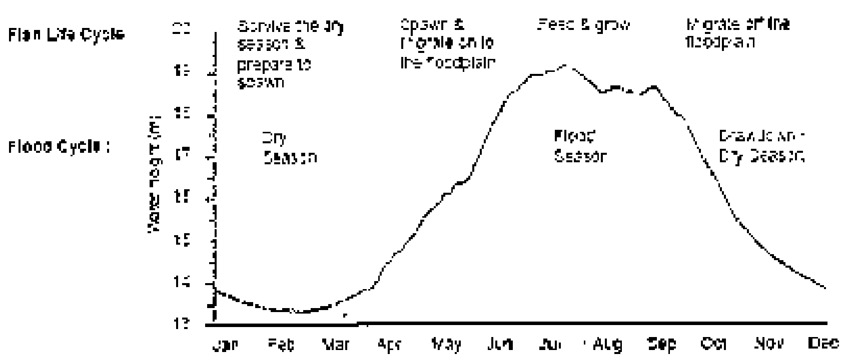
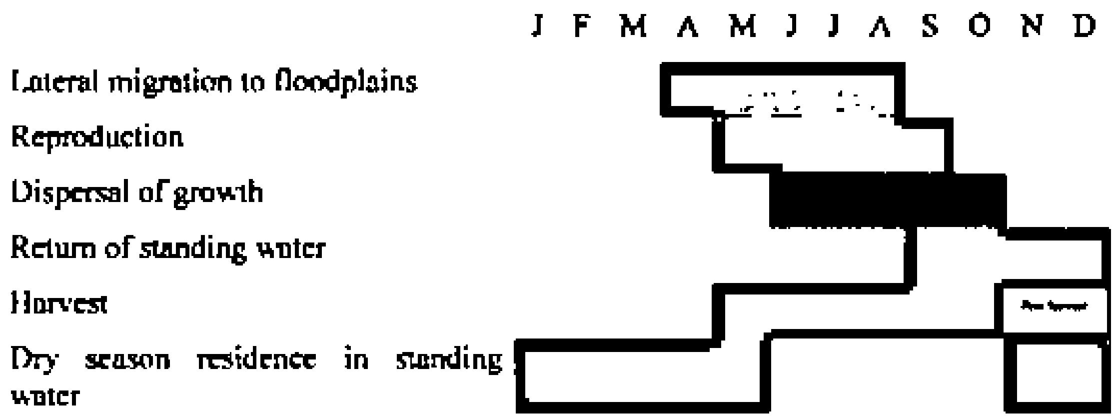


Figure 6.6: The relationship between the seasonal Life cycles of fishing biology and flooding. Modified from Hoggarth et al. (1999).

All the open water components i.e. rivers, canals, beels (deep depressions within the low flood plains with area of seasonal or perennial water) and the flood plains become connected with each other and turn into an integrated single biological production system during the monsoon month. This integrated production system lasts for up to five months, providing suitable habitat for reproduction, migration, feeding and growth of aquatic organisms. Many of fish species breed in favourable habitat conditions in the inundated floodplains, where the new born juveniles feed and grow in the nutrient rich flooded lands. Young and juveniles of many fish species resulting from breeding in the flowing rivers and estuaries also migrate to the inundated land for feeding and completing early growth. At the end of the monsoon the fish species return to the rivers and beels from the flood plains with the receding water. The following Figure 6.7 shows the total activity of the fish species in the floodplain.

Figure 6.7: Fresh water fish activities in the open waters (Source: Welcome, 1979)

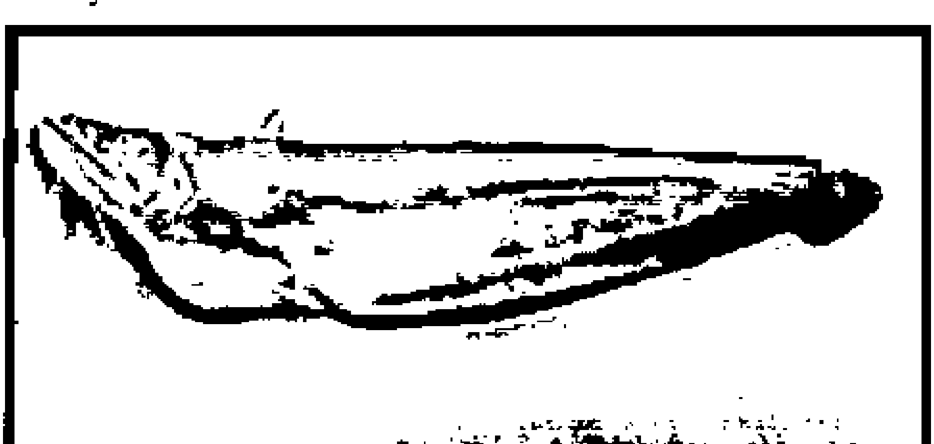


6.7 Life cycle of indicator species

(1) ***Wallago attu*** [Source: Rahman (2005) and Shafi and Quddus (2004)]

Local name: Boal

Family: Siluridae



Habitat

Found in large rivers, lakes and tanks. Sluggish and stays on muddy or silty bottom in search of food.

Feeding and breeding

They are voracious feeder, and are well known for its predatory behaviour and are often termed as 'freshwater shark'. They also eat floating materials of terrestrial insects, even mouse, and also other fish. They spawn in June and July. They start migration during pre-monsoon from overwintering place to river. They are floodplain breeder species. Boal prefers to breed in areas at a shorter distance from rivers (likely in adjacent khals and beels) (Shawanigan Lavalin Inc. and others, 1994). As soon as the streams and tanks are flooded by rains, they run up shallow water for breeding and offer parental care.

(2) *Labeo rohita* [Khan and Jhingran. 1975]
Local name: Rui
Family name: Cyprinidae

Habitat

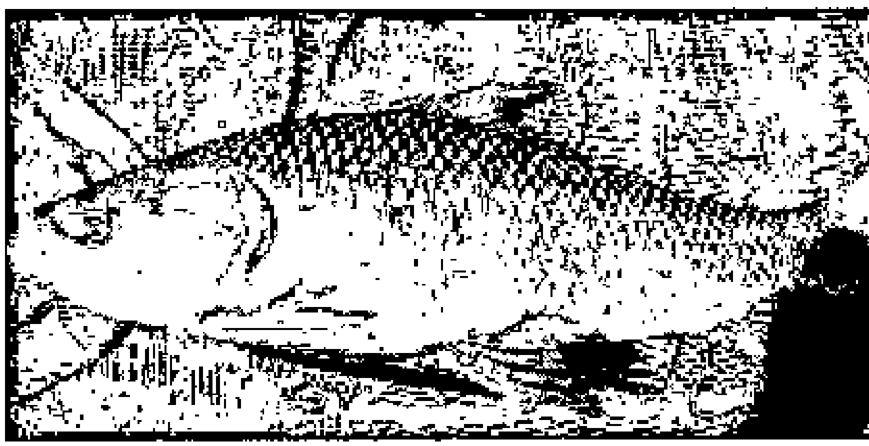
Found in streams. lakes, lagoons, Estuaries and rivers. Sometime found in burrows.

Feeding and breeding

They feed on plants. Spawning season generally coincides with the southwest monsoon. They spawn in May, June and July. They start migration laterally from over wintered place to rivers during pre-monsoon. Spawning occurs in flooded rivers.

Preferred spawning sites are in middle reaches of rivers, where flood water spreads in more or less limpid shallows over fertile flats, well above tidal reaches. Spawning also takes place in reservoirs and bundh-type tanks.

(3) *Catla catla* [www.fishbase.org]
Local name: Catla
Family name: Cyprinidae



Habitat

Catla fish species occurs in rivers, lakes and culture ponds.

Feeding and Breeding

They spawn in June and July. They breed in rivers. They start migrate laterally from over wintering place to river during pre-monsoon. They are surface and mid-water feeders, mainly omnivorous with juveniles feeding on aquatic and terrestrial insects, detritus and phytoplankton.

6.8 Relationship of indicator species with haor hydrological cycle

The relationship between haor hydrology and indicator species is illustrated in Table 6.17. It is seen that first three months of the year become dry season and the middle months, April and May represent the water rising time. June and July are the peak time of rainy season, August and September are the flooding time, and October to December is the water recession period. The table shows the indicator species function in each month in relation with the haor hydrological cycle.

Table 6.17: Interaction between Haor Hydrology versus Species life cycle

Local Name	Species Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Haor hydrological cycle											
		Dry season			Pre-monsoon flood Water enter begin into haor		Full monsoon flood and Haor become a single floodplain				Flood recession		Dry Seas-on
		Operation mode of the structure											
		Open			Closed		Breaching of the structure				Closed		Open
Rui	*Labeo rohita*	Survive beels in Dry season and prepare to spawn			Migrate to river and search suitable spawning habitat		Spawn in river		Feeding and growth in river and floodplain		Migrate off river and survive beel in dry season		
Catla	*Catla catla*	Survive beel and river in Dry season			Migrate to river and search suitable spawning		Began to spawn, feeding and growth in river and floodplain				Migrate off river and survive beel in dry season		
Boal	*Wallago attu*	Survive river in Dry season and prepare to spawn			Migrate to flood plain and search suitable spawning habitat		Spawn in floodplain		Feeding and growth in floodplain		Migrate off floodplain and survive river in dry season		

■ Vulnerable Month

From the table it is clear that early migration is affected in all three haors. The submersible embankment prevents onset of migration of species Boal, Rui, and Catla and causes delay to it. Thus the river, floodplain and beel breeders would be prevented from breeding, and consequently ripen eggs in their ovaries will be resorbed through autolysis. Submersible embankments thus reduce the brood stocks of major carps (Rui and Catla) by preventing early migration. An earlier study by Ali (1990) had similar observations. This is likely to be the major cause of deterioration of the regeneration and dispersion of carp species of Rui and Catla. It was discussed before that the fish migration routes in Chaptir haor are better than Tangua and Baram haors. There are some open khals in Chaptir haor that help relatively good fish migration. Fish migration is relatively worse in Tangua haor, in which some old rivers present in the haor allow for some migration routes. In Baram haor fish migration is the worst affected since the sluice gates at the entrance of the connecting khals are either mud sealed or closed.

Wallago attu (Boal) makes limited longitudinal migrations in the rivers and lateral movements on to the floodplain (Shawinigan Lavalin Inc. and Others, 1994a; ODA, 1994). The species Catla and Rui tend to migrate from floodplains to rivers. As reported by previous studies (Khan and Jhingran, 1975; Jhingran and Khan, 1979), these species may make full migration to the rivers or may end up remaining in the khals or beels and breed there if migration is obstructed.

The species would require sufficient depths for breeding and regeneration. As seen in previous sections, the depths of rivers, khals and beels in Chaptir haor are much better than the other two haors, that in Baram haor being the worst. So the impacts on these species in the three haors have taken place accordingly. Removal of weeds and bushy trees for extensive cultivation is also adding to the cause. Weeds and bushy trees are suitable place for breeding and they also serve as supplementary food for fish. This is more significant for Boal. This species has a predatory nature, and when the species do not get sufficient food they eat their own juveniles. This will affect the species of Boal regeneration and dispersion.

After the monsoon period the fish try to migrate off the floodplain and beels back to the rivers during the period of flow (i.e. October and November). The closure of regulator/sluices to store water for later use in irrigation for the boro crop causes a hindrance to the migration of fish.

From the above discussion it is a growing concern that water management interventions have severely reduced fish stocks by reducing habitat areas. These water management interventions obstructed the channels connecting beels and floodplain to the main rivers (fish migration routes), so it is likely that they have reduced the riverine and floodplain spawning stocks and prevented the return distribution of fish fry to the floodplain and river.

Chapter Seven

Conclusion and Recommendations

7.1 Conclusion

The impact of water management interventions on overall haor ecosystem has been clear from their roles in modifying the physical and hence fisheries ecosystem in the three haors. The conclusions of the study are as follows.

- Water management interventions are now found to have negatively impacted fish ecosystem by delaying the fish migration and affecting fish habitat areas.

- Construction of structures and submersible embankment block access to spawning grounds for few days during April/May and feeding migration of many fish species to and from the floodplains, river and khals, thus reducing their breeding stocks and reproduction.

- Flood protection embankments also reduce conveyance capacity of river channels because of riverbed sedimentation, and the resulting increase in peak flow causes increased sedimentation in the floodplains, including beels, haors and khals.

- Fish biodiversity was found good in Chaptir haor and moderate in Tangua haor. While the same in the Baram haor was poor.

- When different fish catch among three haors are compared, it is clearly found that all the species in Baram haor suffered significant declines compared to the other two haors.

- Chaptir haor fish ecosystem health is best among the three selected haors. It is mainly due to higher depth of beels, khals and presence of relatively better migration routes.

- Tangua haor fish ecosystem health is better than Baram haor. Baram haor is the most affected haor because of obstruction to free movement of fish species and reduction in habitat area.

- Three species indicative of the status of the ecosystem could be identified. These are Rui. Catla and Boal. Low availability of Rui, Catla and Boal (especially Rui and Catla) is an indicator of heavily disturbed ecosystem, while moderate availability indicates moderately disturbed and good availability indicates relatively (naturally) undisturbed ecosystem.

- Effective FCD projects reduce the areas of beels and flooded land, causing a direct reduction in fish catches. There may also be a cumulative and synergistic effect on fish populations as the area of FCD has expanded and natural fish migration and dispersal has been interrupted.

7.2 Recommendations

A number of recommendations are provided below. It is noted here that many of them came from the local people in the study area during field investigations.

- Fish spawn/fry passage in regulators: Bangladesh floodplain fishery depends on spawn and fry drifting into the floodplain from the rivers, and on major carp which migrate into the river system to move upstream to breed. To permit managed migration of fish, both new operating rules and modifications to structures would be required.

- Declaring fish sanctuary: Rehabilitating of the haors and declaring certain area (including certain time and certain path, for example, a fish migration route) as fish sanctuary (protected areas) is very much important to save the fisheries resources in the study area. After declaring fish sanctuary additional protection or management practices can be taken up.

- Preserving mother fishery: Mother Fishery is the area where brood, young and juvenile fish aggregate and take refuge during the dry season when the rest of the haor area becomes dry.

- Fish habitat restoration: Improved fisheries resources management should include dredging of rivers and khals. Fish habitat restoration also includes law against complete dewatering of beels.

- Reducing dependency of boro crops: Proper fisheries resources management (mother fishery, habitat restoration) can reduce the dependency of boro crops.

- Plantation of vegetation: Re-plantation of many local species like Reeds, Koroch etc. This will not only benefit fisheries resources and wildlife but also protect the project area from erosion and save local people from flooding.

7.3 Suggestions for future study

The study considered three haors, all of which have flood control interventions through submersible embankments. It will be an interesting future work if one haor without any interventions can be selected and its ecosystem is compared with that in other haors with interventions.

There are possibilities of using methods other than PRAs to get more quantitative data. If time and resources permit, good data can be obtained through long term, seasonal direct sampling or catch assessment survey. It will allow statistical analysis of data, and generate different fish indices. In this way, there is a possibility to obtain indicator species specific to any particular haors, which was not possible in the present study.

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