Capture-based aquaculture of wild-caught Indian major carps in the Ganges Region of Bangladesh

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INTRODUCTION

Background and country context

Bangladesh is a riverine floodplain country with over 700 small, medium and large rivers and three major river systems (the Ganges, Brahmapura and Meghna) that originate from the Himalayan chain, cross the country and then join before emptying into the Bay of Bengal. The rivers cover over 24 000 km which constitutes approximately 6 percent of the total area of the country. Apart from rivers, there are numerous natural wetlands in the form of canals, *beels, haors, baors*[1], mangrove swamps and lands which flood seasonally for 5–6 months of the year. The wetlands range from 7.5 to 7.8 million hectares (Table 1) (Nishat, 1993). The floodplains are very rich in natural productivity and support a diverse flora and fauna, among which fish is considered the most important natural resource, as it supports the livelihoods of millions of inhabitants, including many of the rural poor.

Bangladesh has a humid climate with three broad seasons: warm summer (March to May), wet monsoon (June to October) and cooler winter (November to February). Rainfall is abundant and ranges annually from 140–400 cm, with over 80 percent received during the monsoon months. The temperature during the summer varies from 35.0–37.5 °C, reaching 43 °C at times, while in winter the temperature ranges from 17.5–24.0 °C, falling as low as 4.5 °C in some locations.

Monsoon flooding strongly influences the biophysical and socio-economic functions of the country. With the onset of rains in April–May,

TABLE 1
Area of seven types of water bodies in Bangladesh

Types of water bodies	Area (ha)
Large reservoirs	90 000
Coastal shrimp farms	141 000
Permanent rivers and streams	480 000
Estuaries and mangrove swamps	610 000
Shallow lakes and marshes	120 000–290 000
Ponds and ditches	300 000–400 000
Seasonally flooded lands	5 770 000
Total	**7 511 000–7 801 000**

Source: Nishat, 1993.

[1] *Beels* are floodplain lakes, which may hold water permanently or dry up during the winter season; *haors* are depressions in floodplains located between two or more rivers, which function as internal drainage basins; and *baors* are oxbow lakes (Hasan and Ahmed, 2002).

the water level in the river systems start to rise, and gradually overflows the river banks and inundates nearly one third of the country for 5–6 months. The river water starts rising even before the monsoon, because of the rise of temperature that causes snow melt in the Himalayas.

The warm temperatures and high rainfall, coupled with numerous rivers and wetlands that are rich in nutrients, have endowed the country with rich fisheries resources. The wetlands in Bangladesh support around 265 species of freshwater bony fishes representing 154 genera and 55 families. There are also more than 30 species of prawns and shrimps in freshwater systems and coastal waters. Of the 265 freshwater fish species, four species of Indian major carps are commercially important, and make up a significant proportion of both the inland capture and culture fisheries production.

Information availability on capture-based aquaculture

Although there is an established practice of collecting major carp spawn from rivers to supply seeds to the carp aquaculture industry, this aspect of the fishery has not been well documented. However, studies have been conducted on some of the main aspects of carp stocks in the wild, and on breeding behaviors and spawn collection, by different research projects and by the Bangladesh Fisheries Resources Survey Systems (BFRSS) of the Department of Fisheries (DoF).

Most of the available information is focused on the biological aspects of carp, their migration and breeding behaviors, spawning times and grounds, and on spawn collection and nursery rearing. Since 1984, the BFRRS have been collecting data on major carp spawn collection from the main river sources. This database includes spawn collection centers by river systems, number of nets used, collecting period (season), quantity caught, price, and the number of people engaged. However, there is no mention of the socioeconomic aspects of the people engaged in the wild-caught spawn fishery, nor of the marketing and distribution systems for the wild-caught spawn. The environmental implications of collection of major carp spawn from the wild are poorly documented.

Some literature highlights the stock of major carps and spawning-related information, indicating concern over declining carp stocks in the wild and making recommendations. Tsai and Ali (1985) analysed the BFRSS data, and found no significant adverse impact of carp spawn collection from the wild on the natural stock of major carps in Bangladesh.

There has been extensive work on the Halda River stock of carp in southeast Bangladesh, the only main carp spawning grounds in the country, and from which fertilized eggs are collected. Changes in the course of rivers made by the Bangladesh Water Development Board (BWDB) resulted in negative impacts on carp spawning grounds. The harvest of broodstock fish from Halda River, especially while they migrating to their spawning grounds, has negative impact on the wild stock. The other stock of major carp spawn is in the upper reaches of the rivers outside Bangladesh, a location from which spawn, rather than fertilized eggs, are collected.

MAJOR CARP FISHERY IN BANGLADESH

General information on the carp

The four species of carp found in the waters in Bangladesh are grouped together as Indian major carps: catla (*Catla catla*), roho labeo or rui (*Labeo rohita*), mrigel (*Cirrhinus mrigala*) and kalibaush (*Labeo calbasu*). Although the age of maturity for spawning varies by species, all require at least two years to attain sexual maturity and spawning ability; rui require at least two years, mrigel requires 2–3 years, and catla and kalibaush mature at three years (Table 2).

TABLE 2
Four species of major carp of Bangladesh with key biological and aquaculture characteristics

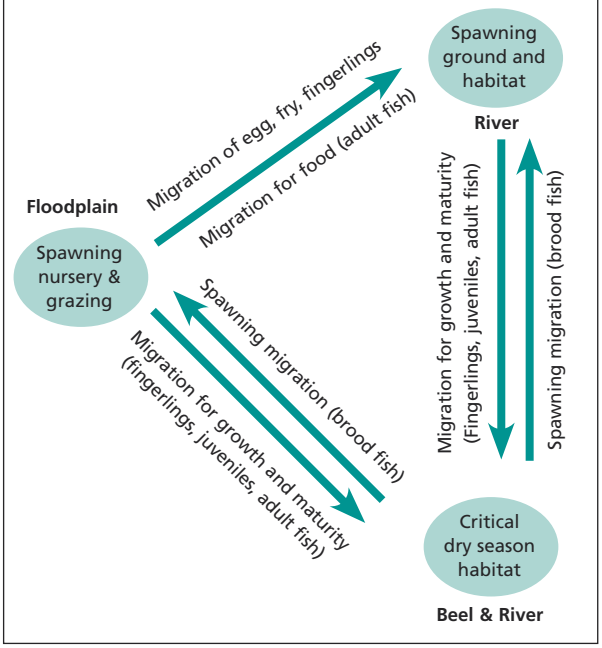
Major carp species	Key biological and aquaculture characteristics
 Catla: *Catla catla*	*Age of maturity:* 3–5 years *Trophic level:* Surface feeder *Growth potential:* High *Aquaculture potential:* High *Share in pond aquaculture:* 19.9 % (2004–05) *Share in Kaptai Lake*: 31 % of major carp (2004–05) *Share in annual Beel catch:* 7 % (2004–05)
 Rui: *Labeo rohita*	*Age of maturity*: 2–3 years *Trophic level:* Column feeder *Growth potential*: Medium *Aquaculture potential*: High *Share in pond aquaculture:* 23.4 % (2004–05) *Share in Kaptai Lake*: 11.9 % of major carp (2004–05) *Share in annual Beel catch:* 8.2 % (2004–05)
 Mrigel: *Cirrhinus mrigala*	*Age of maturity*: 2–3 three years *Trophic level:* Column feeder *Growth potential:* Medium *Aquaculture potential*: High *Share in pond aquaculture:* 16.2 % (2004–05) *Share in Kaptai Lake*: 6.9 % of major carp (2004–05) *Share in annual Beel catch:* 7.3 % (2004–05)
 Kalibaush: *Labeo calbasu*	*Age of maturity:* 3 three years *Trophic level:* Column feeder *Growth potential*: Medium *Aquaculture potential:* Low *Share in pond aquaculture:* 0.6 % (2004–05) *Share in Kaptai Lake*: 50.1 % of major carps (2004–05) *Share in annual Beel catch:* 2.2 % (2004–05)

All of these species require similar environmental conditions and use similar spawning grounds (Tsai and Ali, 1985). Each carp species undertakes a spawning migration to reach their respective breeding grounds (Tsai and Ali 1985, 1986). The adult carp begin their spawning migration in the pre-monsoon season (March), coinciding with the gradual rise of water flow due to snow melt in the Himalayas, and the early rains and the rise in water temperatures. Spawning starts in May with the onset of southwest monsoon rains, and continues until July (Azadi, 1985; Shaha and Haque, 1976; Tsai and Ali, 1985). Soon after spawning, the adults and fish larvae migrate downstream to the floodplains for feeding and remain there for 4–5 months. They passively migrate with the water current, and drift laterally onto the extensive productive floodplains (Figure 1). They then migrate back to deeper areas in the rivers and *beels* for overwintering along with the receding water during late monsoon. The fish over-winter in these habitats, escaping mortality from fishing and natural causes, and start their spawning migration in the next pre-monsoon season. Although much is known about the spawning behaviour of major carp, there is little detailed knowledge of their spawning behaviour in relation to environmental requirements.

Wild stock of major carp

Based on the differences in the spawning grounds, spawning seasons, and geographic distribution, the major carp in Bangladesh are often divided into four stocks named by the respective river system: i) Brhamaputra-Jamuna stock, ii) Upper Padma stock, iii) Upper Meghna stock, and iv) Halda stock (Azadi, 1985; Tsai and Ali, 1985). There is little information available about another stock of major carp, in Kaptai Lake.

FIGURE 1
Migration cycle of floodplain fish

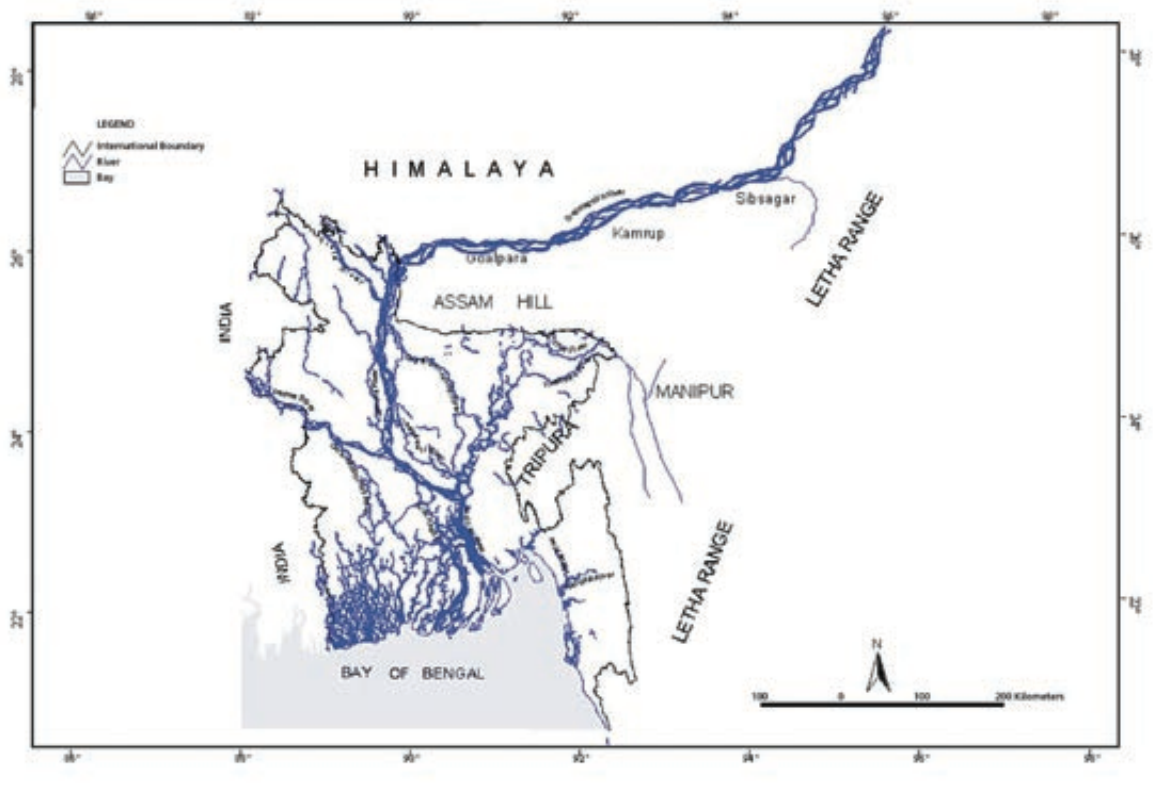


Brhamaputra-Jamuna stock

The Brhamaputra stock is the largest in Bangladesh, covering a wide range of areas and various tributaries of the Brhamaputra and Jamuna river systems (Azadi, 1985; Tsai and Ali, 1985; Tsai *et al.*, 1981). The rivers and floodplain *beel* included in this stock cover Brhmaputra, Jamuna, Old Brhamaputra, Kaliganga, Dhaleswari, Meghna (down to its confluence with the Old Brhamaputra River), lower Padma (down to its confluence with the Jamuna river), Kumar, and Arial Khan rivers and their tributaries, and canals and *beels* in the Borga, Pabna, Dhaka and Faridpur basins (Tsai and Ali, 1985).

The carp in this stock possibly do not spawn within Bangladesh, as only major carp juveniles are collected from the Brhapamutra-Jamuan river systems even in the upper reaches of the river near the Indian border (Kurigram district). The Brhamaputra-Jamuna stock travels a long distance from the lower reaches of the rivers to their spawning grounds at the southern tributaries of the upper Brahmaputra river in the Assam Hills and Letha Range, in Assam, India (Alikhuni, 1957) (Figure 2). The major carp in this stock spawn in the wild. Major pulses of spawn are caught in May and June, with less captured in July, coinciding with the onset of the southwest monsoon with the rise of water flow, temperatures and rainfall.

FIGURE 2
Major carp spawning ground in Brhamaputra and Upper Meghna River in India



The Brhamaputra stock of major carp start their spawning migration from their over-wintering habitats at the lower reaches in late February and continue until late April, coinciding with the gradual rise in water flow and temperature, and often with the start of the pre-monsoon rains. These fish perform a long, mostly longitudinal, migration to reach their spawning grounds. Soon after spawning the adults swim back along the river and laterally migrate to floodplains for feeding and growth until the late monsoon, and then they migrate to deeper pools in rivers in lower reaches as well as large perennial *beels* in the floodplains.

Upper Padma stock

This stock of major carp is found in the Padma River below the Farraka Dam and its associated tributaries, canals and *beels*. This stock occurs in the lower Meghna, Kumar, Arial Khan, and in other rivers below the confluence of the Padma and Jamuna rivers. This stock thus mixes with Brhamaputra-Jamuna stock due to close downstream connectivity among the rivers.

Similar to the Brahmaputra-Jamuan stock, no eggs from this stock are collected in the Padma River within Bangladesh, indicating that spawning occurs upstream and outside of Bangladesh. In neighboring India, the most important fry collection center in the Ganges River is upstream of Farraka Dam, where fry are collected from May to September (Jhingran, 1983). In Bangladesh, fry collection in the Padma River takes place during June, July and August, suggesting that there might be a different spawning ground of major carp in the Padma River downstream of the Farraka Dam (Tsai and Ali, 1985). Based on the time of availability of carp spawn in the Upper Padma, it is assumed that the spawning migration of major carp in the Padma River occurs from April to May/June, which is later than that of the Brhamaputra-Jamuna stock. As with the Brhamaputra-Jamuna stock, after spawning, the adults of the Padma stock move back and laterally migrate to flooded lands for feeding and growth.

Upper Meghna stock

This stock remains at the upper reaches of the Meghna River from its confluence with the Old Brhamaputra River, up to the tributaries, *beels* and *haors* in Bangladesh and India (Borak River basin). The major tributaries in the area include the Surma, Kushiyara and Khoai rivers that originate in the Letha Range, as well as the Boulai River that originates in the southern slope of the Assam Hills of India. There is relatively little information on carp spawning grounds and spawn collection centers on the upper Meghna in Bangladesh.

Unlike other river systems, there are no commercial carp spawn collection centers in the Upper Meghna River basin. Spawning of this stock may take place long distances upstream in India, or the spawning may be so limited that it does not attract fry/spawn collectors. However, some authors indicate that there are spawn collection centers located at the headwaters of the Surma River in Manipur province, and some in the Tripura province in India (Jhingran, 1983).

Paul (1997) does mention some locations where local fishermen collect carp spawn from the wild, noting seven carp spawn collection points in the greater Sylhet basin: i) Juri river in the Hakaluki haor upstream from the Fenchugonj Bridge; ii) Kawani River near Daulatpur and Milonpur, the Boroiya River near Shanbari bazaar, and the Baulai River near Mukshedpur in Dharampasha Upazila; iii) Baulai river near Alamduarer bank in Tahirpur upazila; iv) Surma River near Sunamgonj; v) Dhanu River near Ranichapur and Chalamati of Khaliajuri upazila; vi) Kalni River near Maruli of Derai Upazila; and vii) Khoiltajuri River near Dighirpar in Companigonj Upazila. However, these sites have not been investigated, and thus detailed information on the natural carp spawn collection and breeding grounds in the area is not available.

Halda stock

The Halda River in the southeast of Bangladesh originates from three major tributaries that come out of the Chittagong Hill tracts, namely the Dhurang, Talpari and Sareakhal. The river flows downstream and discharges into the Bay of Bengal, joining with the Karnafuli River at the south end where there are visible tidal effects. The river has meandering courses, and there are three ox-bends (Ankurdigji, Sonairchar and Urchirchar) in the southern reach of the river covering 32 km, that are reported to be the major carp spawning grounds. Three species of major carp (*C. catla*, *L. rohita* and *C. mrigala*) spawn in this tidal river every year. This is the only tidal river located very close to the coastline where major carp have been naturally spawning. This spawning ground is considered as one of the richest and oldest carp spawn fisheries, and has been meeting the demand of carp fry for pond aquaculture in the immediate area as well as much of the other parts of the country.

Other stock – Kaptai stock

This stock of major carp is limited to Kaptai Lake and its associated tributaries in the southeastern hill district of Bangladesh and constituted about 21 percent of the total landings (Hye, 1933). As with other stocks, spawning also occur here during May and June. Kaptai Lake, located in the Chittagong hill tract, is an oligotrophic lake containing a major carp stock, and the Freshwater Fisheries Research Sub-Station at Rangamati reports some carp spawning grounds in this lake. Collection of carp fry from the lake by the staff of the Research Sub-Station was noted by Azadi (1985). Possible spawning grounds in this lake included the Kassalong range (Mainimukh to Marishaya), the Barkal range (Subalong to border area), the Chengi range (Burighat to Mahalchari) and the Reinkonh range. These points are located at the headwaters of the Kaptai Lake however no detailed study on the major carp spawning is available.

MAJOR CARP FRY FISHERIES

All floodplain fish species in Bangladesh spawn in the pre-monsoon to monsoon months (March–October), the exact timing depending on the climatic conditions that affect the different species. All four species of carp breed during the monsoon and rivers play a vital role in their breeding functions. Therefore, rivers not only providing habitats for the capture fishery, but also support the very important major carp grow out, spawn and fry fisheries.

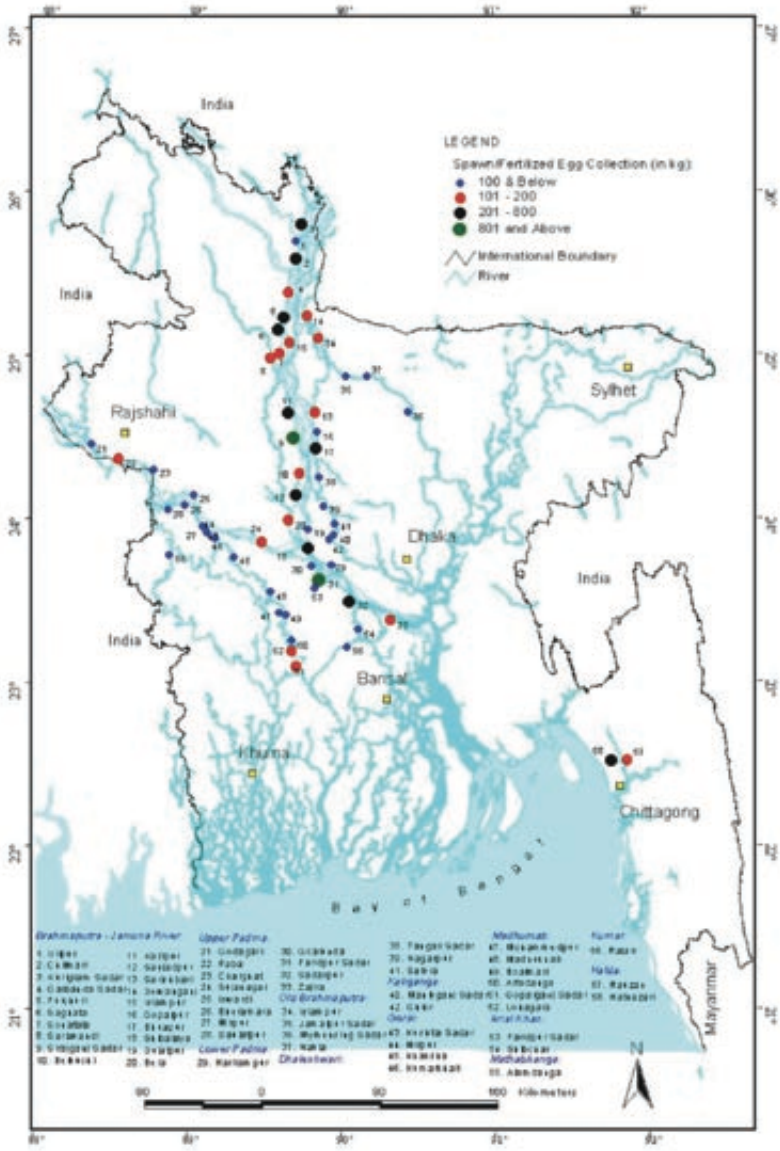
The collection of major carp spawn from rivers for sale to the aquaculture industry is an old practice in Bangladesh. Therefore, information related to places and time of carp spawn collection is well known. However, detailed information of all the spawn collecting sites in the country, with quantity and quality of spawn, and with relevant socioeconomic attributes is not well documented. The only reliable or usable source of carp spawn data in the country is the Fisheries Resource Survey System (FRSS) of the Department of Fisheries (DoF).

Spawn or fry collection has been the only source of initial support for the aquaculture or the culture fishery sector in Bangladesh until artificial spawning in hatcheries started in the early 1980s.

Fry collection sites

Of the various river systems from which the carp spawn is collected, three rivers and their tributaries are particularly important. These are Ganges-Padma (southwest), Brahmaputra-Januma (north central) and Halda (southeast) river systems. It is estimated that there are over 90 spawn collecting centers or points in the country's three major river systems (Figure 3). Of the various points for spawn collecting and sales, the location in Sirajgonj on the Jamuna River is one of the most important sites.

FIGURE 3
Carp spawn/fertilized egg collection centres in Bangladesh



Source: Fish Catch Statistices of Bangladesh, DoF.

In June 1994 approximately 5 million taka (US$73 000) worth of spawn was sold or distributed for every single mile of the river fished.

Species of carp by river systems

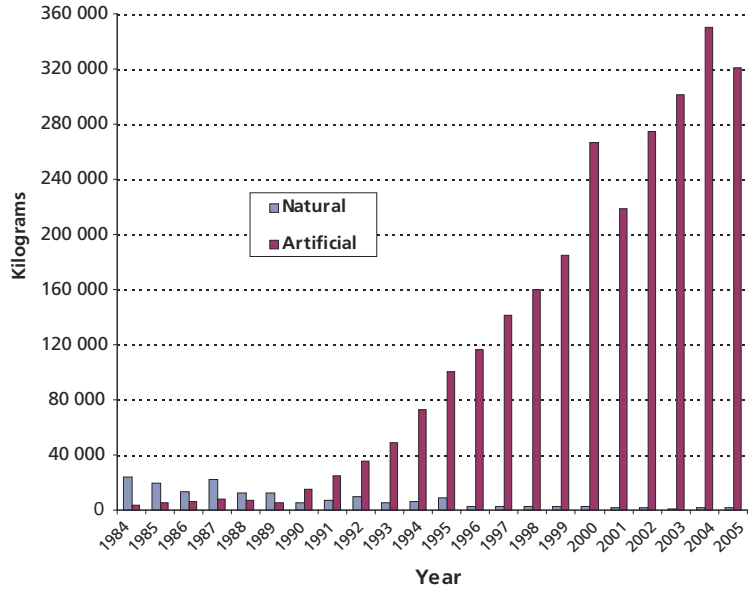
The major carp species in the collected spawn from the Halda River are catla (*C. catla*) (70%), the remainder being rui (*L. rohita*) and mrigel (*C. mrigala*), with catla being the fastest growing Indian major carp species. The demand for Halda spawn remains very high compared to spawn from other river sites. Tsai and Ali (1987) analysed species composition of fingerlings raised from Halda spawn stocked and found that catla comprised 81.8 percent, while rui was 9.5 percent and mrigel was 8.7 percent. The fry captured a month later had a different composition, with catla, rui and mrigel being 23.5, 32.8 and 43.2 percent, respectively. This suggests that major spawning of catla takes place earlier than other two species in the Halda River, although these three species started spawning on the same dates and in same spawning grounds. The Halda adult carp fishery is also dominated by the abundance of catla followed by rui and mrigel.

TABLE 3
Species composition of spawn (excluding Hilsa spawn) in the Lohajang River in 1994

Species	Percentage of total	Remarks
Labeo rohita	30.4	Major carp
Cirrhinus mrigala	2.9	Major carp
Catla catla	0.9	Major carp
Colisha lalius	5.8	Gourami
Glossogobius giuris	23.5	–
Rasbora daniconius	19.6	Small fish
Others	16.7	Unidentified fish

The spawn of other river systems (Ganges-Padma and Brhamaputra-Jamuna) is a mix of all species of major carps, including a small percentage of minor carps (*Labeo bata* and *Cirrhinus reba*). A study on the species composition of spawn of Brahmaputra-Jamuna stock collected from the Lohajong River (a secondary tributary of Jamuna River) found a mix of species, as shown in Table 3. Most of the spawn collected in the Lohajong River in 1994 was made of Hilsa shab (*Tenualosa ilisha*). One of the major carp species, the rui (*L. rohita*), dominated the remainder of the spawn and constituted 30.4 percent of the total catch and nearly 90 percent of the total major carp spawn. Mrigel and catla constituted a small quantity in the catch.

FIGURE 4
Decrease in natural catch and increase in artificial supply of Indian major carp spawn from 1984–2005



Trends in natural carp spawn collection

The quantity of spawn collected from river sources was previously much higher than at present (Figure 4). The average yearly catch has declined from 17 241 kilograms in the 1980s (mean of 6 years data), to 5 194 kilograms in the 1990s (mean of 10 years data), to only 2 255 kilograms in the 2000s (mean of 6 years data).

Degradation of natural breeding habitats

Flood Control Drainage and Irrigation (FCDI) projects have altered many important fish breeding and nursery areas in Bangladesh. The infrastructure built under FCDI projects, such as embankments, sluice gates and closures, not only reduced the wetland area but also blocked and/or obstructed the fish migration routes. As a result, migration for spawning, nursery and feeding areas has been seriously impacted, resulting in a decline in the carp fishery as a whole. The Farrakka barrage caused severe damage to the Upper Padma stock, hindering both adult migration to their breeding habitats and the subsequent drift of spawn downstream. This problem of free passage is further aggravated by the shortage of water in the dry season, leaving the fish vulnerable to fishing and natural causes. The stocks of mature wild fish have seriously declined, and this affects overall fish production, especially among major carp species that require 2 to 3 years to attain sexual maturity.

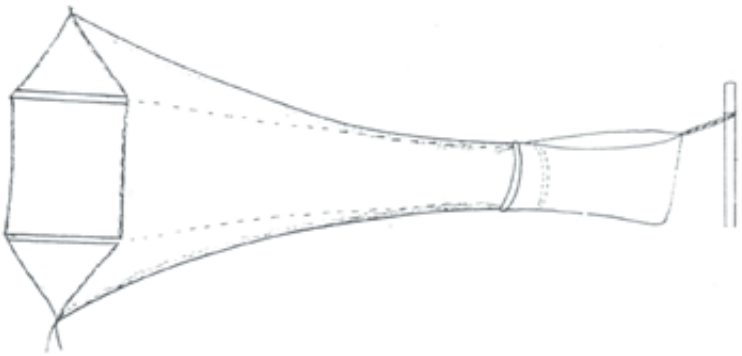
Destructive fishing practices, such as the increased use of fixed gears across rivers and canals during fish migration, the complete water drainage of the wetlands in the dry season, and the use of monofilament nylon gillnets have collectively impacted the capture fishery as a whole.

Fry sources

Over the last decade there has been a major shift in demand from wild-caught major carp spawn to hatchery-produced spawn. This has mainly been due to establishment of numerous private and government hatcheries and nurseries. The production capacity, especially that of the private facilities, has increased many fold, and their services and communications have also improved, thus providing a very attractive alternative to wild-caught spawn. Furthermore, by purchasing hatchery-raised fry, the customer is assured of getting the desired species, whereas with wild-caught spawn there is often the risk of getting spawn that includes several fish species. However, many hatchery operators use poor quality broodstock, producing inferior quality fry, thus creating a negative image among potential customers.

FIGURE 5
View of a river bank in Bangladesh with a number of savar nets

FIGURE 6
Sketch of a typical savar net used in major rivers in Bangladesh for major carp spawn fishing



Spawn fishing gears

The major carp spawn fishing gear that has traditionally been used in the two major river systems (Ganges-Padma and Bhrhamaputra-Jamuna) is a funnel shaped fixed net, popularly called a "savar net". This is a type of set bag net specially designed to fix the net at the shallow, gently sloping shoreline of the rivers, where the depth of water is negotiable without any aid.

The savar net is usually small, with a collection pocket at the tail end (Figures 5 and 6). The net is made of a fine mesh that traps tiny eggs or spawn that drift with the water flow during the monsoon months. A water flow in the range of 20–60 cm/sec. is desirable for spawn trapping (Kumar, 1992). The accumulated spawn are collected and held in water for sale and transportation. These nets are locally made and easily available, costing approximately US$10 each.

Natural fish spawn collection method

The savar spawn collection nets are placed in several rows near the shore, facing the current, at intervals of 2–8 m, and each row may have between 3–15 nets. The front extensions of the adjacent nets are tied together to the same bamboo pole, the poles having been set in the river at the beginning of the fishing season to mark the area of each savar site. The upper edge of the tail bag is kept about 4–5 cm above the water surface to prevent the escape of spawn.

When the river water rises to a level favorable for spawn collection, a few test nets are set. As soon as the desired spawns are spotted in the test nets, all the nets are set rapidly in the river, and spawn collection begins in earnest. A collector walks from

one net to another at regular intervals to scoop up spawn from the tail bag and place it in an earthen or aluminum pot known as *patil* or *handi* (Figure 7). The spawn are subsequently sieved through a screen box and kept in *hapas* nets fixed near the spawn collecting sites to await sale.

FIGURE 7
A – Fixing a savar net at the shoreline of a river;
B – A group of savar nets;
C – Collection of spawn from a savar tail end;
D – The collected spawn is frequently checked;
E – Spawn waiting in *hapas* for sale or transport to nurseries

Boats

Locally made boats of various sizes and shapes, mechanized and non-mechanized, are used for spawn collecting and transport. The most commonly used boat is small and normally carries 1–2 fishers while larger mechanized boats may carry up to 3 fishers and are usually preferred as the collected spawn can be transported quickly to the sale sites.

FIGURE 8
Two fishers carrying carp fry in metal pots

Handling and transportation of spawn

Usually a spawn collector operates more than one net, depending on the suitability of the sites and extent of spawn availability. Depending on silt load, water depth and spawn pulses, the operators remove, clean and reattach the nets as needed. During strong spawn pulses the spawn is scooped from the net traps every 15 to 30 minutes. The collected spawn is then transferred to aluminum or clay containers partly filled with water (Figure 8). The spawn is then sieved through mosquito netting, to separate major carp spawn from debris and larger fish. The spawn is then conditioned in either *hapas* or in small earthen ponds before transportation.

The spawn collected from rivers is generally a mixture of spawn of major carps, minor carps, and other fishes. The operators often try to segregate the major carp spawn from the spawn and fry of other fishes either before or after conditioning.

FEEDING OF CARP SPAWN

Nursery rearing of fish seed generally has two distinct phases: (i) rearing of post-larvae to fry and (ii) rearing of fry to fingerling. In the earlier developmental stage the fry are dependent on natural live food from the pond itself, which can be enhanced through pond fertilization (mustard oil cake) and manuring (caw dung). As the post-larvae develop, their diet changes from microorganisms such as protozoa, to larger prey items such as rotifers. At the post-larvae stage, due to their feeding habit and mouth size, the fish will not take any artificial feed even if it is supplied. Nursery operators in Bangladesh do not normally use wild-caught food. Instead, they produce live food in the nursery ponds and, as the fry grow bigger, they start supplying supplementary feed. A typical feeding schedule for carp post larvae/fry is given in Table 4.

Once the fry are released into the nursery ponds, both hatchery-produced seed and wild seed receive the same treatment described above. Within 3–5 days the natural food produced in the nursery pond is usually consumed and supplementary feeding is needed. The feed is usually prepared at the farm, with attention being given to maintaining a good nutritional balance, and sometimes the food is fortified with vitamins and minerals. Wheat or molasses are sometimes used as binders. Seed growers use only mustard oil cake mixed in water and the solution is sprayed over the water. Subsequently rice bran is mixed with mustard oil cake at a ratio of 1:1. At the fingerling stage, oil cake, rice bran or wheat bran is used, along with other protein sources like fishmeal

TABLE 4
Feeding schedule of carp post larvae/fry for the first 50 days after stocking

Days after stocking	Feed per day
1–5	2 x weight of stocked biomass
6–10	3 x weight of stocked biomass
11–15	4 x weight of stocked biomass
16–25	40–45 g/decimal[1]/day
26–35	80–100 g/decimal/day
36–50	200 g/decimal/day

[1] 100 decimals = 1 acre; 2.46 acres = 1 hectare.

or blood from cattle. At this stage the feed is normally granular or in pellets. In carp nurseries the feed is normally applied at around 10 a.m. If feed is applied twice a day, the second feeding is in mid-afternoon, with equal amounts given at each feeding. Some carp nursery farmers use artificial feeds for catfish and shrimp in order to achieve faster growth.

AQUACULTURE DEPENDENCE ON THE WILD FISH SEED

Over the last 15 years there has been a marked decrease in dependence on wild seed of major carp for aquaculture due to increasing capacity for producing spawn at private and government hatcheries in Bangladesh (see Figure 4). In 1965, induced spawning of major carps was first successfully demonstrated at the Freshwater Fisheries Research Center (FFRC) and in the early 1980s commercial hatchery production of carp fry was initiated at the FFRC. Since then, a rapid proliferation of hatchery spawn production has occurred in both the public and private sectors.

The Fish Seed Multiplication Farms (FSMFs) of the DoF (Department of Fisheries), and some fisheries research and training centers of the DoF, also established large hatcheries in the 1980s and started mass production of major carp spawn, and that of various exotic carps. The successful operations of the government hatcheries created a large market for the induced spawn, and a growing demand for hatchery-produced spawn. The availability of quality spawn for selected species positively impacted the rapid expansion of pond aquaculture all over the country.

However, the growth of the aquaculture industry was so rapid that the government hatcheries could not meet demand, and space was created for the growth of private sector hatcheries. Private entrepreneurs developed innovations in hatchery systems, in their design (e.g. circular, funnel or bottle-type incubators), as well as in the techniques for broodstock and nursery rearing. The BFRSS data shows that in 1985 there were only 69 private hatcheries that collectively produced 3 952 kilograms of carp spawn with an average production of 57 kilograms per hatchery. By 2005, the number of private hatcheries had increased to 731 (Table 5) and they produced 315 892 kilograms of carp spawn, which comprised over 98 percent of the total annual carp spawn production of Bangladesh.

ADVERSE IMPACT OF SAVAR FISHING

The adverse impacts of savar fishing for carp spawn have been summarized as:

- Reducing the natural recruitment potential of carp (also to some extent, that of other species) and thereby gradually diminishing the natural stock.
- Reducing the shallow nursery and rearing areas in the river basin due to operation of savar fishing, thus negatively impacting natural productivity.
- Reducing the natural gene pool due to indiscriminate savar fishing.
- Affecting the natural productivity of carps in the wild due to mishandling of spawn fishery operations by inexperienced net operators, which may cause mass mortality of spawn.
- Negatively affecting overall capture fisheries production in the wild as a result of thousands of spawn of other fishes being damaged during the process of catching major carp spawn.

RECOMMENDATIONS

- Identify all the major carp natural breeding grounds both inside and outside Bangladesh through scientific investigations, and delineate them for future protection and enhancement of habitats.
- Obtain data on each natural major carp spawn collection center, investigate and update and map their biophysical and socioeconomic attributes (for example where they harvest and when, types and numbers of nets, quantity and quality

TABLE 5
Growth in number and productivity of private and government hatcheries, 1985–2005

	Private hatcheries					Government hatcheries				
Year	No. of hatcheries	Spawn production (kg)	Average spawn production kg/ hatchery	Growth in spawn production since 1985 (%)	Growth in the number of hatcheries since 1985 (%)	No. of hatcheries	Spawn production (kg)	Average spawn production kg/hatchery	Growth in spawn production since 1985 (%)	Growth in the number of hatcheries since 1985 (%)
1985	69	3 952	57			78	1 010	13		
1986	117	4 911	42	24	70	80	1 376	17	36	3
1987	214	6 880	32	74	210	82	1 459	18	44	5
1988	162	5 697	35	44	135	82	1 152	14	14	5
1989	526	4 315	8	9	662	84	1 348	16	33	8
1990	204	13 014	64	229	196	89	1 758	20	74	14
1991	218	22 171	102	461	216	89	2 512	28	149	14
1992	222	33 070	149	737	222	85	2 781	33	175	9
1993	256	45 701	179	1 056	271	102	3 263	32	223	31
1994	439	69 356	158	1 655	536	102	3 180	31	215	31
1995	533	97 205	182	2 360	672	102	3 272	32	224	31
1996	616	112 596	183	2 749	793	102	3 616	35	258	31
1997	473	137 042	290	3 368	586	101	3 888	38	285	29
1998	613	162 781	266	4 019	788	103	4 014	39	297	32
1999	591	180 551	306	4 469	757	112	4 112	37	307	44
2000	629	262 859	418	6 551	812	112	3 994	36	295	44
2001	667	214 682	322	5 332	867	112	3 663	33	263	44
2002	671	271 277	404	6 764	872	112	3 229	29	220	44
2003	696	297 781	428	7 435	909	112	3 902	35	286	44
2004	756	345 227	457	8 636	996	112	4 802	43	375	44
2005	731	315 892	432	7 893	959	112	5 128	46	408	44
Total		**2 606 960**					**63 459**			

of spawn caught, how many people are engaged, who they are, what do they do, income and expenditure in spawn fishing, marketing and transportation).
- Undertake research to improve the spawn collection systems and techniques to reduce anthropogenic (human-induced) mortality and improve rearing and transportation systems.
- Identify the current barriers and constraints to the carp spawn fishery in the wild, especially regarding overwintering and migration of broodstock, morphological aspects of habitats (especially in the Halda River) in the context of water control structures, and suggest measures to overcome these barriers.
- Conduct socioeconomic studies of the people engaged in major spawn fishing in the wild and suggest alternative livelihood options to reduce pressure on this fragile and sensitive major carp spawn fishery.
- Ensure that existing sluice gates/water control regulators are operated in a manner that would facilitate fish and larval migration from rivers to floodplains and vice versa.
- Establish closed areas and seasons to allow major carp broods to migrate to their spawning grounds and spawn successfully.
- Declare and delineate carp sanctuaries in the wild, as has been established in the for the *hilsa* (river Shad) fishery in the Meghna River and its tributaries.
- Reduce and restrict the dependence of aquaculture on wild spawn through the improvement of hatchery production systems.
- Reexamine and update fisheries rules relating to spawn fishing from the wild, in order to facilitate natural replenishment of wild stock of fish including major carps.

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