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A Review on Status, Potentials, Threats and Challenges of the Fish Biodiversity of West Bengal

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Abstract

Explorations and germplasm inventories of fish biodiversity in the aquatic water bodies of India are being progressively updated and analysed with several new discoveries however; a well-defined number of existing fish species at regional/state level remains to be determined. Of the total freshwater fish diversity of the country, imperilment ranges from 10-13% indicates widespread and pervasive degradation of aquatic freshwater fish habitats. The State of West Bengal is endowed with 7.5% of the water resource of the country and that is becoming increasingly scarce with the uncontrolled growth of population, expansion of irrigation network and developmental needs. Concern over declining harvests and an obvious reduction in biodiversity of fish species has led to a more holistic approach to fisheries management and research. The state is endowed with vast aquatic resources in the form of rivers, ponds/tanks, reservoir, beel and boar, brackish water fishery and also predominated by several wetlands. Perusal of literature reveals that several scattered information on fish biodiversity of West Bengal is available. In the present review, altogether, 190 native freshwater fish species were recorded from the West Bengal contributing nearly 23% of the Indian freshwater fishes. The presented review highlighted a concise review of Indian fish biodiversity, analyse the threats, challenges, conservation programmes and offer hope for the future of the nation's imperilled freshwater fish sustainability of the West Bengal. Conserving the biodiversity of these fishes and at the same time managing their exploitation in a sustainable way is a difficult exercise. The diverse assemblages of freshwater species of the state should be targeted by all who have a stake in our freshwater heritage. This paper highlights the pattern of freshwater fish biodiversity in many perspectives, utilization, threats and discusses the management strategies to be implemented for the conservation of freshwater fish diversity in the state.

Keywords: Fish biodiversity; Utilization; Resources; Threats; Conservation; West Bengal

Introduction

Fishes are the most diverse group of vertebrates, with 32,447 species [1]. Knowledge of the fish fauna of tropical Asia is still in its exploratory phase particularly in India where survey work is incomplete [2]. Fish Base has now grown into a huge on-line encyclopaedia with information on 32,447 fish species and serves as an important tool for scientists [1].

In India, the National Bureau of Fish Genetic Resources (NBFGR) has developed a strong database on fish genetic resources of the country. West Bengal is on the eastern bottleneck of India, stretching from the Himalayas in the north to the Bay of Bengal in the south. The state has a total area of 88,752 square kilometres (34,267 sq. m). The Ganga-Padma river artery divides the states in two parts, North and South Bengal. West Bengal's climate varies from tropical savannah in the southern portions to humid subtropical in the north.

West Bengal has been able to secure the leading position in fish production for seven successive years and has been rewarded accordingly by the Central Government as best productivity award. The aim of the study was: to review the past and current pattern of freshwater fish biodiversity, review the threats to fish diversity and to make recommendations for fish biodiversity conservation and management. This paper also discusses the management strategies to be implemented for the conservation of freshwater fish diversity in the state through conservation of habitat and conservation of fish stocks.

Review of Literature

In West Bengal the total production of inland fish was 15.30 lakh ton and marine fish was 2 lakh ton. Total Inland production of fish is varies time to time with increasing and declining order which is showed in Figure 1. Comparison of fish production of West Bengal (WB) with respect of Bihar, Utter Pradesh (UP) and India are enlisted in Figure 2.

Different authors recorded different numbers of species from different drainages of West Bengal. 46 species belonging to 7 orders, 18 families and 26 genera are recorded from Damodar River, Burdwan district [3]. It is documented that W. B. having 45 species under 29 genera, 18 families and 8 orders during 1990-1995 [4]. It has been also recorded 70 indigenous ornamental fish species belonging to 45 genera, 30 families and 9 orders [5]. 39 local endangered fishes is recorded from the state [6]. 171 species also recorded [7]. A total of 155 fish species belonging to 49 families and 15 orders were recorded from the tidal freshwater zone of the Hooghly estuary [8]. 218 species of fish are listed from whole Himalayas [9]. 65 species of fishes are recorded from the River Teesta [10]. 21 species [11] and 125 species [12] were mentioned from Darjeeling Himalayan upland. A total of 176 indigenous ornamental fishes are reported belonging to 98 genera under 41 families and 10 orders [13]. A total of 67 species of finfish

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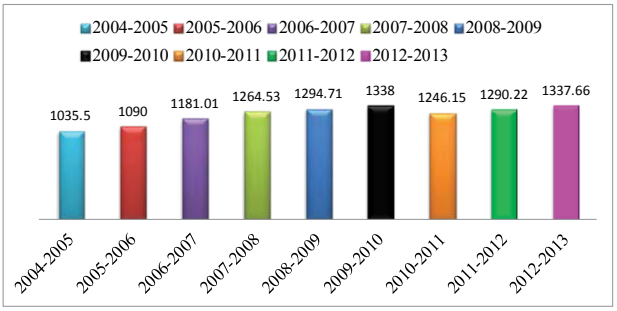

Figure 1: Inland fish production in West Bengal [54].

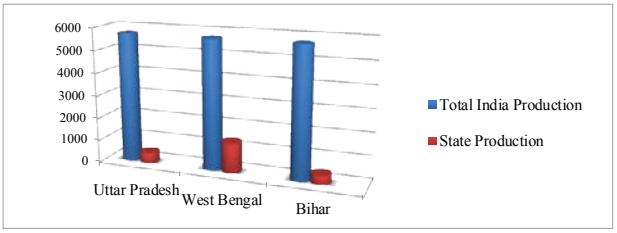

Figure 2: Comparison of fish production of West Bengal with respect of Bihar, UP and India.

were recorded from Sundarbans [14]. A list of 250 fishes [15], 172 species [16] and 207 species [17] are recorder from Sundarban. Figure 3 indicated fish diversity on order and family wise.

District-wise Freshwater Area

There is only one district namely Murshidabad which consists of more than 20,000 ha area under river. Rest of the districts has less than 20,000 ha area under river. With respect to Beels, there are only two districts namely North 24-Pargana (8861.19 ha) and South 24-Pargana (5749.47 ha) which have more than 5000 ha of Beels under their control. More than 3000 ha Beels are contained in 7 districts. Out of these seven districts, namely Malda (4551.55 ha), Nadia (4271.61 ha) and Hooghly (3884.76 ha) have large area of Beels under their administrative control for the development of the fisheries.

Marine and Brackishwater Area

In the state of West Bengal, only three districts contain brackishwater area. These are North 24 Pargana (35371.26 ha), South 24 Pargana (17759.00 ha) and Purba Midnapur (5227.00 ha). Total coast line of West Bengal is 158 km. The inshore and offshore areas of Bay of Bengal in the Purba Midnapore districts are respectively 777 Sq. km. and 1813 Sq. km. The Continental shelf area is 17049 Sq. km. The total inland water resources are enlisted at Table 1 and 3. The total fishery resource of West Bengal is enlisted at Table 2.

Drainage of River Basin

Ganges enters West Bengal near Rajmahal and then flows in a south-eastern direction and divides into two near north of Dhulian in Murshidabad. One branch enters Bangladesh as the Padma, while the other flows through West Bengal as the Bhagirathi River and Hooghly River in a southern direction and reach to Bay of Bengal (Figures 4 and 5). The Mayurakshi, Ajay, Damodar, Kangsabati, Rupnarayan and their tributaries which rise in the Western plateau and high lands flow eastwards through the different districts of West Bengal and joins the Bhagirathi on the right bank. The Dwarakeswar and Shilabati rivers join to form Rupnarayan. Kangsabati and Keleghai rivers join to form the Haldi. The Rupnarayan and Haldi fall into the Bhagirathi. The Subarnarekha River after flowing for a short distance in West Bengal renters into Orissa. The distributaries of the Padma River like Bhairab, Jalangi, Mathabhanga River and their tributaries enters West Bengal and joins the Bhagirathi on its left bank. The Mathabhanga divides into branches namely; Churni and Ichhamati, while the Churni meets the Bhagirathi while the other flows southwards and joins the Kalindi.

The major rivers of Sundarbans are Hoogly, Matla, Gosaba, Saptamukhi, Haribhanga, Piyali, Thakuran/Jamira, Raimangal, Kalindi and Ichhamati. The Teesta flow cutting deep gorges from north to south in the mountainous Darjeeling district; it enters the plains at Sevoke and flows in a mighty stream on straight line towards the south east until it pours its waters into the Brahamaputra in Bangladesh. Torsa, Jaldhaka, Kaljani, Raidak, Sankosh and Mahananda rivers are in the northern hilly region which rise in the Himalayas and flow in a southernly direction through the districts of Darjeeling, Jalpaiguri, Cooch Behar and North and South Dinajpur and enters Bangladesh. The Mahananda rises from the Dow Hills forest, near the town of Darjeeling and are fed by similar small rivers like, Mahanadi, Balason, and Machi and runs in a zig-zag way through the district of Malda and joins the Padma in Bangladesh. In the central region, the main river is the Mahananda. The Tangon and Punarbhabha, and Atrai arises in the plains, while the former two joins together and flows into Mahanadi, Atrai flows into the Padma.

Major Rivers and Biodiversity

It is reported the Gangetic system alone accounting 143 species of fish contributes about 20% of freshwater fish of the total fishes reported in India [18]. 126 species have been recorded from Brahmaputra followed by Mahanadi 99, Cauvery 80, Narmada 95 and Tapti 57 [19-21]. The high species richness of river Ganga has reported on several occasions [22-25]. Some of the major tributaries of river Ganges basin in viz. Gomti, Ghaghara, Betwa, Ramganga, Ken and Gerua rivers also harbours the rich species spectrum of threatened, migratory and commercially important fishes with a wide distribution of species, families and genera [26-30]. Studies on the fish fauna of the Ganga and its tributaries have been made by various authors and information was published on the systematic, bio-geographical and ecological aspects [31-36].

Studies revealed that changes in climate and hydrology of the of Ganges basin is now become a serious concern [18,27]. A number of fish species which were never reported in the upper stretch of the river and available in the lower and middle stretches in the 1950s [37] were reported distributed from the upper cold-water region [18]. Recently,

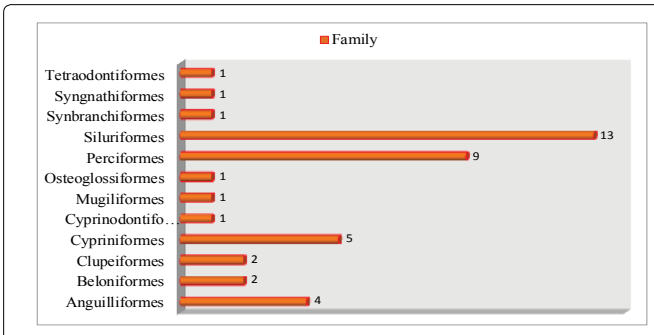

Figure 3: Fish diversity on order and family wise (modified after from Zoological Survey of India (2012).

Resources	Area (lakh Ha)	Under Culture (In Lakh Ha)	% of Resource Area Under Culture
Open water systems:			
Rivers	1.64	-	-
Canals	0.80	-	-
Reservoirs	0.28	0.13	48.15
Estuarine	1.50	-	-
Enclosed water bodies			
Tanks & ponds	2.88	2.61	90.62
Flood plain lakes/ derelict waters	0.42	-	-
Beel & Boar	0.42	0.21	50.00
Sewage fed fishery	0.04	0.04	100.00
Brackish water fishery	0.60	0.59	98.33

Table 1: Inland water resources of West Bengal [50].

Indigenous fresh water fishes	190
Indigenous brackish water fishes	28
Indigenous fresh water ornamental fishes	176

Table 2: Total fish diversity of West Bengal (Modified after ZSI, 2012).

an eel-loach *Pangio pangia* Hamilton, which was once described in 1822 from East India in the River Ganges have been re-described by NBFGR from in the middle Ganga in Uttar Pradesh [38]. River wise comparative study of available species with respect of total species indicated in Figure 6.

Fish diversity in Ganga Basin

The Ganga River Basin covers over 1,080,000 km^2 (416,990 sq. mi) in India and ranks among the largest in the world in drainage basin area and length. The Ganga and its major tributaries, the Yamuna, Ram Ganga, and Ghaghara are the only Himalayan Rivers that have significant base and flood flows. The river is home for more than 140 fish species, of which many are commercially important, are listed in Table 4. Figure 7 indicates the fish diversity of West Bengal with respect of Bihar, Uttar Pradesh and India.

Diversity of Special Significant Area

Sundarbans is the largest protruding delta on this planet covering about one million ha in the delta of the rivers Ganga, Brahmaputra and Meghna is shared between Bangladesh (~60%) and India (~40%). The Indian Sundarbans (Latitude 21° 32'-22°40'N, Longitude 88° 22'-89°0'E) in the north east coast of India occupy 9630 square kilometre and are bounded by River Hooghly in the West, River Raimangal in the East, Bay of Bengal in the South and Dampier Hodges line in the North. The group of islands is interspersed by innumerable rivers, creeks, etc. which makes most of the area inaccessible and rest is reserved forest, falling under the Sundarbans Biosphere – a world heritage site. The whole area of the Sundarbans encompasses about 0.6 million hectares of which 0.4 million hectares are forest areas and the remaining part includes water bodies. About 15-20% of the total fish requirement of Kolkata market is being supplied from Sundarbans. A total of 172 species of fishes, 20 species of prawn and 44 species of crabs including two edible crabs have reported [15].

The East Kolkata Wetlands (EKW) (22°27' N and 88°27' E), are a complex of natural and human-made wetlands lying east of the city of Kolkata. The wetlands cover 125 km^2, and include salt marshes and salt meadows, sewage farms and settling ponds. In August 2002, 12,500 hectares of the EKW area was included in the 'Ramsar List' making it a 'wetland of International Importance'. The wetlands are used to treat Kolkata's sewage, and the nutrients contained in the waste water sustain fish farms and agriculture. It comprises 254 sewage fed fisheries, small agricultural plots and solid waste farms. Development of vegetation based microenterprise (150 units), ornamental fish culture (300 units) and fish cum duck rearing (300 units) for livelihood diversification of EKW communities. The commercially important aquatic species in the EKW includes 50 species of fish, 11 species of prawns, 3 species of crabs and 20 species of molluscs. Among the 50 species 17 are cultured and 33 are wild species [39]. 13,000 tonnes of fish are produced annually in ponds managed for wastewater aquaculture.

Endemic species and New Species

During the last decade many fish species from the biodiversity hotspot area like North East and Western Ghat region have emerged new species. Britz discovered a new species Channa andrao from Jalpaiguri, West Bengal [40].

Endemic species

Noemacheilus devdevi (Hora, 1935). Mainly found at all stream below Darjeeling. The fish is IUCN listed nearly threatened species.

Figure 4: River drainage in West Bengal.

Resource Type	Length / Area
Rivers & Tributaries (km.)	45,000
Canals (km.)	126,334
Total	171,334
Reservoirs (ha)	3,153,366
Ponds & Tanks (ha)	2,355,300
Flood Plain Wetlands (ha)	202,000
Derelict Water (ha)	868,000
Total	6,578,666

Table 3: Freshwater Resources of India [18,19,21,27].

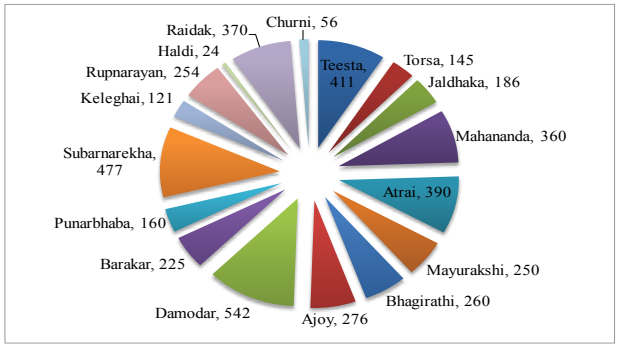

Figure 5: Length (Km) of some important rivers of West Bengal.

Noemacheilus multifascialus (Day, 1878). Mainly found at Darjeeling.

Balitora brucei (Gray, 1830). Commonly known as Gray's Stone Loach. The fish is IUCN listed nearly threatened species.

Puntius dukai (Day, 1878). Mainly found in North Bengal.

State fish

Tenualosa ilisha is the state fish of west Bengal. The fish is commonly known at West Bengal as Ilish in Bengali. The fish is marine; freshwater; brackish; pelagic-neritic; anadromous in nature. Within a tropical range; 34°N-5°N, 42°E-97°E in marine and freshwater. It can grow up to 60 cm in length with weights of up to 3 kg. The fish schools in coastal waters and ascends up the rivers for around 50-100 km to spawn during June to September and also in January to March.

Figure 8 indicate that the Hilsa production declining year to year due to the over exploitation of juveniles and brooders are the main threats of Ilisha. If any population is affected by the 'recruitment overfishing', the population might be seriously hampered to attain the sustainable yield in the long run, so the fishing regulation must be strong for Hilsa to make this species sustain for a long time in future. Towards conservation of this high value fish the Department of Fisheries; West Bengal established the country's first ever dedicated Hilsa Conservation and Research centre (HCRC) at Diamond Harbour, South 24 Parganas [41].

Coldwater Species

Darjeeling Himalaya region has a pronounced seasonal climate and lies north of the tropical belt (The district lies between 27°13'05" and 26°17'10" North latitudes and between 88°53'00" and 87°59'30" East longitudes). Being the integral part of the eastern Himalaya the region is regarded as freshwater biodiversity hotspot. The important contributors on North Bengal fresh water fish fauna are 21 species [11] and 125 species [12] were mentioned from Darjeeling Himalayan upland. Cold water fish species from 39 genera and 10 families with ornamental, food and sport value of which 11 species were ubiquitously found. Fishes of family Cyprinidae were found to be dominant followed by Sisoridae and Balitoridae. Most of the fish species were found very rare in the river, which may be due to various anthropogenic factors. Maximum number of species (30) recorded were of family Cyprinidae. Similar greatest diversity in Cypriniformes and Siluriformes in the freshwater habitats were reported from other parts of Himalaya.

Introduced and Transplanted Species

Exotic species have made socio-economic benefits to each country. The exotic species have played significant roles in ensuring food security and crop diversification for rural poor. In culture system about 19/20 species of food fish has been used. Some of these exotic fish has been legally introduced and some are un-authorised introduction. Silver carp, Common carp, Grass carp, Tilapia are common and valuable exotic food fish which play an important role in state fishery. The demand of exotic ornamental fishes is increasing remarkably due to their important role in the world trade for fish and fishery production. About 288 exotic varieties of ornamental fishes are popular in West Bengal among these 27 species are liver bearer and 261 species are egg layerer [42]. Many exotic ornamental fishes are also commercially cultured in different farms. The exotic ornamental fishes are one of the major export materials. Except of fresh water exotic fishes, many marine ornamental fishes are also played very important role in West Bengal fishery. *Gambusia affinis patruelis* and *Poecilia reticulata* fishes are larvae eater and known as Mosquito fish. So, it is also commercially cultured in West Bengal to control the mosquito. The fishes which are introduced from different state of same country are known as transplanted species. *Osteobrama belangeri* is the important transplanted species from Manipur.

Threatened Species

The IUCN Red List of Threatened Species is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. The introduction in 1994 of a scientifically rigorous approach to determine risks of extinction that is applicable to all species, has become a world standard. There are a number of species in threatened and endangered condition. Without proper attention those fishes may be extinct from the environment. The Critically Endangered species are: *Erethestis montana montana, Ompok bimaculatus, Pangasius pangasius*. In West Bengal required data of many fishes still unavailable for IUCN Red list evaluation. So there is a need of proper study on those fishes. The IUCN Red listed endangered species are enlisted in Table 5. Comparison of threatened, vulnerable and endangered fishes are described in Figure 9.

Potential Marine Species

West Bengal has a short coastline - only about 64 km, spread along the southern edge of its two maritime districts, South 24 Parganas and Midnapore. This represents approximately one per cent of India's coastline. The marine resource base comprises 780 km^2 of inshore area (upto 20 m depth), 1815 km^2 (between 20 m and 80 m depth) and a continental shelf of 17,049 km^2 (upto 200 m depth). Brackish water areas in the deltaic region encompass a territory of 200,000 ha. The Rv Dr Fridtj of Nansen survey (1979-1980) in the upper Bay of Bengal (the area adjacent to Swatch of No Ground, Bangladesh) and exploratory fishing by the Fishery Survey of India off northern Orissa found significant quantities of demersals, such as croaker, catfish, threadfin

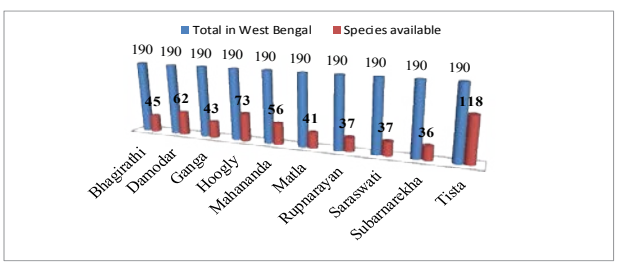

Figure 6: River wise comparative study of available species with respect of total species (Source: ZSI with own compilation).

Stretches	Available fishes
Upper Stretch (Tehri – Kanauj)	34
Middle Stretch (Kanpur – Patna)	47
Lower Stretch (Sultanpur – Katwah)	63
Estuary (Gradient zone, Nabadwip – Haldia)	56
Estuary (Marine zone, Kakdwip – Frazergunj)	45

Table 4: The list of commercially important species described in various stretches is given in the following table [51].

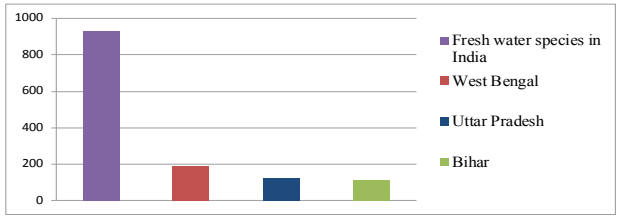

Figure 7: Comparison of fish diversity of West Bengal with respect of Bihar, Uttar Pradesh and India.

breams, bulls eye, ribbonfish, shark and skate, and pelagics, such as Indian mackerel, scads, sardine-like fish and anchovy, in the 50-100 m depth range. Near about 403 species of marine fishes are available in the state according to ZSI. Potential also exists for exploitation of tuna and pelagic shark in the pelagic zone beyond the continental shelf and deep sea lobster, shrimp, snake mackerel, bulls eye, threadfin, catfish and other small deep-water fin fish species are available in significant quantities in the 200-300 m deep sea bottom. Of all the maritime states, West Bengal has the largest brackish water culture potential. It has been estimated that there is about 200,000 ha of water area, out of which 85,000 ha has been found suitable for culture. At present, about 35,000 ha. has been brought under cultivation, an utilization of about 40%. This also represents 75% of the total area cultivated in the whole of India. South 24 Parganas accounts for 83% of water area brought under culture in the private sector. This area is almost exclusively used for paddy-cum-fish culture. At present, the average production is reported to be 800 kg/ha/annum -200 kg of prawn and 600 kg of mullet. The production of cultured prawn has increased from 3600 t in 1980 to 6800 t in 1987. It is reported that about 900 million seeds of *Penaeus monodon* are collected annually by about 40,000 persons, including women and children. There is, however, a need to establish prawn hatcheries to meet the requirements for semi-intensive culture of another 30,000 ha.

Shellfishes

In West Bengal there are a wide range of shellfishes have been found which comprises different groups such as, Crustaceans (Shrimp, Prawn, Lobster, Crayfish and Crab), Molluscs (Clam, Mussel, Oyster and Scallop) and others (Octopus, Snailsand Sea-urchins etc.). According to ZSI approx. 64 fresh water and low saline water molluscs are present in the state. There are also 94 estuarine and marine water molluscs belonging to 65 genera and 42 families are observed in the state. 251 crustaceans species are also available in this state. Family Ariophantidae and Cyclophoridae show highest molluscs diversity in fresh water and family Neritidae has highest number of genera in marine water. Highest number of fresh water molluscs reported from Darjeeling and South 24 Parganas is richest in respect of marine molluscs.

Utilisation of Biodiversity

In West Bengal 174 indigenous fishes are used as food fish and there are also few exotic species which are used as food fish. It is estimated that freshwater fishes make up more than 6% of the world's annual animal protein supplies for humans [43]. Fish provides a good and cheapest source of high quality protein and contains many vitamins and minerals. It represents a unique source of long chain PUFA, EPA, DHA which are essential for human health. It may be classed as either whitefish, oily or shellfish. Whitefish, such as haddock and seer, contain very little fat (usually less than 1%) whereas oily fish, such as sardines, contain between 10-25%. The latter, as a result of its high fat content, contain a range of fat-soluble vitamins (A, D, E and K) and essential fatty acids, all of which are vital for the healthy functioning of the body. Fishes are sensitive to many stresses from parasites to diseases to acidification. Further, due to such factors as rapid growth rates, large body sizes, habitat choice, and trophic level, many fish have the capacity to bioaccumulate toxic substances [44]. Scientists have been able to extract antifreeze proteins form pond smelts (Hypomesusnipponensis) that can be used to protect the internal structure of products containing water (hydrated substances e.g. meat, vegetables, processed foods, blood, cells, tissues and organs). Fish are used in management to mitigate vector borne diseases like schistosomiasis and malaria. Due to bioaccumulation, predatory species have also been used as sentinels for the presence of toxic chemicals in waterways [44]. It is said that the facility that does not house at least one colony of zebra fish, medaka, or other fish species is probably not at the forefront of biomedical research [45]. Therapeutic value of fish is listed in Table 6.

Total 14 cultured species have been adopted and presently available throughout the state among which Indian major carp; *Clarias batrachus, Anabas testudineus, Labeo bata* are the main cultured species. Apart from these *Pangasius pangasius, Ompok pabda, Channa striata, Channa marulius, Notopterus chitala, Mugil cephalus, Lates calcarifer, Amblypharyngodon mola* are very much popular in fish culture farm and fetches high marlet value. Many exotic fishes are also very popularly cultured in the state. In Figure 10 the amount of cultured, ornamental, food and medicinal fishes are described.

Export potentiality of Fishes

This state has been considered as a pioneer state in respect to ornamental fish trade and Kolkata is the main place associated with this business a major portion of the India's ornamental fish trade (85%) is contributed by West Bengal. However, 90% of the export is based on natural wild collection. Out of the 140 potential native ornamental species available in different water bodies of the region, presently about 73 species are included in the export list and are gradually becoming popular among the local hobbyists. "Galiff Street Market" in Hatibagan at Kolkata is the largest wholesale ornamental fish market of Eastern and North-Eastern India [42]. Among these 73 collected exported species, 30 species were under Classified Aquarium Fish Category (kept in aquarium throughout their life span) *Amblypharyngodon mola, Esomus danricus, Puntius sophore, Badis badis* etc. and rest 43 species were under Non Classified Aquarium Fish category (kept in aquarium only during juvenile) like *Scatophagus argus, Anabus testudineus, Chitala chitala* etc. The FOB price offered by the exporter for native ornamental fish is significantly high and varies from about 0.06 US$ to 4.825 US$ [46]. The profit percentage of different stakeholders in ornamental fish trade from the state is described in Figure 11.

In West Bengal, there is a good scope and a bright prospect in ornamental fish trade and can also contribute a lion's share in Indian fish export.

IUCN Status	No. of Species
Critically Endangered	03
Endangered	14
Vulnerable	26
Low Risk-near threatened	44

Table 5: The IUCN Red listed endangered species are enlisted below.

Sl. No.	Name of the fish	Uses
1	*Amblypharyngodon mola*	Source of Vitamin A, micro nutrients and minerals
2	Crabs, Prawns, Shrimps and Mussels	Souse of Zinc, Calcium, Iron
3	Trout	Source of EPA and DHA
4	Catfish	Source of EPA and DHA
5	*Tenualosa ilisha*	Source of omega 3 fatty acid
6	*Esomus danricus*	Source of Vitamin A, micro nutrients and minerals
7	*Coricasoborna*	Source of Vitamin A, micro nutrients and minerals
8	Molluscs	Source of Vitamin A, B and D
9	*Channa straitus*	Anti-inflammatory and analgesic property
10	*Clarias batrachus*	Cure infections and reduce pain
11	*Heteropneustes fossilis*	Cure infections and reduce pain
12	*Anabas testudineus*	Cure infections and reduce pain
13	*Monopterus cuchia*	Folklore medicine
14	*Tor puttitora*	Folklore medicine
15	*Channa punctatus*	Folklore medicine
16	*Labeo rohita*	Folklore medicine

Table 6: Therapeutic value of fish [52,53].

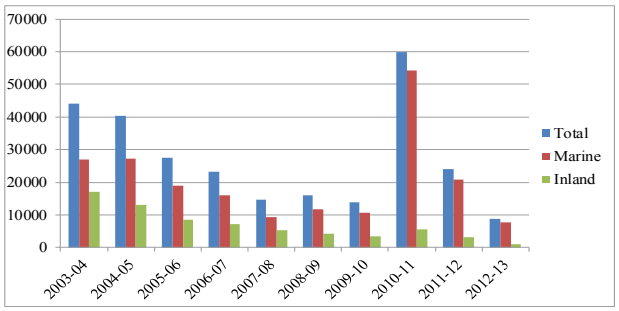

Figure 8: Total Hilsa catch from inland and marine water (2003-2013).

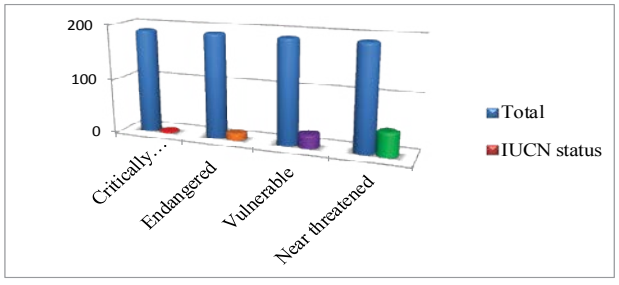

Figure 9: Comparison of threatened, vulnerable and endangered fishes.

National Importance of Fish Species

1. **Stock characterization, captive breeding, seed production and culture of Hilsa (*Tenualosa ilisha*):** The project is started under the programme "Breeding and culture of high valued food fish" sponsored by the NBSFRA at the lead institute CIFRI, Barrackpore from 1st November, 2012 to 30th November, 2017. Except CIFRI, 6 other institutes are also involved NBFGR, CIFE, CIBA, CIFA, CMFRI and VBU. The objective of this project is: evaluation of osmo-regulatory and endocrine changes of Hilsa in relation to ionic homeostasis and gonad maturation.

2. **The Indian council of agricultural research launched an All India Coordinated Research Project on Air-breathing Fish Culture in May 1976:** This project launched with a view to develop a viable technology for culturing air-breathing fishes in swamp, ponds, tanks, cages and in pens. Different aspects of air-breathing fish culture viz., their biology, seed production, induced breading, fry and fingerling rearing, development of suitable feeds in nursery and grow out phase; diseases and their control were studied at different centres of the project. In West Bengal at Kalyani the work was done *on Clarias batrachus, Heteropneustes fossilis* and *Anabas testudineus*.

3. **MPEDA launched under the project "Rainbow Revolution of India"**: a scheme named 'Ornamental Fish Assistance Scheme' in 2010: The aim of the project is increasing the production of Ornamental Fishes in India for domestic and export marketing.

Technology on Captive Propagation

Captive breeding is the process of breeding animals in human controlled environments with restricted settings. This technique is used to produce fry of fish species that have or potentially have great economic significance for aquaculture, which do not reproduce spontaneously in captivity. Usually pituitary glands are used to induce the fish for spawn. Apart from this many synthetic hormones also use for induced breeding; Gnopro, Ovaprim, Ovatide etc. The process was successfully experimented by the CIFRI ground 1957. Except common carp, all the other five Indian and Chinese major carps, viz. catla, rohu, mrigal, silver carp and grass carp, cultivated under composite fish culture do not breed in pond conditions although they attain full gonadal maturity. However, they breed in bundh type tanks.

The Asian catfish, *Clarias batrachus* popularly known as magur is highly popular in India as an expensive table fish. A study of the breeding and larval rearing of *Clarias batrachus* is conducted in both on-station and on-farm situations, mainly at Canning, Nimpith and Kalyani of West Bengal [47].

Pangasius sutchi fish have already established their importance as profitable species in aqua-farming of Bengal. As a result of its remarkable growth rate (almost one kg in 90 days), now there is much enthusiasm among the fish-breedersand farmers of Bengal for its artificial spawning and culture. In view of the increasing demand for *Pangasius sutchi* seed we tested techniques for induced spawning and larval rearing of this fish.

In West Bengal, a persistent job and income oriented drift from villages and urban areas resulted in overcrowding in cities and subsequent loss of work force in rural areas. In such condition, breeding and culture of ornamental fish may be an additional source of income for the rural mass. Breeding and culture of ornamental fish is a highly lucrative venture that can be an attractive alternative to check such migration. Induced breeding of Pacu (*Piaractus brachypomus*) is done captivity with pituitary extract. Besides breeding individual species, the fish breeders are also interested in conducting hybridisation programmes between Indian major carps and exotic species, as they are largely unaware of the genetic consequences of such activities.

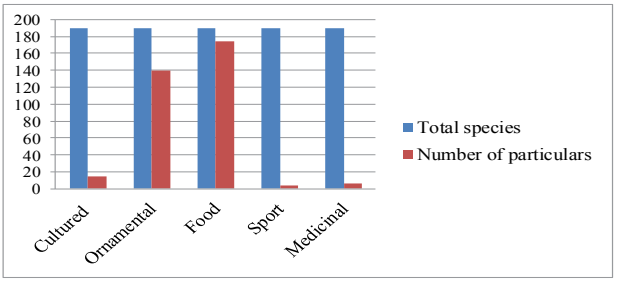

Figure 10: Comparison of cultured, ornamental, food and medicinal with respect of total fish diversity.
Total cultured fishes: 14; Total ornamental fishes: 140; total food fishes: 174; total sport fishes: 4; total medicinal value fishes: 6.

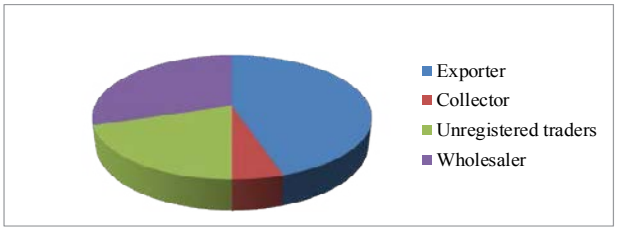

Figure 11: Percentage of different stakeholders in ornamental fish trade from the state.

Threats to Fish Diversity

Habitat alteration

Damming, deforestation, diversion and withdrawal of water for irrigation, urban and industrial consumption has caused large scale changes in the channel bed and hydrology of the river in terms of flow, flow-rate, flood-rhythm and regime. Dam impedes upstream spawning migration of fishes and displaces populations from their normal spawning grounds. It may also result in separating a population into two smaller groups as in Hilsa (*Tenualosa ilisha*) above and below the Farakka barrage. The migration routes of important native fishes like mahseer (*Tor putitora* and *T. tor*) and snow trouts (*Schizothorax richardsonii* and *S. plagiostomus*) have been blocked. The upland fast-moving habitat has been lost to reservoirs which are unfavourable for rheophylic species.

Wanton destruction

Wanton killing by the use of dynamites, electric shocks and poisoning and brood fishes in spawning season and juveniles during post-monsoon periods have affected a number of food and game fishes of upland waters. About 50,000 fry collectors of *Penaeus monodon* in Sundarbans simply destroy an average of 191 juveniles of other fishes for every fry of their choice. Mass scooping of prawn seed in many anicuts and hilsa juveniles just below the Farakka barrage are examples of such destruction. For every tiger shrimp seed caught, an average of 318 other prawn seeds, 8 fish seeds, 60 crab seeds, 1 mollusc seed and 13 unidentified seeds, totalling 400 seeds are destroyed [48].

Exotic fish species

NBFGR under its mandate has been working on screening of alien fishes for their invasive characters. Many alien species introduced have been found invasive and they have the ability to establish themselves, invade, out-compete native species and take over the new environments. Seven risk sectors of illegally introduced fishes have been identified. These are (i) ecological threats (pests and invasive), (ii) general (hybridization with local species), (iii) environmental (alteration in aquatic ecology), (iv) introduction of exotic pathogens, (v) food safety and public health, (iv) financial (vii) social. Uncontrolled introduction of exotic fishes also exterminated the indigenous fishes in some ecosystems. Common carp introduced into Kashmir valley has almost exterminated the native Schizothoracine fishes in the Kashmir valley. In the Gobind sagar reservoir Indian major carps, especially *Catla catla* has already been replaced by the exotic silver carp. The introduction of trouts in almost a virgin niche at high altitude coldwater streams has, however, remained encouraging.

Overexploitation

Over-fishing affects heritable life history parameters like growth and age of sexual maturity. Over-exploitation of fishery resources due to its higher economic value has exacerbated the vulnerability of the population in different ecosystems, viz. *Tor spp.* and *Schizothorax spp.* in upland waters, *Chitala chitala, Ompok pabda, Pangasius pangasius, Eutropiichthys vacha, Semiplotus semiplotus*, etc. in warm water, *Mugil cephalus, Liza tade, Nematolosa nasus, Lates clacifer*, etc. in brackish water and *Rhiniodon typhus*, *Polynumus indicus, P. heptadactylus, Pomadasy shassta*, some sharks, skates and rays etc. in marine ecosystem; they are declining at an alarming rate.

Climate change

Global climate change is likely to result in severe droughts and floods with major impact on human health and food supplies, according to the India's report to the United Nations as per recent report, reduction in river discharge due to combined effect of climate change and water withdrawal will make the up to 75% global freshwater fish biodiversity to become extinct by 2070 [49]. Research is required to link available biological and ecological information on the impacts of climate change to water resource and the immediate priority should be to conduct studies of closely linked species, ecosystems and fisheries that have data and information rich Climate Variation and Changes (CVS) response in cold water ecosystem. There is need to intensify efforts for increasing climate literacy among all stakeholders as well as farmers.

Conservation Measures

Due to factors such as human modifications to the environment, overexploitation, habitat loss, exotic species and others, aquatic biodiversity is greatly threatened. In order to preserve these threatened areas and species for future generations, immediate action in the form of aquatic biodiversity conservation strategies are necessary. The conservation policy should promote the management practices that maintain integrity of aquatic ecosystem, prevent endangerment and enhance recovery of the threatened species [50-60].

Through probability of inbreeding in hatchery-bred seed normally cannot be ruled out, conservation aquaculture is gaining importance in rehabilitation programmes of endangered/threatened fishes. Interestingly, sea bass (*Lates calcarifer*) a vulnerable species of the brackish water, has been successfully cultured in West Bengal for about 6 months by stocking the hatchery-produced seed.

The Department of Fisheries, Government of West Bengal is trying to conserve these species with the following objectives:

1. Brood stock management: Artificial breeding of threatened species for restocking in their natural habitat and to establish gene banks using cryopreservation techniques.

2. To overcome disease problems in larval rearing tanks and culture ponds.
3. To generate income, self-employment and skill for interested farmers through demonstration and training.
4. To provide technical support to private hatchery owners to help them to maximize production of quality seed.
5. For conservation purposes, artificial reproduction techniques are applied to establish an Endangered Fish Species Breeding Programme. The two main components of this programme are a) a live gene bank and b) gamete/embryo bank.

Apart from the Central government act there are also some state government acts are also in West Bengal [61-70]. In West Bengal it was with the enactment of the West Bengal Inland Fisheries Act, 1984 that environmental concerns regarding water bodies became a part of policy. Some other relevant statues are:

- The West Bengal Panchayat Act, 1973.
- The West Bengal Town and Country (Planning and Development) Act, 1979 (As Amended by West Bengal Act 18 of 2001).
- West Bengal Inland Fisheries (Amendment) Act, 1993 and 2008.
- West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005.
- The West Bengal Land Reforms (Amendment) Act, 2005.
- West Bengal Trees (Protection and Conservation in Non-Forest Areas) Act, 2006.
- The East Kolkata Wetlands (Conservation and Management) Act, 2006.

Potential Areas of Research

In India, the NBFGR, Lucknow is the nodal institution under Indian Council of Agricultural Research, for collection, cataloguing, and documentation of fish genetic resources using operational strategies of partnership and cutting edge technologies. Innovative approaches to fish conservation programme by declaring a State Fish has been adopted [19]. The conservation of the cold water fishes in the upper stretches should be considered as the priority. Restoring the natural fish stocks should be a priority, which includes ensuring minimum flow requirements and thereby sustaining the recruitment process. In addition, restoration of floodplain and associated wetlands should be a priority for conservation because floodplains play an integral part of riverine ecosystem. Efforts should be made to check the sediment flow by extensive plantation of native trees, shrubs, etc. on the riverbank and adjoining catchment area. Effective construction of fish passage structure is necessary [71-77]. Capacities for the assessment, study and systematic observation and evaluation of biodiversity need to be reinforced. Effective national action and international cooperation is required for the in-situ protection of ecosystems, for the ex-situ conservation of biological and genetic resources and for the enhancement of ecosystem functions. The participation and support of local communities are elements essential to the success of such an approach [78-82].

Conclusion

Although the state and central government have already taken several measures to conserve the fish biodiversity in the River Ganga basin, we feel more conservation is needed in order to retain as many of the natural ecological processes and functions of the rivers and associated waterbodies as possible. Since the River basin is undergoing drastic deterioration as a consequence of anthropogenic changes, the conservation strategies must be innovative and integrated. Success will depend on the extent to which conservationists, water commissions, corporations, and municipalities work cooperatively in these places to maintain or restore natural water habitats of the state. Moreover, there is need to improve knowledge on biodiversity by strengthening the taxonomic capacity using computer, image analysis, and molecular tools etc. There is also an urgent need to maintain the integrity of these aquatic ecosystems by restoring ecological processes of the natural waters.

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