MAINSTREAMING BIODIVERSITY

Inland Fisheries and Aquaculture

A Key for Food and Nutritional Security

Centre for Biodiversity Policy and Law
National Biodiversity Authority

2019

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A Key for Food and Nutritional Security

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Dr. B. Meenakumari & Dr. Rupam Mandal

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National Biodiversity Authority

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LIST OF ABBREVIATIONS

BD	Biological Diversity
BHS	Biodiversity Heritage Site
BIS	Bureau of Indian Standards
BMC	Biodiversity Management Committee
BMP	Best Management Practice
BOD	Biological Oxygen Demand
BSI	Botanical Survey of India
CAA	Coastal Aquaculture Authority
CBD	Convention on Biological Diversity
CCRF	Code of Responsible Fisheries
CEBPOL	Centre for Biodiversity Policy and Law
CIBA	Central Institute of Brackishwater Aquaculture
CIFA	Central Institute of Freshwater Aquaculture
CIFRI	Central Inland Fisheries Research Institute
CIFT	Central Institute of Fisheries Technology
CMFRI	Central Marine Fisheries Research Institute
CMS	Convention on Conservation of Migratory Species
CPCB	Central Pollution Control Board
DAHDF	Department of Animal Husbandry, Dairying and Fisheries
DCFR	Directorate of Coldwater Fisheries Research
DPP	Draft Project Proposal
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organisation
FSI	Fisheries Survey of India
GAP	Ganga Action Plan
GoI	Government of India
GVA	Gross Value Added
ha	Hectare
ICAR	Indian Council of Agricultural Research
IUCN	International Union for Conservation of Nature
LMT	Lakh Metric Tonne
MMT	Million Metric Tonne
MoEA	Ministry of External Affairs
MoAFW	Ministry of Agriculture and Farmers' Welfare
MoEFCC	Ministry of Environment, Forest and Climate Change
MoUD	Ministry of Urban Development
MoWR	Ministry of Water Resources

MPEDA	Marine Products Export Development Authority
MSL	Mean Sea Level
NAARM	National Academy of Agricultural Research Management
NBA	National Biodiversity Authority
NBAP	National Biodiversity Action Plan
NBFGR	National Bureau of Fish Genetic Resource
NFDB	National Fisheries Development Board
NIE	National Institute of Environment
NIFAP	National Inland Fisheries and Aquaculture Policy
NPCA	National Plan for Conservation of Aquatic Ecosystem
NRCD	National River Conservation Directorate
NRCP	National River Conservation Plan
NTC	Normally Traded as Commodities
NWCP	National Wetland Conservation Programme
PBR	People's Biodiversity Register
SBB	State Biodiversity Board
SDG	Sustainable Development Goal
SEA	Strategic Environmental Assessment
SHG	Self Help Group
TEEB	The Economics of Ecosystems and Biodiversity
UNFCCC	United Nations Framework Convention on Climate Change
UT	Union Territory
ZSI	Zoological Survey of India

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I sincerely thank the Directors of CIFRI, Central Institute of Brackish Water Aquaculture, National Bureau of Fish Genetic Resources, National Academy for Agricultural Research Management for their support and providing the required information.

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FOREWORD

Biodiversity mainstreaming is the process of embedding biodiversity considerations into policies, strategies and practices of key public and private actors that impact or rely on biodiversity so that biodiversity is conserved and sustainably used, both locally and globally. The concept of mainstreaming was included in Article 6(b) of the Convention on Biological Diversity (CBD) which calls on the parties to "integrate the conservation and sustainable use of biological diversity into relevant sectoral or cross sectoral plans, programs and policies". The Goal A of the Strategic Plan for Biodiversity 2011-2020 of CBD addresses the underlying causes of biodiversity loss and emphasises on mainstreaming biodiversity across government and society.

India's rich aquatic genetic resources comprise 9,456 species, which is approximately 9.7 percent of the total number of animal species (97,708 species). The inland fish diversity comprises 113 brackish water, 936 fresh water and 462 exotic fishes. The inland fisheries contribute significantly to the overall fish production in the country. There has been a shift from capture fisheries to aquaculture in the last two and a half decades. India is the second largest producer of inland fishes and the second largest aquaculture nation in the world. The total fish production in India has increased from 5.66 MMT in 2000-01 to 11.41 MMT (7.77 MMT from inland and 3.64 MMT from marine) in 2016-17. The transformation of inland fisheries from traditional capture fisheries to commercial scale aquaculture has led to an increase in fish production. Some of the major concerns related to the inland sector includes river water pollution, agriculture runoff, water abstraction, diminishing environmental flow, sedimentation, spread of invasive alien species, destructive fishing practices, illegal trade of ornamental fishes, etc.

All the States/Union Territories are expected to play an important role in addressing the above mentioned concerns and initiate action for effective implementation of the Biological Diversity Act, 2002. Further, the States/UTs must take necessary action for identifying the unique and ecologically fragile ecosystems and designate them as fish sanctuaries or Biodiversity Heritage Sites. The Central Government, in consultation with the State Governments, should notify the aquatic species in the verge of extinction/threatened and to take appropriate steps to rehabilitate those species. Also most importantly the collection of fish or shrimp seeds from the wild must be stopped through appropriate legal or regulatory means.

I congratulate Dr. V.V. Sugunan, Former Assistant Director General, Indian Council for Agricultural Research, New Delhi and Dr. C. Thomson Jacob, Consultant (Biodiversity Policy), Centre for Biodiversity Policy and Law, National Biodiversity Authority for bringing this important publication. I hope this document will facilitate better understanding of the concept of biodiversity mainstreaming and help India in achieving its national targets and ultimately help in conserving the precious Inland aquatic resources.

Dr. Satyendra Datt Tripathi
Former Director, Central Institute of Fisheries Education

CONTENTS

1. INTRODUCTION

The inland water resources, namely lakes, rivers, canals, reservoirs, ponds, streams, springs, cave waters, floodplain wetlands, estuaries, coastal lagoons, mangrove creeks, marshes, backwaters and swamps are habitats for fishes, amphibians, water birds, semi-aquatic animals and plants and support highly endemic and endangered taxa[1]. These dynamic ecosystems support various ecosystem services, such as climate regulation, flood mitigation, nutrient recycling, water purification and waste treatment. They also provide food, nutrition and livelihood for millions of people around the globe.

In India, the fish catch from inland water bodies are declining due to habitat degradation and loss of biodiversity. Hence, aquaculture has become an alternative source of income to meet the global demand of fish production. Aquaculture produces more than five million metric tonnes (MMTs) of fishes and shrimps annually, making India the second largest fish producer in the world[2]. The deteriorating habitats in the aquatic ecosystems and unregulated growth of aquaculture industries pose a threat to the country's rich biodiversity. There is an urgent need to bring focus on biodiversity related concerns into the inland fisheries and aquaculture sectors and to develop a road map and action plan towards mainstreaming biodiversity into the national policy. This document describes the efforts made by the Centre for Biodiversity Policy and Law (CEBPOL).

1.1 India's aquatic genetic resources

India's rich aquatic genetic resources comprise 9,456 species, which is approximately 9.7 percent of the total number (97,708) of animal species. The freshwater invertebrates include Phylum Arthropoda (5,923 species), Nematoda (422 species), Rotifera (419

1. Convention on Biological Diversity, 2017 (Web source: www.cbd.int).
2. Ayyappan et al., 2011 (Ed, Ayyappan, S, Moza, U, Gopalakrishnan. A, Meenakumari, B, Jena, J. K. and Pandey, A.K.), 2011. Handbook of Fisheries and Aquaculture, Indian Council of Agricultural Research (ICAR), New Delhi, July 2011, PP 1116.

species), Mollusca (217 species), Annelida (167 species) and Platyhelminthes (163 species). The Phylum Chordata comprises fishes (1,047 species), amphibians (275 species), aves (243 species), reptiles (46 species) and mammals (6 species)[3]. The inland fish diversity comprises 113 brackish water, 936 freshwater and 462 exotic finfishes.

The Gangetic river system harbours around 265 species of fish; river Brahmaputra has 126 species and the peninsular rivers have more than 76 fish species[4]. The inland waters also support some of the charismatic species such as Gharial and Irrawaddy dolphin. The warm water fish species found in the Indian waters include:

- Major and minor carps namely, *Labeo rohita, L. calbasu, L. bata, L. fimbriatus, Gibelion catla, Cirrhinus mrigala, C. cirrhosa and C. reba*;
- Catfishes, such as *Clarias magur, Heteropneustes fossilis, Sperata aor, S. seenghala, Wallago attu, Pangasius pangasius, Silonia silondia, Bagarius bagarius* and *Rita rita*;
- Murrels such as *Channa striata, C.marulius, C.punctatus*;
- Other important species are *Anabas testudineus, Chitala chitala, Notopterus notopterus, Labeo gonius* and *L. dycheilus*.

The west flowing rivers are rich in fish diversity and harbour several endemic species[5].

1.2 Inland fisheries and aquaculture - global scenario

Inland fisheries and aquaculture provide the most important sources of nutritious food accessible to the poor across the world and food from these sources have high-quality proteins (with all essential amino acids), essential fats (for example, long chain omega-3 fatty acids), vitamins (D, A and B) and minerals (calcium, iodine, zinc, iron and selenium). The global capture fishery production in 2016 was 90.9 MMT, of which 79.3 MMT came from marine waters and 11.6 MMT from inland waters. Aquaculture fish production is growing faster than other major food production sectors. The global aquaculture production in 2016 increased to

3. Kailash Chandra, Gopi, K.C., Rao, D.V., Valarmathi, K. and Alfred, J.R.B. 2017. Current status of freshwater faunal diversity in India: 1-624pp. Zoological Survey of India, Kolkata.
4. Das, M.K., Samanta, S. and Saha, P.K. 2007. Riverine health and impact on fisheries in India. Policy paper No.1, Central Inland Fisheries Research Institute (CIFRI), Barrackpore, Kolkata.
5. Kuldeep K. Lal and J.K. Jena, National Bureau of Fish Genetic Resources: A center for aquatic genetic resource management research in India. IAC Souvenir, 1st International Agrobiodiversity Congress, Science, Nov.6-9, 2016, New Delhi, xxvii+142.

80.0 MMT of food fish, 30.1 MMT of aquatic plants and 37,900 MMT of non-food products. The farmed food fish production included 54.1 MMT of finfish, 17.1 MMT of molluscs, 7.9 MMT of crustaceans and 9.4 MMT of other aquatic animals. China is a major producer of farmed food fish and other major producers are India, Indonesia, Vietnam, Bangladesh, Egypt and Norway[6].

1.3 Indian scenario

The inland fisheries contribute significantly to the overall fish production in the country. There has been a shift from capture fisheries to aquaculture in the last two and a half decades. India is the second largest producer of inland fishes and the second largest aquaculture nation in the world. The total fish production of India touched 12.61 million tonnes in 2017-18 with a contribution of 8.92 million tonnes (about 71%) from inland sector. This sunrise sector contributes about 1% to National Gross Value Added (GVA) and 5.43% to Agricultural GVA (2015-16) while engaging over 14.5 million people at the primary level and almost twice the number along the value chain. During 2017-18 the export of fisheries products reached over 1.37 million tones valued at INR 451070 million (US$ 7.08 billion)[7]. The transformation of inland fisheries from traditional capture fisheries to commercial scale aquaculture has led to an increase in fish production (Figure 1).

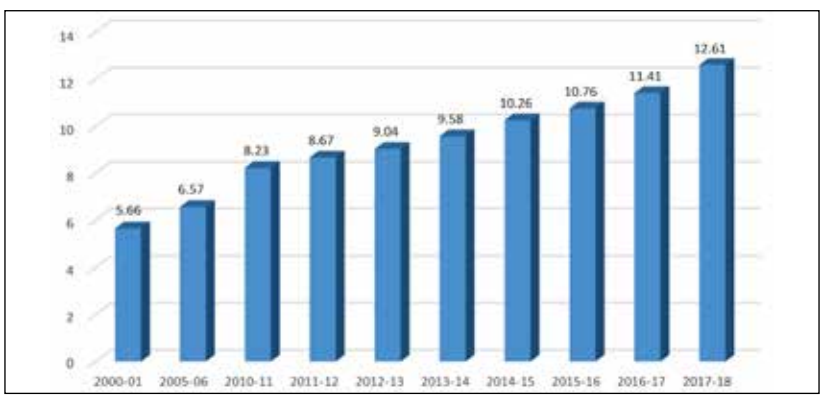


Figure 1: Fish production trend in India

6. FAO, 2018. The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO.

7 Draft National, Inland Fisheries and Aquaculture Policy (NIFAP), F.No13001/12016-FY, Published by the Department of Fisheries, Ministry of Agriculture & Farmers Welfare (MoAFW), Government of India (GoI).

In India, the fisheries sector contributed around 0.92 percent to the Gross Value Added (GVA) and 5.23 percent to the agriculture GVA during 2015-16. The historical scenario of the Indian fisheries reveals a paradigm shift from marine dominated fisheries to inland fisheries. The latter has emerged as a major contributor to the overall fish production with a share of 68.1 percent of the total fish production (Figure 2)[8].

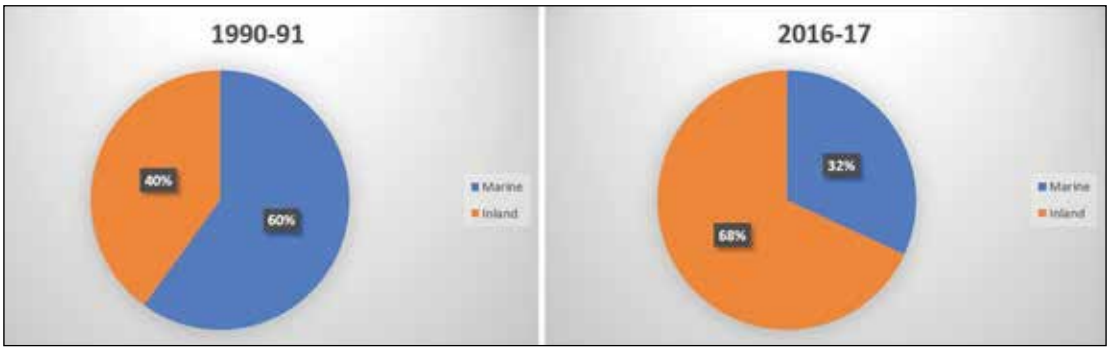


Figure 2: Marine and inland fish production during 1990-91 and 2016-17

8. Annual Report 2017-18. Published by the Department of Animal Husbandry, Dairying and Fisheries (DAHDF), Ministry of Agriculture & Farmers Welfare (MoAFW), Government of India (GoI).

2. INDIA'S INLAND OPEN WATER RESOURCES

In the Inland fisheries, there is a shift from capture fisheries to aquaculture in the last two and half decades. The freshwater aquaculture production share has increased from 34 percent in the mid-1980s to around 80 percent in recent years. So far, around 0.895 million hectares (M.ha) of water area has been brought under fish farming, covering 1.1 million beneficiaries. The annual yield is around 3.0 tonnes/hectare. India has vast and varied inland resources that comprise of 191,024 kms of rivers and canals, 1.2 M.ha of floodplain lakes, 2.36 M.ha of ponds and tanks and 3.54 M.ha of reservoirs (Table 1). Although, inland fisheries have grown, the rate of growth in terms of its potential is not yet achieved. The average fish production potential was estimated at 250 kilograms (kg)/hectare (ha) in reservoirs and about 350 kg/ha for wetlands[9]. While reservoirs and freshwater aquaculture can be considered as the two main pillars of growth, another major activity in aquaculture sector called the cage/pen culture in open waters, has shown significant growth in recent years. It offers vast potential for inland aquaculture in the country. The production potential from sustainable cage culture production is about 50 kg/cubic metre (m^3).

Table 1: Inland fishery resources in India and their utilisation modes

S. No	Resource type	Resource size	Fish production system
1	Rivers and canals (Kms)*	191,024	Capture
2	Reservoirs (M.ha)*	3.54	Culture-based fisheries/Stock enhancement/ Cage culture
3	Ponds and tanks (M.ha)*	2.36	Aquaculture
4	Brackish water area(M.ha)*	1.24	Aquaculture
5	Floodplains and lakes (M.ha)**	1.2	Culture-based fisheries and pen culture
6	Wetland (Inland and coastal) (M.ha)	15.26	Capture and aquaculture
7	Beels (M.ha) **	1.3	Culture-based fisheries/ Aquaculture

Source: * Department of Animal Husbandry, Dairying and Fisheries (DAHDF) Annual Report, 2017-18.

**Draft National Inland Fisheries and Aquaculture Policy (NIFAP), 2019.

9. Scheme on Development of Inland Fisheries and Aquaculture - An Analysis. Standing committee on Agriculture, 2017-18, Fifty Third Report. Published by the DAHDF, MoAFW, GoI.

2.1 Rivers

India's river systems comprise 14 major, 44 medium and 153 small rivers with a combined length of 0.19 million kms. This includes 25 basins and 101 sub basins. They harbour one of the richest biodiversity in the world and support millions of riparian population. Only 4 of the 14 major rivers are completely perennial; rest of them dry-up in summer. Majority of the rivers have been obstructed by a cascade of dams and barrages[10]. The fish production in the riverine system has declined due to impaired flows, habitat alterations, over exploitation, and industrial and sewage pollution. *For example*, in river Ganga, only 198.3 kg/ha/year of fish resources are harvested, thus, meeting only 15.2 percent of its production potential[11]. The riverine scenario is a complex mix of artisanal, subsistence and traditional fisheries with highly dispersed and unorganised marketing system. A database on fish production trends of rivers is elusive. The Indian Council for Agricultural Research (ICAR) - Central Inland Fisheries Research Institute (CIFRI) has reported that, in some stretches of rivers Ganga, Brahmaputra, Narmada, Tapti, Godavari and Krishna, the fish yield varies from 0.64 to 1.64 tonnes per km, with an average of 1 tonne per km.

2.2 Estuaries, coastal lagoons and backwaters

Brackish water estuaries have the peculiarity of fluctuating salinity due to tidal effects, which holds large potential for both fish and shellfish production. Estuaries provide nursery and breeding grounds for commercially or ecologically important species, such as fishes, shrimps, oysters, mussels, lobsters, prawns, crabs, dolphins and crocodiles. Many types of finfishes, shellfishes, crustaceans and marine animals rely on estuaries for breeding. The important brackish water fish species found in the estuaries are mullets, milkfish, pearl spots and sea bass. Among the crustaceans, *Penaeus monodon, Fenneropenaeus indicus* and crab *Scylla serrata* are commercially exploited. India has 53 estuaries spread along its coastline, which support stocks of hilsa, mullets, prawns, crabs, and so on. The major estuaries are Hooghly, Mahanadi, Godavari, Krishna, Cauvery, Narmada and Tapti, covering a total area of 0.3 M.ha. besides the coastal lagoons, Chilika, Pulicat and backwaters of Kerala. Estuaries

10 . Vision 2050, 2015, Published by ICAR-CIFRI, Barrackpore, Kolkata.

11. Das, M.K., Sharma, A.P., and Samanta, S. 2014. Health of Inland Aquatic Resources and its Impact on Fisheries Policy Paper No. 4, ISSN, 0970-616X, CIFRI, Barrackpore, Kolkata. P.43.

consist of diverse habitats, such as mangroves, salt marshes, seagrasses and mud flats; provide essential ecosystem services and keep the system healthy[12].

2.3 Mangrove ecosystem

The mangrove cover in India is spread over an area of 4,921 square kilometre (km^2), accounting for nearly 3.3 percent of the world's mangrove vegetation. Sundarbans in West Bengal accounts for almost half of the total area of mangroves in India[13] and provides home for many threatened umbrella species. Mangroves are biologically sensitive ecosystems, which play a vital role during the breeding and nursery phases of many riverine and marine organisms[14]. Sundarbans harbours a good number of rare and globally threatened animals including the estuarine crocodile (*Crocodylus porosus*), fishing cat (*Felis viverrina*), common otter (*Lutra lutra*), water monitor lizard (*Varanus salvator*), Gangetic dolphin (*Platanista gangetica*), snubfin dolphin (*Orcella brevirostris*), river terrapin (*Batagur baska*), marine turtles like Olive Ridley (*Lepidochelys olivacea*), green sea turtle (*Chelonia mydas*) and hawksbill turtle (*Eritmochelys imbricata*)[15].

2.4 Reservoirs

Reservoirs are man-made impoundments created by erecting a dam of any description across a river, stream or any other flowing watercourse to obstruct the surface flow. Reservoirs constitute vast, rich and diverse resources that is grossly underutilised. In India, the average fish production potential in the reservoirs is 250 kg/ha[16]. The country has 3.15 M.ha of water-spread area under reservoirs. About 56 large reservoirs contain a total water-spread area of 1.14 M.ha; 180 medium reservoirs covering 0.53 M.ha and around 19,000 small reservoirs with total area of 1.49 M.ha[17]. Development of reservoir fisheries is important for biodiversity. The main management intervention in reservoir fisheriesis the stocking

12. ibid.
13. Indian State of Forest Report, 2017. Published by Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India, ISBN No. 97881929285-6-2.
14. Kathiresan, 2000. Review of studies on Pichavaram mangrove, southeast India. Hydrobiologia 430:184-205.
15. Sundarban Biosphere Reserve (Web Source: http://sundarbanbiosphere.org).
16. Scheme on Development of Inland Fisheries and Aquaculture - An Analysis. Standing committee on Agriculture, 2017-18, Fifty Third Report. Published by the DAHDF, MoAFW, GoI.
17. Sugunan, V. V., 1995. Reservoir fisheries of India. Food and Agriculture Organisation (FAO) Technical Paper No.345. FAO Rome, pp.

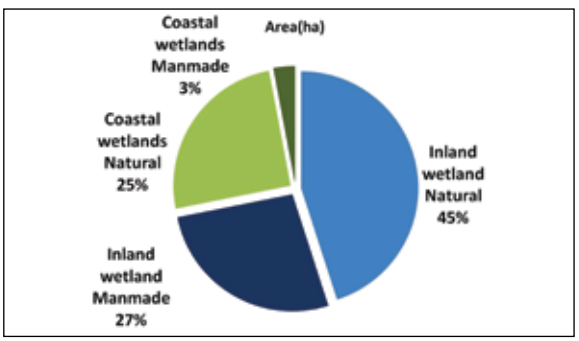
compliance. Reservoirs are generally managed collectively as a common property resource by the fishing communities. Often low yields and profitability are attributed to lack of effective co-management institutions that empower and motivate the members of the communities to effectively manage resources. Therefore, a governance arrangement, built on a co-management platform, with active participation of all stakeholders can lead to improved yield from reservoir fisheries, apart from making the system sustainable and equitable. Cage and pen culture is very useful for raising stocking materials in a desired size and number and cost-efficient manner.

2.5 Wetlands

Wetlands are an important source of freshwater and provide ecosystem services. There are 19 different types of wetlands in India, ranging from mangroves, lakes, marshes, ponds and they cover an estimated three percentage of India's land area. Wetlands are rich and diverse in biodiversity, and range from the high-altitude lakes of the Himalayas, floodplains and marshes of the Gangetic-Brahmaputra alluvial plains, saline flats of green Indian desert to the extensive estuarine wetlands bordering the country's east and west coastline. India has 757,060 wetlands covering an area of 15.26 M.ha, roughly equal to 4.63 percent of the country's geographical area. Inland wetlands constitute 69.23 percent (10.56 M.ha) and coastal wetlands cover an area of 27.13 percent (4.4 M.ha) (Figure 3)[18].

The average fish production potential in the wetlands is about 350 kg/ha. These wetlands are treasures of biodiversity and they support unicellular algae, bryophytes, mosses, ferns and woody angiosperms. Some of the faunal species found in the wetlands are dolphins, otters, swamp deer, hog deer, fishing cats, rhinoceroses, elephants, wild buffaloes, and so on[19].

Figure 3: Wetland distribution in India e.g. Type



18. National wetland Atlas, 2011. Published by the Space Application Centre (ISRO), Ref. SAC/EPSA/ABHG/NWIA/ ATLAS/34, 2011, Ahmedabad, India, 310p.
19. MoEFCC & GIZ, 2014. The Economics of Ecosystems and Biodiversity, TEEB India Initiative: Interim Report - Working 7 Document. 92p.

Dal Lake (Kashmir), Khajjar Lake (Himachal Pradesh), Nainital Lake (Uttarakhand), Vembanad and other lagoons in Kerala and Kodaikanal (Tamil Nadu) are important wetlands that provide livelihood support for the local communities. For conserving lakes and wetlands, the Ministry of Environment, Forest and Climate Change (MoEFCC) is implementing the National Plan for Conservation of Aquatic Ecosystem (NPCA). The scheme aims at holistic conservation and restoration of lakes and wetlands for achieving the desired water quality and enhancing biodiversity and ecosystem through an integrated multidisciplinary approach. To control degradation and conserve wetlands, the National Wetland Conservation Programme (NWCP) was initiated for implementing an action plan for conservation and management of identified wetlands. India being a signatory to the Ramsar Convention, 26 Ramsar sites have been notified and a regulatory mechanism was set in place through wetlands (conservation and management) Rules[20] for managing these wetlands.

Photography: V.R. Suresh, ICAR-CIFRI.

20. Annual Report, 2017-18, Published by MoEFCC, GoI

2.6 Floodplain wetlands (beels)

There are about 1.3 M.ha of beels and other derelict water bodies in India. The beels represent the lentic component of floodplains namely, ox-bow lakes, sloughs, meander scroll depressions, residual channels and back swamps. Beels are shallow depressions connected to the principal rivers and they receive backflow water from rivers or catchment areas during floods or monsoon rains, respectively. Beels form an important fishery resource in Assam, West Bengal and Bihar where thousands of fishermen depend on these water bodies for their livelihood. The biotic communities of beels, thus adapt themselves to spatial and temporal fluctuations leading to a high degree of floral and faunal diversity[21]. The major biotic communities in beels that have a bearing on fish productivity are plankton, benthos and macrophytes. The beels are considered as biologically sensitive habitats as they play a vital role in the recruitment of fish populations in the riverine ecosystems and provide nursery grounds for commercially important fishes. They form an important fishery resource in the northern and north-eastern states of the country[22].

21. Scheme on Development of Inland Fisheries and Aquaculture - An Analysis. Standing committee on Agriculture, 2017-18, Fifty Third Report. Published by the DAHDF, MoAFW, GoI.

22 Dr. Ravi Shankar Piska, Fresh Water Aquaculture, Fisheries Paper 1, Intermediate Vocational Course State Institute of Vocational Education and Board of Intermediate Education (Web source: http: www.bieap.gov.in/Pdf/FreshwaterAquaculturep65.pdf).

3. AQUACULTURE

In India, the annual fisheries and aquaculture production has increased from 0.75 million tonnes in 1950-51 to 9.6 million tonnes in 2013-14 and globally India takes the second position[23]. India's aquaculture involves over 600 freshwater and marine animal species drawn from various tropic levels. These species are cultured using wide range of technologies and inputs and they are classified as freshwater and coastal (brackish water) aquaculture. Some of the important species cultured include major carps and prawns. Besides these, ornamental fish culture and weed farming are gaining importance as alternative livelihood supporting sectors. In India, the freshwater aquaculture primarily depends on cultivating carp species. However, despite the rich diversity of fish species in the country, Indian aquaculture depends only on a few species[24].

3.1 Freshwater aquaculture

Major carps form the backbone of freshwater aquaculture in India. The freshwater aquaculture production systems in India comprise 2.36 M.ha of ponds and tanks[25]. In eastern India, aquaculture is practiced in ponds and tanks of less than 1 ha. area, whereas in western India aquaculture is operated on a larger scale, with watersheds of 1525 ha. In northern India, open water aquaculture is practiced and in southern India, crop irrigation (ponds) are used for aquaculture. India has 877 freshwater fishery resources. Some of the species used for freshwater aquaculture include:

23. FAO. 2014. National Aquaculture Sector Overview India, p. 1; Handbook on Fisheries Statistics, 2014, p.5. Published by DAHDF, MoAFW, GoI.

24. Dilip Kumar, 2017. Aquaculture and resilient food system. Published in 29th All India congress of Zoology, International symposium on 'Culture based fisheries in Inland Open Waters' and Satellite Symposium on Fish Immunology'. ICAR- CIFRI, Barrackpore, Kolkata. pp: 177.

25. Scheme on Development of Inland Fisheries and Aquaculture - An Analysis. Standing committee on Agriculture, 2017-18, Fifty Third Report. Published by the DAHDF, MoAFW, GoI.

- Indian major carps (*Catla catla*), rohu (*Labeo rohita*) and mirgal (*Cirrhinus mirgala*) (contributes between 70 and 75 % of the total freshwater fish production);
- Silver carp, grass carp, pearl spot, tilapia and common carp (contributes from 25 to 30% of the production);
- In addition, the giant freshwater prawn (scampi) is produced in freshwater ponds and these species are widely cultivated in West Bengal, Andhra Pradesh, Telangana, Karnataka, Kerala, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Rajasthan and Uttar Pradesh.

The present concern with the freshwater aquaculture is species diversification. India possesses several endemic carp species, such as *Labeo calbasu, Labeo fimbriatus, Labeo gonius, Labeo dussumieri, Labeo bata, Cirrihinus cirrhosa, Cirrihinus reba, Puntius sarana* and *Puntius jerdoni*[26] but the country still depends on few species. It is estimated that only about 40 percent of the available area of ponds and tanks have been utilised and an immense scope for expansion of area exists under freshwater aquaculture.

3.2 Coastal (brackish water) aquaculture

Brackish water estuaries are another set of water bodies which has huge potential for both fish and shellfish culture. Shrimps, oysters, mussels, crabs, lobsters, sea bass, groupers, mullets, milk fish, cobia, silver pompano, pearl spot, ornamental fishes and weeds are being cultivated in the brackish waters. But in India, brackish water aquaculture sector largely depends on farming of *Penaeus monodon; Penaeus indicus, Penaeus merguiensis* and *Penaeus semisulcatus*. India has 11,90,900 ha of land area that has potential for brackish water aquaculture, however only 1,75,670 ha (14%) area is used for brackish water aquaculture. West Bengal and Gujarat have higher potential for brackish water aquaculture owing to the high tidal amplitude. Andhra Pradesh developed almost 57 percent of available area for shrimp culture, whereas Maharashtra and Gujarat utilised only 0.6 to 1.2 percent of the available area. Some of the traditional brackish water aquaculture practices in India include Bheries (manmade impoundments in coastal wetlands) in West Bengal and Pokkali cultivation (salt resistant deep-water paddy) in Kerala. In the traditional system of culture, tidal water is impounded in the inter-tidal mudflats by raising bunds and the marketable sized fish and shrimps are harvested during spring. These systems have been sustaining production

26. National Inland Fisheries and Aquaculture Policy (NIFAP), 2017. Second Draft as on 1st October. Published by DAHDF, MoAFW, GoI.

levels between 500-750 kg/ha/year with shrimps contributing 20-25 percent of the total production[27].

A major shift in policy on shrimp farming took place with the introduction of an exotic species of shrimp, namely, *Litopenaeus vannamei* and technologies for breeding and seed production of Barramundi or Sea bass, (*Lates calcarifer*), crabs (*Scylla serrata* and *Scylla tranquebarica*), milkfish (*Chanos chanos*), pearlspot (*Etroplus suratensis*) and mullets (*Mugil* spp.). The Coastal Aquaculture Authority (CAA) is regulating these activities in saline and brackish water systems within 2 km from the High Tide Line for sustainable development of coastal aquaculture sector.

Table 2: Brackish water aquaculture in India

State	Potential brackish water area in ha (% of total area)	In %	Area developed (ha.)	In %
West Bengal	4,04,000	34.01	50,405	12.44
Odisha	31,600	2.65	13, 400	2.65
Andhra Pradesh	1,50,000	12.60	84,951	56.63
Tamil Nadu	56,000	4.70	6,104	10.90
Pondicherry	800	0.07	144	16.00
Kerala	65,000	5.46	14,875	22.88
Karnataka	8,000	0.67	1,945	24.31
Goa	18,500	1.55	340	1.84
Maharashtra	80,000	6.72	1,135	1.42
Gujarat	3,76,000	31.57	2,371	0.63
Total	**11,90,900**	**100**	**1,75,670**	**14.97**

Source: Vision 2050, ICAR-CIBA, 2015.

Currently, Central Institute of Brackishwater Aquaculture (CIBA) is promoting the native Shrimp in the coastal States of Odisha, West Bengal, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat as a monsoon crop and emphasis is given for promoting the native indigenous species.

Photography: Google images.

27. Vision 2050, Central Institute of Brackish water Aquaculture, ICAR, Tamil Nadu (www.ciba.res.in).

4. COLDWATER FISHERIES & AQUACULTURE

Coldwater fishery resources in India are distributed in the form of upland streams, rivers, lakes and reservoirs that are located at medium to high altitudes of the Himalayan corridor, such as Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, West Bengal and North-Eastern States. This region is the hotspot for endemic, indigenous and exotic coldwater fish species offering enormous prospects for developing upland farming practices, game and ornamental fisheries[28]. The Himalayan region has around 8,243 km long streams and rivers, 20,500 ha. of natural lakes, 50,000 ha. of reservoirs and 2500 ha. of brackish water lakes. Coldwater resources harbour diverse groups of fishes belonging to 258 species constituting approximately 17 percent of the total fish fauna of the country. Fish produced in upland aquaculture namely rainbow trout, snow tout, common carp, golden mahseer, chocolate mahseer are captured from the wild and contributes around 75,000 MMT, which is about 1.5 percent of total inland fish production[29]. Coldwater fishes are rich in amino acids, fatty acids and minerals and they also contains nutrients and bioactive components, such as long-chain n-3 polyunsaturated fatty acids, vitamin D, B12 and A, selenium, iodine, iron, zinc, choline and taurine[30].

Table 3: Indian cold-water resources

Type of water bodies	Length/Area (in ha.)
Rivers in Himalayan and Deccan Plateau (km)	10,000
Brackish water lakes (>3000 Mean Sea Level (MSL)	2,390
Freshwater natural lakes (1500-2000 MSL)	18,150
High Mountain Kashmir lakes (>3000 MSL)	400
Valley lakes in Kashmir (140-1600 MSL)	3,000
Shiwalik lakes in Jammu (<600 MSL)	100
Central Himalayas Freshwater lakes in Kumaon	450
Himalayan manmade lakes/reservoirs	43,770
Peninsular uplands natural lakes/ reservoirs	85

Source: K. K. Vass, 2017

28. Vass. K.K, 2017. Livelihoods through Coldwater Fisheries and Development Strategies. Published in the Souvenir on National Seminar on Strategies, innovations and sustainable management for enhancing Coldwater fisheries and aquaculture.
29. Singh A. K. and Debajit Sarma (Eds) 2017. Aquatic resources and fish diversity of the Himalayas. Narendra Publishing House New Delhi 345pp. ISBN 978-93-86110-81-7.
30. Singh, A.K., Baruah, D., Sarma, D and Akhtar. M.S, 2017: Abstract book – National seminar on 'Strategies innovations and sustainable management for enhancing Coldwater fisheries and aquaculture'. ICAR- Directorate of Coldwater Fisheries Research (DCFR), Bhimtal, Nainital, Uttarakhand, pp: 1-189.

5. ISSUES

5.1 Pollution

The quality of aquatic resources of the country is deteriorating significantly with increasing pollution caused by rapid industrialisation and indiscriminate discharge of waste water in inland water bodies, which cause mass mortality of fishes and other aquatic organisms. The discharge of pollutants degrades the water quality and affects the health of aquatic ecosystems. About 70-80 percent of the pollution load in rivers such as Ganga and Yamuna contain organic waste, sewage, trash food and human and animal remains which lead to eutrophication. The remaining 20-30 percent are effluents from industries, carrying chemicals that impact the ecosystem integrity and biota[31]. The industrial effluents include a wide variety of chemical toxicants and heavy metals contributing substantially to the Biological Oxygen Demand (BOD). According to the Central Pollution Control Board (CPCB), the estimated polluted riverine length is around 12,363 kms covering 351 river stretches which includes 650 towns and 35 cities. The water quality of the river Ganga is largely affected due to industrial effluents and untreated sewage which make the river unfit for bathing. The toxicity level of the Yamuna at Mazawali was found highly toxic with 100 percent of mortality of test organisms[32].

5.2 Agriculture runoff

Agricultural runoff is one of the important causes of environmental degradation in inland water bodies and there is an increase in the production of fertilisers over a period. The actual production of all the fertilisers during 2016-17 was 414.41 lakh metric tonnes (LMT) and the estimated production of fertilisers during 2017-18 is 462.20 LMT[33]. In the food cycle of

31. Vision, 2015, Published by ICAR-CIFRI.

32. Annual Report 2015-16. Central Pollution Control Board, MoEFCC, GoI (Web source: www.cpcb.nic.in).

33. Annual Report 2017-18. Published by the Department of Fertilizers, Ministry of Chemicals and Fertilizers, GoI.

consumption, human health is at risk due to agricultural runoff and its bio-accumulation and bio-magnification in the aquatic ecosystem. The adverse impact of the agro-chemicals is further accelerated due to reduced environmental flows in rivers due to obstructions of river courses through dams and barrages. These stressed aquatic ecosystems lead to the extinction of aquatic resources/endemic species/restriction of gene flow and in turn reduces the genetic diversity.

5.3 Water abstraction

Riverine fishes are extremely sensitive to change in flood regime because of their dependence on seasonal floods, which inundate the grounds needed for feeding and reproduction. The sizeable fractions of the resident fishes that take shelter in the systems are destroyed when water level decreases to minimum. Similarly, many of the mature fishes coming from the lower reaches for breeding to the upstream during monsoon and post-monsoon seasons are killed due to water abstraction or minimum water flow in the riverine system[34].

5.4 Dams and environmental flows

Effects of dams, barrages, weirs and other hydraulic structures on riverine ecosystems are manifested in three ways namely, reduced discharge, habitat destruction and obstruction of migratory pathways of fishes. In the Ganga basin, 33.5 billion m^3 of water is presently held in storage reservoirs behind the weirs and barrages apart from the 18 major canal networks diverting the water to irrigate 7 M.ha of agricultural land. Indian major carps are known to undertake short breeding migrations to the limpid shallow areas during monsoon. Hilsa is a classic example of anadromous fishes affected due to obstruction in their upriver migratory path due to barrages and dams. The lucrative Hilsa fishery recorded up to 350 kms of upper stretches above the Farakka barrage has collapsed after commissioning the barrage in 1972. The Buxar landing centre recorded a mean catch of less than 2 tonnes of Hilsa during 1972 to 1986 (period after erecting the Farakka barrage in 1972), against a mean catch of 41.3 tonnes recorded in the pre-Farakka period (during 1961 to 1967)[35]. Catadromous migrants like eels, freshwater prawns and catfish (*Pangasius pangasius*) have also been affected by the barrage.

34. Joshi K.D and Lal K.K, 2017. Status of Coldwater Fish Diversity in India and Strategies for Conservation. Published in the Souvenir on National seminar on 'Strategies, innovations and sustainable management for enhancing 14 Coldwater fisheries and aquaculture, ICAR-DCFR, Bhimtal, Nainital.

35. Sinha, M., De, D. K. & Jha, B. C. 1998.The Ganga-Environment & Fishery. Central Inland Capture Fisheries Research.

5.5 Sedimentation

Erosion of topsoil in the catchment area is the main man-made factor that leads to increased sediment load in rivers. Excessive sediment load in river water reduces transparency, light penetration and chemical quality of water. Removal of forest cover in the slopes for logging, cattle grazing and road making or for human settlements makes the soil susceptible to erosion, leading to increased sedimentation in the river. Heavy siltation from catchment areas cuts off floodplain oxbow lakes and deep pools during summer. Major carps are known to retreat to these areas during dry season. The silt, cobbles and boulders from the mountain slopes find their way to adjoining streams, rivulets, rivers, lakes and reservoirs and deteriorate the feeding and breeding grounds of fishes. The sudden influx of the massive silt load in the stream or river waters after heavy rains causes choking of the gill rakers and eye and causes mass mortality in fishes. Fish mortality also occurs when residue of forest fire alters the physico-chemical parameters of the natural waters[36].

5.6 Invasive species

The inland rivers and wetlands are invaded by exotic species, threatening the existence of many of the habitats and considerably affecting the native species. Some of the plant invasive species recorded are water hyacinth (*Eichhornia crassipes*), pink morning glory (*Ipomea carnea*), butterfly fern (*Salvinia auriculata*), parrot's feather (*Myriophyllum aquaticum*), reed canary grass (*Phalaris arundinacea*) and so on. Over 300 exotic fish species have been brought to India for aquaculture, sport fishing, mosquito control and aquarium purposes and some of them have entered into the natural inland water systems and in turn caused extensive damage to the native species. These include Common carp (*Cyprinus carpio*), African catfish, (*Clarias gariepinus*), Sucker mouth catfish (Pterygoplichthys spp.), Tilapia (*Orecohromis mossambicus*), Grass carp (*Ctenopharyngodon idella*), Silver carp (*Hypophthalmichthys molitrix*) and so on. In the river Ganga, presence of exotic species such as *Cyprinus carpio* and *Oreochromis niloticus*[37] are increasing. The occurrence of African catfish is

36. Joshi K.D and Lal K.K, 2017. Status of Coldwater Fish Diversity in India and Strategies for Conservation. Published in the Souvenir on National seminar on 'Strategies, innovations and sustainable management for enhancing Coldwater fisheries and aquaculture, ICAR-DCFR, Bhimtal, Nainital.

37. Singh, A.K. and M.S. Akhtar, 2015. Coldwater fishery resources, fish diversity and its sustainable management in India. In: Faunal Diversity in India (eds. R. C. Soblti, Kamal Jaiswal and Suman Mishra) Narendra Publishing House, Delhi, India pp 397-412.

reported in rivers Ganga, Yamuna, Sutlej, Godavari and Periyar and lakes such as Vembanad[38]. In Kerala, the high occurrence of tilapia species in inland waters has been reported, due to which the native species such as *Puntius dubius* and *Labeo kontius* face extinction. It was also reported that the ornamental alien fish species hybridise with indigenous species in the wild, diluting the wild genetic stock leading to long-term introgression of gene pools[39].

5.7 Ornamental fishes

In India, the exotic ornamental fish species dominate the aquarium trade, and are propagated for domestic and export purposes. More than 600 fish species are available in the country to meet the demand of the customers. The domestic market of ornamental fish is over ₹500 million and India's contribution to the global trade is 0.08 percent. About 96 percent

Photography: TNAU

38. Singh, A.K.2014. Emerging alien species in Indian aquaculture: Prospects and threats. Journal of Aquatic Biology and Fisheries, 2(1) 2014:32-41.

39. Pimentel. D et al 2001. Economic and environmental threats of alien plant, animal and microbe invasions. Agriculture, Ecosystem and Environment 84:1-20.

of ornamental fishes are freshwater species and many of these species escape from culture facilities or they are deliberately released into the riverine system[40]. Some of the biodiversity concerns related to the ornamental fish trade are very serious as nearly 85 percent of the ornamental fish exported is caught from the wild stock. The north-eastern region and the Western Ghats are known for its rich repository of ornamental fish species. Out of the total 225 species reported, about 187 (74 %) are known for their ornamental value and some of the important species are *Puntius conchonius, P. gelius,P. ticto, P. sophore, Brachydanio rerio, Botia almorhae, Carassius carassius, C. auratus, Badis badis, Barilius barna, B. vagra*, etc[41].

5.8 Destructive fishing practices

Destructive fishing practices are reported in most of the riverine systems. People catch fish with the help of locally fabricated gears such as cast nets, gill nets, mosquito net, traps, rod and lines. The fishers are almost completely replaced by poachers in the smaller streams or rivers during summer when the water level is at its minimum. Several highly destructive and illegal fishing methods, such as dynamite fishery, poisoning using plant extracts and bleaching powder, electrocution, complete sieving and mass destruction of fishes on religious grounds are practised in the hilly regions. The Indian Fishery Act, 1897 stipulates ban on some of these gears and practices but many States have not framed rules.

40. A.K. Singh, Dinesh Kumar, Sharad C. Srivastava, Abubakar Ansari, S.M. Srivastava and Sudhir Raizada, 2013. Exotic Ornamental Fish Species in Uttar Pradesh. Published by NBFGR, ICAR.

41. Joshi K.D and Lal K.K, 2017. Status of Coldwater Fish Diversity in India and Strategies for Conservation. Published in the Souvenir on National seminar on 'Strategies, innovations and sustainable management for enhancing Coldwater fisheries and aquaculture, ICAR-DCFR, Bhimtal, Nainital.

6. MAINSTREAMING BIODIVERSITY

Mainstreaming is an important policy tool, which helps in strengthening the linkages between biodiversity and fisheries. The Convention on Biological Diversity (CBD) has urged parties to develop national and regional biodiversity targets, using the strategic plan and its global Aichi targets. The Aichi targets emphasise that 17 percent of terrestrial and inland water areas, especially areas of particular importance for biodiversity and ecosystem services are conserved by well-connected systems of protected areas and effective relevant conservation measures. Accordingly, India has developed 12 national biodiversity targets[42]. The targets (5, 6 and 8) related to inland fisheries emphasise to achieve sustainable fisheries, conservation of ecologically representative areas and safety of areas of ecosystem importance (For example, inland water bodies, wetlands and aquatic fauna). Some of the approaches suggested for mainstreaming biodiversity into the inland fisheries include: (a) Ecosystem approach; (b) Access and user rights; (c) Marketing incentive and export; (d) Policy and institutional strengthening[43].

Photography: V.R.Suresh, ICAR-CIFRI.

42. National Biodiversity Action Plan, Addendum 2014 to NBAP 2008. Published by MoEFCC, GoI.

43. The Ecosystem approach to fisheries, 2003. ISSN 1020-5292; ISBN 92-5-104897-5, Published by FAO Corporate document repository.

6.1 International and national initiatives

India is committed to several international conventions, Code of conduct and guidelines towards conserving land-based aquatic biodiversity resources namely, CBD 1993; Convention on Conservation of Migratory Species (CMS), 1982; Ramsar Convention on Wetlands, 1982; United Nations Framework Convention on Climate Change (UNFCCC); FAO Code of Conduct for Responsible Fisheries (CCRF); Food and Agriculture Organisation (FAO) guidelines on eco-labelling for inland fisheries; FAO technical guidelines for aquaculture certification and FAO technical guidelines for small scale fisheries, and so on. To conserve the wetlands, a wetlands (Conservation and Management) Rule, 2017 was notified under the provisions of the Environment (Protection) Act, 1986. The Ministry of Urban Development (MoUD) has issued an advisory on conservation and restoration of water bodies in urban areas and a river conservation programme was initiated with the launch of Ganga Action Plan (GAP) in 1985 and was expanded to cover other rivers under the National River Conservation Plan (NRCP)[44].

Photography: ICAR-DCFR, Bhimtal, Nainital.

44. India's Fifth National Report to the Convention on Biological Diversity, 2014. Published by MOEFCC, GoI.

7. OBJECTIVES

For undertaking a study on mainstreaming biodiversity into the inland fishery resources, a policy analysis was carried out on the existing policy, schemes, and programmes of the inland fisheries sector implemented by the Ministry of Agriculture and Farmers Welfare (MoA&FW). This study has brought out a set of recommendations to address the biodiversity concerns in the inland sector. These recommendations were deliberated though a consultative process and a national level policy dialogues were organised on the 28 and 29 of November, 2017 at National Academy of Agricultural Research Management (NAARM), Hyderabad. The objectives of the study are to:

- Develop a roadmap for achieving the National Biodiversity Targets (NBTs) and Sustainable Development Goals (SDGs) related to the inland fisheries sector;
- Integrate biodiversity related activities into the existing schemes, projects, programme and plans of the concerned ministry towards increasing the indigenous fisheries resources wealth of the country into the inland water bodies;
- To develop framework for conservation of the ecologically representative areas in inland waters especially those of particular importance for species, biodiversity and ecosystem services.

Photography: V.R.Suresh, ICAR-CIFRI.

8. RECOMMENDATIONS

8.1. Inland open water systems

8.1.1 *Conservation* and *restoration of inland aquatic ecosystems*

Inland open water bodies are repositories of fish and other aquatic biodiversity. Hence, there is a need to conserve the whole ecosystem to sustain the biodiversity of these water bodies. Many such water bodies are facing different levels of habitat degradation and even habitat loss, which can lead to decline or loss of biodiversity. It is important to conserve and restore the degraded river stretches, wetlands and other inland water bodies towards conserving the aquatic bioresources for the well-being of humans.

Action Points

1. An Ecosystem health card (based on (a) water quality index; (b) habitat index; and (c) living resources index) can be prepared for the major river stretches, reservoirs, lakes and wetlands. Plans must be developed to restore the affected stretches of rivers and lakes through existing national river and lake conservation programmes.
2. The "Sustainable river sand/boulder mining management guidelines, 2016", published by the MoEFCC must be strictly adhered, to ensure environmentally sustainable mining.
3. A major cause of biodiversity loss is the diminishing/impaired flows of water in rivers and associated wetlands due to various water abstraction projects. While providing approvals for river valley projects, environmental flow requirements must be made mandatory as a part of Environmental Impact Assessments (EIA).
4. Providing fish passes/diversion cannel for dams and barrages has been recognised as an effective tool for facilitating upstream and downstream migration of fish species. Fish passes must be designed keeping in mind the swimming and migratory habits of target species, hydrodynamics and the nature of hydraulic structures. Wherever possible umbrella fish pass/ diversion channel suitable for all the species must be considered. Appropriate agencies/Institutes in the country with adequate expertise must be identified and entrusted with the responsibility to suggest the most suitable, location-specific fish passes (fish ladders, fish locks, fish lifts, diversion channels and so on) to meet the requirements of the dams/barrages. This component must be included in Draft Project Proposal (DPP) of dam projects.

5. Hill streams above 3000 m Mean Sea Level (MSL) must be declared as ecological sensitive zones in which developmental activities (including water abstraction) must be avoided.
6. Strategic Environmental Assessment (SEA) must be carried out for developmental projects in the biodiversity rich areas by mainstreaming the environmental concerns into economic development and integrating green economy targets into strategic and project related decision making.
7. Destructive fishing gear such as fixed/stake nets, zero or small mesh nets and fishing methods such as dynamiting, poisoning, capturing juveniles and brooders of declining fish species pose a threat to biodiversity and are detrimental to natural fish populations. Strict implementation of existing rules against using these fishing gears or methods must be ensured.
8. As inland fisheries management is more of a State responsibility, the concerned State government machineries must be strengthened with advisory and monitoring role for central agencies, thus appropriate institutional and governance mechanisms in this direction must be in place.
9. Community-based or co-management of open water fisheries can be strengthened. Fishing in open water resources should be under strong co-management platform involving Corporative Societies, Self Help Groups (SHGs) and Biodiversity Management Committees (BMCs) to ensure responsible fishing practices.

8.1.2 *Conservation of fish genetic resources*

India has rich aquatic genetic resources is representing 9.7 percent (9,456 species) of the known animal species. The Gangetic river system alone harbours 265 fish species whereas the Brahmaputra and peninsular rivers have 126 and 76 species of fishes, respectively. An action plan is required to conserve these species from extinction through *in-situ* and *ex-situ* conservation plans.

Action Points

1. Conservation action plans must be prepared by the States or Union Territories (UTs) for all open water resources where fisheries resources are threatened.
2. Seed production and ranching of indigenous species must be encouraged and incentivised. The seed produced from the original parents (Native germplasm with good effective breeding population and equal sex ratio) collected from pristine stretches of the river should be used for ranching. Seed produced from mixed spawning process and the offspring of farm-based brood stock must not be used for river or lake ranching, as they adversely affect the riverine fish biodiversity. A protocol for ranching must be developed by the ICAR research institutes and the same can be circulated by the Department of Animal Husbandry, Dairying and Fisheries (DAHDF) to all State governments.

To accomplish this, steps must be taken to create basic infrastructure facilities, such as hatcheries, nurseries, fry/advance fingerling raising centres, and so on. Stocking of fishes from unknown sources in the open waters or rivers for any purpose, including religious purpose must be banned.

3. Emphasis should be given for cultivating indigenous species and the viability of the localised species should be improved through breeding programmes.

8.1.3 *Database*

The main constraint in conserving the inland aquatic resources is the absence of reliable database on water resources and their production functions. Unlike the marine segment, the water bodies, landing centres and market chains in the hinterlands are highly diffused and as a result, catch data and resource inventory from different kinds of inland water bodies are not recorded systematically. This calls for action plans for creating reliable databases to enable planning and policy formulations.

Action Points

1. Mapping of indigenous fish species, their habitats and production trends is essential. It is important to document the available inland aquatic bioresources through People's Biodiversity Registers (PBRs) and electronics database.
2. To create an inventory of economically important cultivable native species for propagation through *in-situ* conservation, hatcheries and brood banks.

8.1.4 *Valuation of ecosystem services provided by inland water bodies*

Inland open water bodies like rivers, streams, wetlands, etc. provide several valuable ecosystem services. There is a need to valuate ecosystem services of inland water bodies so that planners and policy makers appreciate the real value of these resources enabling them to take cognizance of the importance of biodiversity when planning, formulating or evaluating development projects related to aquatic ecosystems.

Action Points

1. Proper valuation of ecosystem services provided by the inland open waters such as river stretches, wetlands must be carried out. This will help the policy makers to prioritise, manage and conserve the biodiversity rich areas.
2. A suitable Indian model for valuation of ecosystem services is needed. To achieve this, a pilot study can be conducted.

8.2 Aquaculture

8.2.1 *Regulatory mechanism*

The inland open water fisheries and the freshwater aquaculture are not covered under any strong regulatory frameworks to insulate them against unsustainable practices (namely, hyper-intensive aquaculture, higher stocking density beyond carrying capacity, import of exotic fishes seed without clearance, illegal import of feeds and accessories, and culture practices). This is in contrast to the marine fisheries and coastal aquaculture, where some forms of regulatory mechanisms are already in place. This situation calls for forming a statutory mechanism to regulate activities in inland fisheries and freshwater aquaculture to ensure that biodiversity is not compromised while pursuing production targets.

Action Points

1. An appropriate organisation must be empowered to regulate the activities of the freshwater aquaculture.
2. Fool-proof facilities to prevent escape of fish from aquaculture to open water bodies (natural waters) must be ensured before granting permission to start aquaculture ventures. Guidelines for this must be prepared by the leading Research Institutes and States should ensure strict compliance of such measures.
3. At local and national level, production, marketing and distribution of fish seed must be brought under a strong certification regime. An appropriate agency must be identified and accredited/empowered for this purpose.
4. Aquaculture practices are known to cause environmental degradation (due to farm outfalls like chemicals, feeds, etc.) of adjoining water bodies, agricultural fields, drinking water sources, open waters and land. Adverse impact of these must be assessed and regulated to avoid or minimise such degradation.

5. Use of raw sewage as input to the aquaculture ponds is detrimental to the health of the ecosystem and human beings. Sewage must be allowed into the aquaculture waters only after appropriate treatment in order to ensure that the fish produced are fit for human consumption and the environmental degradation is minimised.
6. Best Management Practices (BMPs) protocols and guidelines should be prepared on important culture systems like cage culture, intensive aquaculture, etc. to be followed by the States.

8.2.2 *Hatcheries*

Many unsustainable hatchery practices are prevalent in the country and cause concerns. Biodiversity norms are compromised when inappropriate brood stock is used. Similarly, mixed spawning of different species leads to serious issues of genetic contamination. There is an urgent need for action plans to streamline and strengthen the brood stock management and seed production systems in the country by bringing them under BMP, apart from creating databases for centralised monitoring.

Action Points

1. The existing single species fish seed hatcheries in the public sector must be converted into multi-species fish seed hatcheries as a measure of diversifying aquaculture species. At the same time, the prevailing practice of mixed spawning of different species of Indian major carps, as followed in some parts of the country, must be stopped through legislative or enforcement measures, backed by appropriate awareness campaigns. The BMP must be developed by the concerned research institutes.
2. State level action plan is required to produce and maintain brood stocks for all important native germplasm under the guidance of national research Institutes. All hatcheries must follow BMPs developed by research institutes.
3. All the existing hatcheries must be brought under a national database for centralised monitoring.

8.2.3 *Ornamental fishes*

Ornamental fish has emerged as a sunrise segment within the fisheries sector that commands a lucrative domestic and overseas trade. However, many unsustainable practices plague the segment. Some of these practices include, collecting precious germplasm from the wild, illegal

export, bringing exotic fishes to the country without clearance, not following quarantine procedures and escape of exotic species to the natural water bodies. Collection of wild fish from biodiversity hotspots like Eastern Himalayas and the Western Ghats is a matter of serious concern.

Action Points

1. A policy is required to ensure compliance of quarantine measures for the trade of ornamental fishes. Existing quarantine mechanisms must be strengthened and quarantine requirements must be enforced strictly for trans-boundary import of seeds, feeds and ornamental fish species.
2. Illegal trade (including online trade) of native/endemic ornamental fishes collected from rivers, lakes must be curbed and the monitoring mechanism strengthened.
3. Collection of wild stocks of ornamental fishes from the rivers and other water bodies in the Himalayas for sale/export needs must be strictly curbed.
4. Incentives for propagation of indigenous ornamental fish for sale or export must be enhanced.
5. A database on the native and endemic ornamental fish species of Eastern Himalayas and the Western Ghats must be created.
6. There is also need for framing and implementing guidelines for hobbyists and ornamental fish keepers about holding and disposal of stock to avoid these species from reaching natural water bodies.

8.3 Incentive mechanisms

Incentives can be provided for biodiversity friendly practices such as: (a) promoting indigenous varieties; (b) following responsible fishing practices; (c) performing organic aquaculture and (d) bringing unused water bodies under sustainable fishing practices.

Action Points

1. Governments must provide incentives to bring the unused or derelict water bodies like, water-logged areas, canals, dead rivers, and so on towards increasing the biodiversity wealth of the country.
2. There is a need to improve and stabilise farm productivity and income generation for the rural poor by encouraging integrated farming practices (including rice- fish diversified farming), fish culture in watershed ponds and water harvesting structures. Also, the backyard or household ponds can be promoted and incentivised.

3. One-stop aqua-shops must be promoted, with proper registration and accreditation for ensuring free movement of disease-free and quality seed, brood stock and other inputs and accessories for shrimp and fish culture.
4. Fishers' Cooperatives and SHGs, who fish in open waters, must be encouraged to resort sustainable fishing practices through appropriate incentives.
5. Polluting industries must pay compensation for damage caused to inland water bodies based on the "Polluter Pays" principle.

8.4 Invasive alien species

Unregulated introduction of alien species is a major biodiversity concern. The existing mechanisms to regulate introductions of invasive alien species are weak. Many alien species exist in the country, which were brought in without clearance from the authorities and many more species are being brought into the country through the porous borders. Keepers or hobbyists also discard ornamental fishes into open waters, when they no longer want to hold them or when the fish grows too large for holding in aquaria. Enforcement, risk assessment and monitoring mechanisms to regulate their entry, culture, sale and disposal must be in place.

Action Points

1. There is a need to prepare a database on exotic or invasive alien species and their invasion pathways. Strategies must be developed for managing or controlling them based on risk assessment. Quarantine measures must be strengthened.
2. The State or UT governments must strictly enforce or implement the existing regulations by effective intervention in curbing the illegal introduction, culture and sale of species that are not allowed by the regulatory agencies.
3. Voluntary guidance must be provided to avoid unintentional introduction of Invasive Alien Species (pets, aquarium species, terrarium species, live bait and live food) associated with trade of live organisms.
4. International Union for Conservation of Nature (IUCN) Guidelines must be strictly adhered when considering introductions or reintroductions of all exotic species.
5. Silver carp, common carp and grass carp must be restricted or discouraged in favour of native species in aquaculture in the Himalayan States.

6. There must be easy-to-use pictorial guidelines to enable the customs officers to identify the species.
7. International cooperation must be secured to regulate unrecognised introductions from neighbouring countries. The Central Government must create norms for uniform quarantine measures for introduction of species and encourage state Governments to follow them.
8. Stocking of rainbow trout in open streams or lakes must be stopped until a policy for stocking rainbow trout and brown trout is developed.

8.5 Certification / Eco-labelling

Certification and eco-labelling are strong tools to promote sustainable fishing and aquaculture practices. There is an urgent need to develop capacity and create institutional mechanisms for this. Fish produced or captured through biodiversity friendly means must be given market promotion and incentives.

Action Points

1. Fish and fishery products from sustainable fishing/aquaculture practices must be brought under a strong certification regime. Organisations must be identified and accredited or empowered to grant Green Certification and eco-labelling for such products.
2. Regular or periodic monitoring and certification of hatcheries are required for availability of quality fish seed.
3. Endemic and indigenous species (as against commonly cultured species) produced in farms must be promoted and incentivised on a larger scale. Developing protocols for branding, organic certification, green labelling, eco-labelling must be developed. Identification, creation, accreditation or empowerment of organisations for ensuring compliance to such protocol is required.

8.6 Post-harvest processing and value additions

At present, the quality standards for post-harvest processing and value addition activities with respect to fish or fish products are followed to meet the needs of export trade. This is achieved by following the strict standards set by overseas buyers. The products sold in the domestic markets do not meet necessary standards or quality and this often acts as a major market disincentive. Therefore, there is a need to encourage high quality post-harvest processing and

value addition in the domestic market so that consumers get hygienic products and producers get better price.

Action Points

1. It is necessary to develop Indian standards for fishery products in the domestic market, similar to the ones set for export.
2. Post-harvest losses must be reduced and infrastructure for cold chain for transportation must be strengthened at the local level.

8.7 Strengthening the implementation of the BD Act

The compliance to the following action points will strengthen the implementation of the existing provisions of the Biological Diversity Act.

Action Points

1. The unique and ecologically fragile ecosystems (namely inland water bodies and river stretches with the presence of high endemism, rare and threatened species, key stone species, species of evolutionary significance, wild relatives, migratory routes and spawning and breeding areas) can be designated as fish sanctuaries or Biodiversity Heritage Sites (BHSs) by the concerned State Governments/UTs in consultation with the local bodies.
2. Similarly, the North-Eastern region and Western Ghats being the biodiversity hotspots, the State Governments along with the State Biodiversity Boards (SBBs) and BMCs must identify areas of biodiversity importance and notify these areas as BHSs.
3. The Central Government, in consultation with the State Government can notify any aquatic species which are in the verge of extinction or likely to become extinct in the near future, as threatened species. Appropriate steps must be taken to rehabilitate those species. Special attention must be given for Himalayan states and Western Ghats.
4. There is a need to develop guidelines for notifying aquatic resources/products under the Normally Traded as Commodities (NTC) ambit.
5. Collection of fish or shrimp seed from the wild must be stopped through appropriate legal or regulatory measures.
6. For mobilising local biodiversity fund, cess fee may be collected by the BMCs for the export of aquaculture species / products.

9. CONCLUSION

The inland aquatic bioresources provide food, nutrition and livelihood security for millions of people around the globe. India's rich aquatic biodiversity has declined significantly over past few decades due to multiple anthropogenic factors. To conserve the aquatic genetic resources, the global - Aichi biodiversity target emphases parties to adopt ecosystem-based approach. This approach eliminates over fishing and develops recovery plans for depleted species to maintain stocks. India's national biodiversity target recommends conserving the ecologically representative areas especially those of particular importance for species, biodiversity and ecosystem services (namely, areas high in species richness or threatened species; threatened biomes and habitats; key biodiversity areas, high conservation value areas and important plant areas). Keeping the obligations of the Aichi target and national targets, the present study has brought few recommendations towards integrating the biodiversity concerns into the inland fisheries sector. There is an urgent need to address the loss of India's aquatic biodiversity.

It is emphasised that the unused water bodies must be mapped and these water resources must be brought under the cultivation practices towards increasing native fish stocks and aquatic biodiversity. For conserving the fish genetic resources, the pristine stretches of rivers must be adequately stocked with the indigenous species and through *in-situ* conservation, hatcheries and brood banks. Freshwater aquaculture is not covered under any strong regulatory framework; hence it is suggested to regulate the activities of the freshwater aquaculture by developing strict guidelines. Some of the suggested recommendations include: prevention of fish escape from the aquaculture pond to the natural open water bodies; production of fish seed under a certification regime; development of protocols on BMPs for cage culture; conversion of single species seed hatcheries into multi-species hatcheries and providing incentives for farmers for promoting indigenous varieties. Also, it is suggested to:

- Develop an ecosystem health card for the major rivers and lakes
- Develop a database on aquatic resources
- Observe a ban period in reservoirs to allow auto stocking
- Diversify native fish/aquaculture species
- Encourage integrated fish farming and poly-culture
- Distribute quality seed and feed for aquaculture

The derelict water bodies can be used to boost the fish production/diversity and in turn, meet the future demands of the country. Coastal Orissa is endowed with large areas of unutilised water bodies like derelict canals and drains. Similarly, the Brahmaputra basin of Assam has enormous beels lying idle. There are about 1.3 million hectares of beels and other derelict water bodies in the country. Bringing these water bodies into the scope of fisheries will tremendously boost fish production.

For strengtheing the implementation of the BD Act, it is recommended to declare the important aquatic ecosystem with high endemism as BHS; notifying rare and threated aquatic species (plant and animal) in the verge of extinction and rehabilitate those species. It is also suggested to regulate the collection of wild stocks of ornamental fishes from the aquatic system and to develop an invasive alien species policy towards prioritising, managing and controlling the spread of these species into the inland water bodies.

A matrix detailing the recommendations, action plans and the responsible agencies are given in annexure 1.

Annexure I

Matrix - Key recommendations, actionable points and responsible agencies

S. No	Actionable points	Responsible Agencies	Linkages with NBAP and BDA
8.1 INLAND OPEN WATER SYSTEMS			
8.1.1 Conservation and restoration of inland aquatic ecosystems			
1	Action plans for conserving and restoring degraded river stretches, wetlands and other inland water bodies. Water quality health cards prepared for the river stretches and other inland water bodies.	MoEFCC, National River Conservation Directorate (NRCD), Ministry of Water Resources (MoWR), CIFRI and National Bureau of Fish Genetic Resources (NBFGR).	92 and 108
2	Sustainable river bed/ boulder mining management guidelines, must be strictly adhered.	MoEFCC and NRCD.	
3	Environmental flow requirements must be mandatory under the EIA clearance.	NBFGR, MoWR, CIFRI and MoEFCC.	91
4	Fish passes must be integrated in the dam/ barrage projects to facilitate migratory movement of fishes.	MoWR, MoEFCC and CIFRI.	
5	Declaring hill streams above 3000 m above MSL as sensitive zones.	State Governments of Himalayan States and Western Ghats states.	
6	Strategic Environmental Assessment must be carried for the developmental projects.	MoEFCC.	
7	Destructive fishing methods/ gears must be banned.	State/UT Governments.	
8	Institutional and governance mechanisms must be strengthened.	State/UT Governments.	
9	Community-based or co-management of open water fisheries must be strengthened.	State/UT Governments.	21
8.1.2 Conservation of fish genetic resources			
1	List of threatened endemic/ charismatic/keystone species in the inland water bodies must be documented for bringing them under the 'Species recovery programme'.	MoEFCC, NBFGR and CIFRI .	119
2	Ranching river stretches with indigenous fish species is needed.	States/UTs, DAHDF, NBFGR and MoEFCC.	

8.1.3 Database			
1	Mapping of indigenous fish species, their habitats and production trends is essential. It is important to document the available inland aquatic bioresources through PBRs and electronics database.	NBFGR, Directorate of Coldwater Fisheries Research (DCFR), SBBs, BMCs and NBA.	115 and 128
2	Creation of inventory of economically important cultivable native species for propagation through *in-situ* conservation, hatcheries and brood banks is required.	States/UTs, CIFRI, NBFGR and DCFR.	26
8.1.4 Valuation of ecosystem services			
1	Proper valuation of ecosystem services provided by the inland open waters such as river stretches, wetlands must be carried out. This will help the policy makers to prioritise, manage and conserve the biodiversity rich areas.	CIFRI, NRCD and MoWR.	165
2	A suitable Indian model for valuation of ecosystem services is needed. In order to achieve this, a pilot study can be conducted.	National Institute of Environment (NIE) and CIFRI.	166
8.2 AQUACULTURE			
8.2.1 Regulatory mechanism			
1	Regulate the activities of freshwater aquaculture.	MoEFCC, Central Institute of Freshwater Aquaculture (CIFA), DCFR and CIFRI.	
2	Develop guidelines to ensure fool-proof facilities exist to prevent escapement of fish from aquaculture to natural open water bodies.	CIBA, CIFA, DCFR, CAA, MoEFCC and States/UTs.	
3	Develop certification procedure to cover marketing and distribution of fish at the local and national level.	State/UTs, CIFA, CIBA, DCFR and CAA.	
4	Assess the adverse impact of environmental degradation due to aquaculture activities and develop regulatory measures to avoid/minimise such degradation.	CIFA, CIBA, DCFR and CAA.	
5	Usage of raw sewage for aquaculture activities must be regulated.	CIFA, CIBA and CAA.	
6	BMPs protocols and guidelines for cage culture, intensive aquaculture, etc. must be prepared.	CIFA, CIBA, DCFR and CAA.	
8.2.2 Hatcheries			
1	Establishment of multispecies hatcheries must be encouraged. The prevailing practice of mixed spawning of different species of Indian major carps, as followed in some parts of the country, should be stopped through legislative/ enforcement measures.	States/UTs, CIFA and MoEFCC.	

2	Preparation of State level action plan to maintain brood stocks for all important native germplasm is required.	State/UT, NBFGR, Governments, CIFA and CIBA.	
3	Bringing all the existing hatcheries under a national database for centralised monitoring is necessary.	DAHDF and State/UT Governments.	
8.2.3 Ornamental fishes			
1	Develop policy and institutional mechanisms to ensure compliance of quarantine measures for the trade of ornamental fishes. Enforce regulation on transboundary import of seeds, feeds and ornamental fish species.	MoEFCC, CIFA, CIBA and NBFGR.	
2	Curb illegal trade of native/ endemic ornamental fishes and strengthen the monitoring mechanism.	State/UTs, MoEFCC and Marine Products Export Development Authority (MPEDA).	13
3	Export based on collection of wild stocks of ornamental fishes from rivers and other water bodies in the Himalayan and Western Ghats states should be strictly prohibited.	MoEFCC, and Governments of Himalayan and Western Ghats states.	
4	Enhance incentives for propagation of indigenous ornamental fish for sale/ export.	State/UT	Governments, DAHDF and MPEDA.
5	Prepare database on native and endemic ornamental fish species of Eastern Himalayas and the Western Ghats.	Governments of Himalayan and Western Ghats states.	
6	Need for framing and implementing guidelines to hobbyists and ornamental fish keepers as to hold and dispose of stock to avoid species reaching natural water bodies.	State/UT	Governments, DAHDF, CIBA and DCFR.
8.3 INCENTIVE MECHANISMS			
1	Provide incentivises to bring unused/derelict water bodies/dead rivers/water logged areas under extensive polyculture/pisciculture practices.	State/UT Governments, National Fisheries Development Board (NFDB) and DAHDF.	54, 55 and 58
2	Encourage integrated farming in watershed ponds and water harvesting structures and backyard/ household ponds by incentivisation.	State/UT Governments, NFDB and DAHDF.	54 and 55
3	Promote one-stop aqua-shops under duly registered and accredited agencies for ensuring free movement of disease-free and quality seed, brood stock for shrimp and fish culture.	MPEDA, NFDB, DAHDF and State/UT Governments.	
8.4 INVASIVE ALIEN SPECIES			
1	Preparation of database on aquatic inland invasive alien species and prioritisation is required.	DAHDF, MoEFCC, NBFGR and CIFRI.	62

2	Strictly enforce/implement the existing regulations in curbing illegal introduction, culture and sale of invasive species.	State/UT Governments.	
3	Prepare voluntary guidance for avoiding unintentional introduction of Invasive Alien Species (introduced as pets, aquarium, terrarium species, live bait and live food) associated with trade in live organisms.	NBA/SBBs/ CIFA, CIFRI, CIBA, Central Marine Fisheries Research Institute (CMFRI) and NBFGR.	
4	IUCN Guidelines must be strictly adhered while considering introductions of exotic species.	MoEFCC.	
5	Silver carp, common carp and grass carp must be restricted or discouraged in favour of native species in highland aquaculture.	DCFR, DAHDF, and Himalayan and Western Ghats States.	
6	Prepare easy-to-use pictorial guidelines to enable the customs officers to identify the species.	CIFA, CIFRI, CIBA, CMFRI and NBFGR.	65
7	Secure international cooperation to regulate unrecognised introductions of Invasive Alien Species from neighbouring countries.	DAHDF, MoEFCC and Ministry of External Affairs (MoEA).	67
8.5 CERTIFICATION/ECO LABELLING			
1	Promotion of green certification and eco labelling of fish and fishery products for sustainable fishing/ aquaculture practices is required.	MoEFCC, ICAR and DAHDF.	102
2	Regular/periodic monitoring and certification of hatcheries is required for availability of quality fish seed.	ICAR and DAHDF.	
3	Endemic and indigenous species produced in farms needs must be promoted and incentivised on a larger scale.	ICAR, DAHDF, CIBA and CIFRI.	
8.6 POST-HARVEST AND VALUE ADDITIONS			
1	Make quality standards of fishery products in the domestic market at par with export trade.	Ministry of Commerce, BIS and Central Institute of Fisheries Technology (CIFT).	
2	Reduce post-harvest losses and strengthen cold chain infrastructure for transportation at the local level.	State/UT Governments CIFT and DAHDF.	
8.7 STRENGTHENING THE IMPLEMENTATION OF THE BD ACT			
1	Unique and ecologically fragile ecosystems must be designated as BHSs.	State/UT Governments SBBs, BMCs and Local bodies.	Section 37 of the BD Act.
2	The North-Eastern region & Western Ghats being the biodiversity hotspots, biodiversity important areas identified and notify these areas as BHSs.	NBFGR, MoEFCC, State Governments/UT and SBBs.	Section 37 of the BD Act.

3	Notify species which are on the verge of extinction or likely to become extinct in the near future as a threatened species and appropriate step to rehabilitate (through *in-situ* and *ex-situ* conservation).	Central/State Governments, SBBs, NBA, ZSI, BSI and FSI.	Section 38 of the BD Act.
4	Develop guidelines for notifying NTCs for the fisheries sector.	NBA, MPEDA and SBBs.	Section 40 of the BDA.
5	Stop collection of fish/shrimp seed and brood stock from the wild through appropriate legal/regulatory measures.	NBA and SBBs.	Section 7 of the BDA.
6	Levy biodiversity cess/fee for export of aquaculture species/ products for mobilising local biodiversity fund.	SBBs and BMCs.	

Annexure II

List of experts contacted while undertaking the study

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Annexure III

List of experts attended the policy dialogue on mainstreaming biodiversity into inland and cold water fisheries at the National Academy for Agricultural Research Management, Hyderabad Held on 28th & 29 November, 2017

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About CEBPOL

Government of India in collaboration with the Norwegian Government has established "Centre for Biodiversity Policy and Law (CEBPOL)" at the National Biodiversity Authority (NBA), an autonomous and statutory body of the Ministry of Environment Forest and Climate Change towards strengthening of expertise in Biodiversity Policy and Law in India. This programme is executed by the NBA in collaboration with Norwegian Environment Agency through the Royal Norwegian Embassy, New Delhi, India.

The Centre aims to provide advice and support to the Government of India and Norway on Biodiversity Policy and Law related issues including complex negotiations on Access and Benefit Sharing and Traditional knowledge as well as governance issues relating to biodiversity at the National and International level. The Centre proposes to help NBA in the effective implementation of International agreements on conservation, sustainable use and the associated access and benefit sharing components of it.

CEBPOL is set up as a specialized Centre of Excellence in Biodiversity Policy and Law to network, organize and consolidate expertise on issues of Biodiversity Policy and Law in India and Norway. The Centre, located at NBA, would function as an independent think tank on Biodiversity Policy and Law. In addition, CEBPOL aims to contribute to the effective implementation of the Biological Diversity Act 2002 and Rules 2004.

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Forest and Climate Change
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