OPEN ACCESS

DOI: https://doi.org/10.52756/boesd.2022.e01.010

Chapter- 10

Conservation and prospects of Indian Lacustrine fisheries to reach the Sustainable Developmental Goals (SDG 17)

Pronoy Mukherjee[#], Aloke Saha[#], Koushik Sen, Hadi Erfani, Nithar Ranjan Madhu and Tanmay Sanyal*

Keywords: Aesthetic Value, Biodiversity, Ecosystem, Lacustrine Fishery, SDGs.

Abstract:

According to the FAO, aquatic resources that have merit for exploration, exploitation, and extension for commercial purposes would be referred to as "fish." Fish provide an important source of food and livelihoods for millions of people, and they are a renewable resource that can be managed sustainably if managed properly. Aquatic resource exploration, capture, catching, cleaning (post-harvest technique), transit, merchandise, processing for semi-prepared food or prepared food, scientific culture (propagation, grow-out operation, seasonal capture), etc., are all examples of lacustrine fisheries. Lacustrine fisheries are capable of providing a source of sustainable economic growth, employment and income opportunities, food security, and improved nutrition. Furthermore, well-managed fisheries can be an integral part of conservation and ecosystem management efforts, providing sustainable access to aquatic resources that are essential to maintaining healthy ecosystems. In addition to providing a source of food and livelihoods for millions of people, lacustrine fisheries also have the potential to help mitigate poverty and increase access to healthy foods. To ensure the long-term sustainability of fish populations, fisheries must be carefully managed, including implementing rules and regulations governing the amount that can be harvested, setting quotas for different species, and enforcing them. In this chapter, we will look at how the lacustrine fishery achieved some long-term development goals, either directly or indirectly.

Pronoy Mukherjee#
Rishi Bankim Chandra College, Naihati, West Bengal, India
E-mail: mukherjee.pronoy007@gmail.com; Orcid iD: https://orcid.org/0000-0002-4901-0141
Aloke Saha #
Department of Zoology, University of Kalyani, Kalyani, Nadia-741235, West Bengal, India
E-mail: alokesaha1999@gmail.com; Orcid iD: https://orcid.org/0000-0001-9985-3481
Koushik Sen
Department of Zoology, Jhargram Raj College, Jhargram, West Bengal, India
E-mail: koushiksen1987@gmail.com; Orcid iD: https://orcid.org/0000-0002-6995-7682
Hadi Erfani
Department of Chemical Engineering, Central Tehran, Branch, Islamic Azad University, Tehran, Iran
E-mail: hadierfani1368@gmail.com
Nithar Ranjan Madhu
Department of Zoology, Acharya Prafulla Chandra College, New Barrackpore, West Bengal, India
E-mail: nithar_1@yahoo.com; Orcid iD: https://orcid.org/0000-0003-4198-5048
Tanmay Sanyal
Department of Zoology, Krishnagar Government College, Krishnagar, West Bengal, India
E-mail: tanmaysanyal@gmail.com; Orcid iD: https://orcid.org/0000-0002-0046-1080
***Corresponding Author**: tanmaysanyal@gmail.com
# These authors have contributed equally to this work.

Nithar Ranjan Madhu & Biplab Kumar Behera (eds.), A Basic Overview of Environment and Sustainable Development. ISBN: 978-81-957954-2-0
Published online: 22nd August, 2022

Introduction:

Today, aquaculture and commercial fishing are the world's fastest-expanding sectors (Tacon, 2020), and they play an important role in food production and employment (Kumar & Shivani, 2014). Aquaculture and commercial fishing are two forms of fisheries that rely on wild caught and farmed fish, respectively. Capture fisheries act as a protein source for about 10% of the global population (*The State of World Fisheries and Aquaculture*, 2020, 2020). India is the hub of both inland and marine fisheries. The country has a wide variety of marine and freshwater fish species and accounts for over 4.3 million metric tonnes of fish production, making it the second largest producer in the world. Despite the fact that India produces a lot of fish, a lot of resources are taken from the natural environment to support these industries. India has made significant efforts to ensure the sustainability of its fisheries, but overfishing, by catch, and water pollution are still very much a problem. This country's coastline is 8,118 kilometres long, and our jurisdiction covers approximately 2.02 million square kilometres, according to the 1977 Exclusive Economic Zone. There are different zones of fisheries, such as inland fisheries (1.96 lakh km), 3.15 million hectares of reservoirs, 2.44 million hectares of ponds or lakes, 0.798 million hectares of beels, 1.24 million hectares of brackish water, and estuaries that also develop at 0.29 million hectares (Ngasotter et al., 2020). According to Holčík (1998), an ancient lake's fish yield capacity is far greater than that of any newly natural or man-made lake. Because true lacustrine species occupy all available habitat in ancient lakes, fish yield capacity is much higher (Holčík, 1998). There are two types of lakes present in India: floodplain lakes and upland lakes. Floodplain lakes occur due to seasonal flooding and the receding of rivers, whereas upland lakes are formed by natural processes such as glacier-induced depressions and human interventions like irrigation. A floodplain is a flat area near the river; it is formed due to the deposition of alluvium, which occurred due to the declining speed of the river. In India, there are over 200000 hectares of floodplain lakes known as jheel, beel, chaurs, mans, and pats in states such as Assam, Bihar, and West Bengal. However, the declining diversity of fishes in these water bodies is now due to the evolution of the river bed, infestation of many aquatic weeds, eutrophication, and devastating floods that can cause habitat destruction as well as bottom muck accumulation (Sugunan, 1997). These threats can have a devastating effect on the species diversity and ecological balance of these lakes, resulting in the gradual elimination of many species that used to inhabit these water bodies. In addition, the introduction of invasive species and excessive extraction of aquatic resources for agricultural, industrial, and recreational activities can further threaten the balance of these water bodies. To prevent further damage to the aquatic species in these water bodies, it is essential to implement conservation measures that would protect the diversity of fish and other species.

Table 1: Distribution of floodplain lake throughout India (Sugunan, 1997).

State	River basin	Area (ha)
Arunachal Pradesh	Kameng, Subansiri, Siang, Dibang, Lohit, Dihing and Tirap	2500
Assam	Brahmaputra and Barak	100000
Bihar	Gandak and Kosi	40000
Manipur	Iral, Imphal and Thoubal	16500
Meghalaya	Someswari and Jinjiram	213
Tripura	Gumti	500
West Bengal	Hooghly and Matlah (Ganga)	42500
Total		**202213**

Another type of lake is an upland lake or mountain lake, and its tropical water quality is different from other tropical regions due to its high altitude (Sreenivasan, 1964). Upland lakes are typically found in mountainous or hilly regions and are fed by glacial meltwater, precipitation, snowmelt, and springs. This causes mountain lakes to have different levels of dissolved oxygen than other lake types, which can affect the organisms that live in them. Upland lakes are usually situated in mountain valleys and tend to be less than 20 m in depth, meaning their water quality is largely dependent on the surrounding ecosystem. There are several upland lakes present in India, such as Dal Lake at Jammu, Suraj Tal Lake at Himachal Pradesh, TSO Lhamo Lake at Sikkim, Tarsar Lake at Kashmir, Sela Lake at Arunachal Pradesh, Prashar Lake at Himachal Pradesh, Pangong Lake at Ladakh, Gurudongmar Lake at Sikkim, Kodaikanal Lake at Madras, Yercaud Lake at Madras, Ooty Lake at Madras, etc.

Definition of Lake:

Lakes, according to Forel (1901), are bodies of stagnant water that span basins but do not connect to the sea. Lakes are large amounts of stagnant water that are deep enough just to stratify thermally. Lakes, according to Welch (1952), are masses of standing water that are fully separated from the sea and have a region of broad, fairly deep water large enough to form a barren, rapid shore somewhere on their border. According to Vernberg & Vernberg (1972), a lake is an inland depression on the surface of the earth, ranging from a few metres to about 150 metres in depth, and containing standing water. A lake is an area of variable extent covered usually by water, where freshwater and saltwater meet, in which water moves in relation to a shoreline. Lakes are contrasted with rivers or streams, which are un-bounded elements of surface or lying mostly in one direction, but are natural lowlands near a stream bed or shore. They may be temporary or permanent entities. A lake exists when there is more water within the lake than outside it (total volume). The deeper parts of lakes retain their water for longer periods of time compared to shallow part. Lakes thus have a greater density because they have more volume for their surface area; however, not all bodies if lakes can be called "lakes".

Fish Diversity in India:

India has 1027 freshwater fish species. The Indian fish biodiversity is classified into two groups: Chondrichthyes and Osteichthyes. On the Indian subcontinent, the Chondrichthyes are represented by 131 species divided into 67 genera, 28 families, and 10 orders. Indian chondrichthyes harvest a total of 33,500 metric tonnes per year, with 15,500 metric tonnes from the eastern coast, 17,600 metric tonnes from the western coast, and the remainder from the islands of Andaman and Nicobar. The Indian bony fish include approximately 2,410 species from 900 genera, 225 families, and 30 orders, with five families, most prominently the Parapsilorhynchidae, being indigenous to India. All those little hill stream fishes are classified into a single genus, *Parapsilorhynchus*, that comprises three members. Furthermore, the species of the family Psilorhynchidae, including the sole species *Psilorhynchus*, are indigenous to the Indian subcontinent. The indigenous fish families account for 2.21 % of the Indian region's total bony fish population. Approximately 22,000 fish species have been identified worldwide, with around 11% present in Indian waters. Among the 2200 species now recorded, 73 (3.32%) are cold-water freshwater fish, 544 (24.73%) are temperate-water freshwater fish, 143 (6.50%) are brackish water species, and 1440 (65.45%) are marine species. Appropriate ecological conservation is required for the persistence of all populations, and sufficient care is required to resist anthropogenic pressures. In the case of commercial species, rational resource utilisation is required.

There are approximately 450 families of freshwater fish worldwide. In India, around 40 species (warm freshwater species) are recorded. Approximately 25 of these families contain economically significant species. In warm water, there are around 544 endemic species. The following are the most important warm-water species: *Bagarius bagarius, Catla catla, Channa punctatus, Cirrhinus mrigala, Clarias batrachus, Heteropneustes fossilis, Labeo bata, L. calbasu, L. rohita, Notopterus chitala, Rita rita,* etc. Cyprinids, live fish (family: Anabantidae, Clariidae, and Heteropneustidae), catfish, clupeids, and mullets are the most common freshwater fish found in India. Cyprinidae comprise one of the biggest categories and are extensively distributed throughout India, with genera varying in size from a few centimetres to nearly a meter. Cyprinidae account for about 24% of India's 544 species of freshwater fish. Many cyprinids are collected and cultured, particularly carps. The carps are divided into major (*Catla catla*, *Cirrhinus mrigala*, *Labeo calbasu*, and *Labeo rohita*) and minor (*L. fimbriatus*, *L. bata*, and *C. reba*) (Mukherjee et al., 2022). A few foreign carps like *Cyprinus carpio* have also been imported for cultural reasons. Mahseers are also classified as Cyprinidae. Many Tor species reside in high-altitude, frigid waters, even though some, like *Tor putitora*, thrive in milder waters. As a result, the genus Tor exhibits a wide variety of species diversity when it comes to adaptability to varied ecological situations. Mahseer fisheries are in critical decline in several habitats, threatening their very survival and necessitating sufficient protection for the fish (Ngasotter et al., 2020).

Commonly Found Lacustrine Fishes:

Table 2: Different group of fishes found in Indian lakes (Sarkar et al., 2015).

Fish Group	Example
Indian Major Carps	*Labeo rohita, Labeo calbasu, Labeo fimbriatus, Cirrhinus mrigala, Catla catla*
The Mahseers	*Tor tor, T. putitora, T. khudree, Acrossocheilus hexagonolepis, A. hexastichus*
Minor Carps	*Cirrhinus cirrhosus, C. reba, Labeo kontius, L. bata, L. dero, L. gonius, L. boggut, L. dussumieri, Puntius sarana, P. dubius, P. carnaticus, P. kolus, P. dobsoni, P. chagunio, P. pulchellus, P. jerdoni, P. curmuca, P. shalynius, Thynnichthys sandkhol, Osteobrama vigorsii*
Snow Trouts	*Schizothorax spp., S. plagiostomus*
Large/Medium Catfishes	*Wallago attu, Sperata aor, S. seenghala, Pangasius sp., Silonia childrenii, Silonia silondia, Ompok bimaculatus, O. pabda, Glyptothorax spp.*
Featherbacks	*Chitala chitala, Notopterus notopterus*
Air Breathing Catfishes	*Clarias magur, Heteropneustes fossilis, C. batrachus*
Murrels	*Channa marulius, C. striata, C. punctatus, C. gachua*
Garra species	*Garra gotyla, G. lissorhynchus, G. mcclellandi*
Minnows and miscellaneous species	*Puntius sophore, P. ticto, Ambassis nama, Esomus danricus, Aspidoparia morar, Amblypharyngodon mola, Oxygaster bacaila, Laubuka laubuca, Barilius barila, B. vagra, B. bola, Osteobrama cotio, Gudusia chapra, Salmostoma bacaila, Johnius coitor, Lepidocephalus guntea, Glossogobius giuris, Danio dangila, Badis badis, Chanda nama, C. baculis, Chagunius chagunio*
Exotic fishes	*Oreochromis mossambicus, Hypophthalmichthys molitrix, Cyprinus carpio specularis, Cyprinus carpio communis, Cyprinus carpio koi, Gambusia affinis, Ctenopharyngodon idella, Clarias gariepinus*

Some other aquatic faunas are also found in Indian lakes, which have their own socio-economic values, such as shrimp, crab, and shrimp, as well as some zooplankton such as copepods, Cladocera, rotifers, veliger larvae of gastropods, mysids, and crustacean larvae (Mohanty et al., 2009).

Fish Consumption Rate in India:

Fish is not only the best protein source, but it also provides a range of essential fatty acids and minerals. Fish is an important part of a balanced diet, providing a wide range of nutrients, including proteins, essential fatty acids, and minerals that can help support healthy growth and development. Eating fish on a daily basis has been linked to a variety of health advantages, including reduced inflammation and a lower risk of heart disease. Studies have shown that consuming fish at least once a week can lower triglyceride levels, reduce the risk of stroke, and decrease the chances of developing type 2 diabetes (Saha et al., 2022a). Fish items are becoming increasingly popular. As more people become aware of the many health benefits of eating fish, there has been an increase in demand for fish-based products. With the growing demand for fish-based products, food retailers are now offering a wide selection of fish items. Approximately 24.8% of the Indian population requires fish on a regular basis, with rural areas accounting for 26.5% of the demand and urban areas accounting for 21%. The pattern of fish consumption in northern India was 6.7%, in western India it was 9.1%, and in central India it was 1.8% (Figure 1) (Barik, 2016).

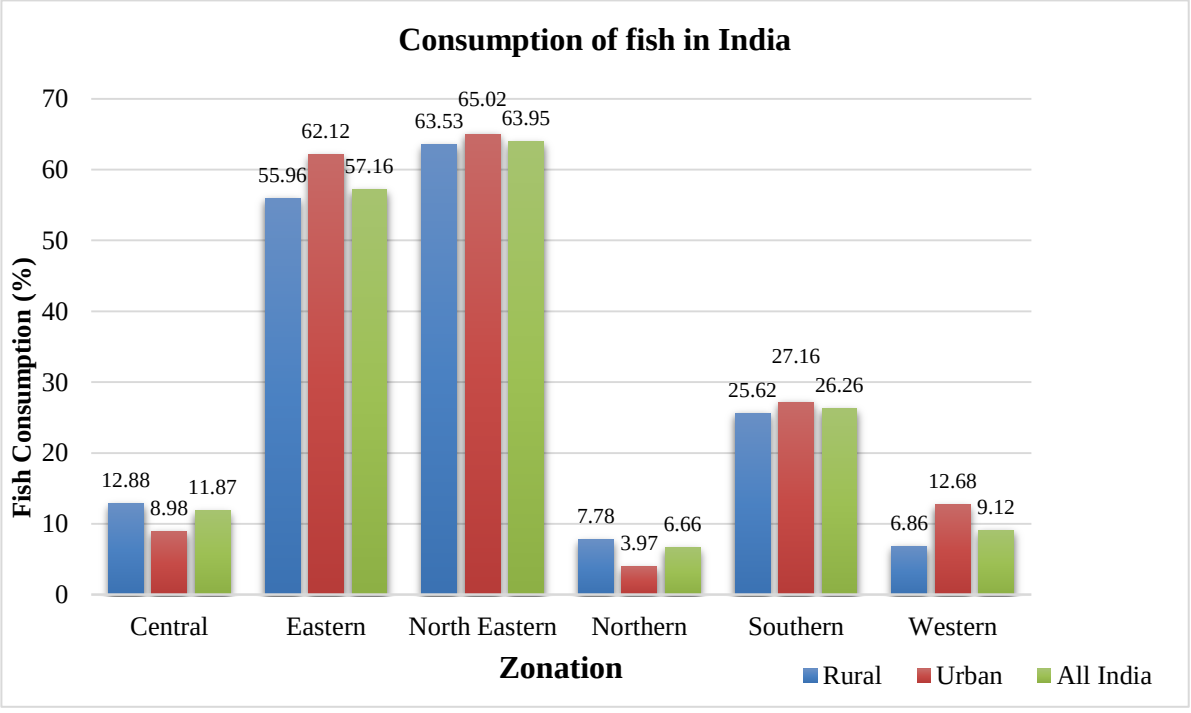

Figure 1. The graphical representation shows that the rate of fish consumption by Indians varies by zone. This figure shows that the North Eastern region of India consumes the highest number of fish in their regular diet, while Northern India consumes the least.

Nutritive Value of Fish:

Fish is high in protein, especially lysine and Sulphur-containing amino acids, as well as essential amino acids and carbohydrates. It is also an excellent source of vitamins and minerals, including iodine, zinc, selenium, calcium, magnesium, vitamins A and D, and omega-3 fatty acids. Fish is an important dietary component for maintaining a balanced, healthy diet. Fish oil is high in vitamins A and D, as well as minerals such as phosphorous. Fish oil is beneficial for promoting healthy hair, skin, and nails, as well as supporting cardiovascular health and neurological development. Eating fish regularly provides numerous health benefits, including a decreased risk of heart disease and stroke, improved cholesterol levels, and increased weight loss. Iodine and omega-3 fatty acids are found in marine fish. Iodine helps to regulate the thyroid, which is a gland in the body that regulates metabolism. Omega-3 fatty acids are important for healthy brain function and can help reduce inflammation. Fish is an excellent source of energy since it is bigger than other bulky carbohydrate sources. Therefore, eating fish on a regular basis can provide the body with the essential nutrients needed to keep it healthy and functioning optimally (Kent, 1987).

Sustainable Development Goals (SDGs):

Globally, mankind is currently confronted with severe ecological, cultural, and economic issues. The United Nations created the 17 Sustainable Development Goals in 2015 to resolve such global concerns on a global, cross-border scale and also to create a more environmentally friendly and brighter life for all. The 17 Sustainable Development Goals aim to protect the world’s ecosystems, end poverty and hunger, provide quality education to all citizens, promote economic growth while protecting the environment, reduce inequality between countries and among individuals, and create peaceful societies with access to justice. Each one of the SDGs contains indicators that are used to track progress toward the objectives. Individual objectives do not exist independently, but instead affect and are related to one another; each goal tackles ecological, cultural, and economic concerns. Therefore, all 17 goals should be worked on in tandem with one another in order to achieve the intended global impact. It is critical to understand how people throughout the world interpret, embrace, and assess the SDGs. Internationally, "combating climate change," "excellent health," and "well-being and excellent education" are prioritized. In comparison, domestically, the emphasis is on creating a clean environment, reducing poverty and inequality, and empowering communities through job creation and sustainable economic growth. People all throughout the globe have such high standards of approval for the SDGs' substance. Despite the wide range of priorities from nation to nation, the core principles and objectives of the SDGs remain constant: to ensure human rights and wellbeing, protect our planet and future generations, foster peace, and promote prosperity (Kleespies & Dierkes, 2022). The United Nations SDG 14: Life Below Water is possibly one of the most difficult of the 17 objectives because of the vastness of the oceans (nearly three-quarters of the planet's area) and the numerous ties to certain other Goals

(Cisneros-Montemayor et al., 2020). Consequently, this goal is tasked with preserving and protecting marine ecosystems, preventing pollution, and conserving and sustainably using the oceans, seas, and marine resources. For example, the Sustainable Development Goals of No Poverty (SDG 1), Zero Hunger (SDG 2), and Great Health and Well-Being (SDG 3) ultimately depend on a stable life below water (SDG 14). If we fail to protect our marine ecosystems and preserve life below water, we risk destabilizing a large portion of the food chain, putting strain on food security and the health of humans and animals alike (Andriamahefazafy et al., 2022). Climate change action (SDG 13) is required to accomplish SDG 14, as well as the ocean, which is critical to attaining SDG 13. Therefore, SDG 14 serves as a vital and urgent goal to protect our marine environment from the threats posed by human activities (Armstrong, 2020). There is still a lot we don't know; in fact, the ocean comprises more than 99% of the area where creatures may dwell, and more than 80% of the ocean, particularly the deep water, remains undiscovered (Molony et al., 2022). It is clear that to protect our marine ecosystems, our oceans, and the life within them, we must take action. We must work together to reduce the human impacts that have already harmed underwater life, such as overfishing, pollution, and climate change.

Figure 2. Diagrammatic representation of some goals of sustainable development achieved through lacustrine fisheries. Here 1–8 denote livelihood, income, food resource and nutritional value, recreational aspects, cultural aspects, educational development, and respectively.

Sustainable Developmental Approaches In Lacustrine Fisheries:

Indian lakes and the fish that inhabit them play a significant role in achieving some goals of sustainable development (Figure 2). Inland fisheries contribute to economic growth by selling and trading fish and fish products, as well as providing employment (Welcomme et al., 2010). The inland fishery industry provides nutritional value to more than billions of individuals throughout the world (Youn et al., 2014). It helps to develop the ecotourism industry through sport fishing (Cooke et al., 2015). The inland fishery also has its own aesthetic values. It contributes cultural heritage and iconic traditions to fishers' cultural services (Noble et al., 2016). Inland fisheries also play a significant role in education, and they provide research opportunities (Postell & Carpenter, 1997). Lacustrine fisheries provide good environmental services by maintaining water ecosystems, biodiversity, and water quality and quantity (Postel & Carpenter, 1997). Because of the high demand for these services, we must ensure the sustainable use of not only lacustrine but also inland fisheries resources (Lynch et al., 2020). Indian lakes have aesthetic value on their own, and they also play an important role in the tourism industry. Lacustrine fisheries provide a cultural sense of the fisher community, and they also help to maintain their cultural heritage and traditions (Noble et al., 2016). Lacustrine fisheries have a high educational value and also provide opportunities for research and training, which ultimately affects the growth of fish productivity (Postel & Carpenter, 1997). Lacustrine fisheries also help to preserve aquatic ecosystems and water quality (Postel & Carpenter, 1997).

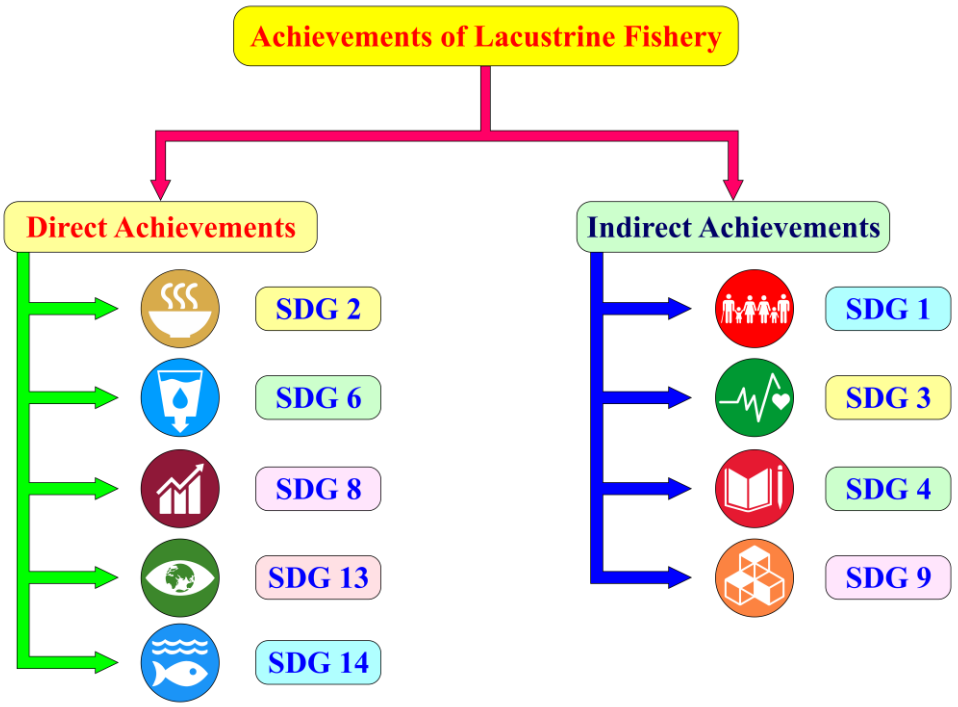

Figure 3. Direct and indirect achievements of lacustrine fishery.

A well-developed lacustrine fishery can achieve the following goals: sustainable development (fish is a good source of protein); Indian lakes play a major role in producing fish, which ultimately achieves the zero-hunger goal (SDG 2); and betterment of the lacustrine fishery through the cleaning of lake water, which achieves the goals of clean water and sanitation (SDG 6). Moreover, by taking steps to ensure the sustainability of the fishery, such as reducing fishing pressure, conserving habitats, and protecting biodiversity, it also contributes to achieving a number of other Sustainable Development Goals (SDGs). The lacustrine fishery has a strong potential to reduce hunger and improve nutrition, support economic growth and provide decent work, promote sustainable consumption and production patterns, protect the environment, combat climate change, and build resilience. Lacustrine fisheries also play a major role in economic growth, which fulfils SDG 9. Finally, by providing employment opportunities for fishers, especially for marginalized communities living in and around lakes, the lacustrine fishery contributes to achieving gender equality (SDG 5) and decent work and economic growth (SDG 8). Moreover, the lacustrine fishery also supports communities in maintaining sustainable livelihoods and strengthening their resilience to climate change. It also meets SDG 12 by producing and consuming fish in Indian lakes. In addition to these contributions, the lacustrine fishery also contributes to ending hunger and achieving food security (SDG 2) by providing access to food and nutrition. A healthy lake is also positively associated with life below water (SDG 14) and climate action (SDG 13). A well-built lacustrine fishery can indirectly achieve (Figure 3) some other SDGs such as no poverty (SDG 1), good health and well-being (SDG 3), quality of education (SDG 4), and industry development (SDG 9) (Lynch et al., 2020).

The Current State of India's Lacustrine Fishery:

Lacustrine fisheries in India can be broadly classified into three categories: benthic fisheries, sub-benthic fisheries, and pelagic fisheries. Benthic fisheries include preparations of benthic creatures, such as crustaceans and mollusks such as prawns, small fish, and aquatic insects. Sub-benthic fishing includes fishing for fish and other organisms using nets or trawls. The catch in this category includes fish like prawns, small fish (bait), aquatic insects, and other crustaceans. Pelagic fishes include turbot, lobsters, and crabs, which are caught through trawling (dragnet fishing) methods. Lacustrine fisheries take place in lakes, ponds, and reservoirs in India. They are not just confined to specific regions but can be found everywhere across the country. The Indian lacustrine fisheries are diverse, with over 60 varieties of fish, most of them exotic species like pomfret and snappers. These shores also house almost all the commercial species indigenous to Asia.

The yield of inland fisheries is relatively higher than that of marine fisheries. Inland fisheries contribute approximately 38.79%, whereas marine fisheries contribute 34% (Paul et al., 2017). In India, there are 19,134 small reservoirs, 180 medium reservoirs, and 56 large reservoirs, and

fish yields in those reservoirs are 174 kg/ha, 94 kg/ha, and 33 kg/ha, respectively (Paul et al., 2017).

Lacustrine fisheries in India provide a significant amount of forage for domesticated animals, primarily sheep and goats. Large-scale production of fish meal and fish oil, co-products obtained during the processing of aquatic products (fish products), played major roles in increasing the production of these two commodities in India. Lacustrine fisheries in India are an important part of the country's economy. The main food staples, rice and wheat, are sourced from these fisheries. Neighbouring countries also depend on Indian freshwater resources for their requirements. There is a high risk of the misuse of this water supply resulting in impacts such as salinity increases and depletion of fish stocks, which can result in the elimination of a major source of nutrition, especially if soil health is negatively affected by salinity or reduced levels of nutrients. Indian lakes have a great economic impact in the fishery industry, but currently they are facing some problems that ultimately affect the production of fish. Now we discuss the problems of lacustrine fisheries.

Major Problems of the Lacustrine Fishery:

Table 3. Some popular lakes in India and their major problems.

Name of the lake	Latitude & Longitude (According to Google Earth)	Problem
Dal lake, Kashmir	Latitude: 34°06'N Longitude: 74°51'E	Water quality is the most important factor influencing Dal Lake, which has nearly 15 drains connected to it. Dal Lake receives phosphorus and nitrate-rich sewage, which raises the pH value of the water. These 15 drains carry about 18.17 tonnes of phosphorus and 25 tonnes of inorganic nitrogen (Qadri & Yousuf, 2007). This raises alkalinity and nutrients such as phosphorous, nitrate, ammonium, and potassium that ultimately contribute to eutrophication. Some heavy metals are also present in this lake, such as Cd, Cr, Cu, Mn, Ni, and Zn. *Azolla pinnata* and *Eichhornia crassipes* are the new floral species in Dal Lake. These plants spread rapidly and have a harmful effect on native flora as well as faunal diversity. *Azolla* acts as a nutrient blocker by hampering water circulation in Dal Lake, which ultimately prevents the growth of water ferns. *Azolla* also prevents penetration, which affects floral and faunal diversity (Mir et al., 2022).

Chilka lake, Odisha	Latitude: 19^{o} 41’ N Longitude: 85^{o} 22’ E	The introduction of pesticides in Chilka Lake is one of the remarkable problems in lacustrine fisheries. The origination of pesticides comes from different sources, such as Palur Bridge, the Daya River Estuary, and the Makara River. Basically, organo-chlorinated (OC)-based pesticides recorded about 25% of the water sample from Chilka, and some other pesticides were also found in varying concentrations (0.025 to 23.4 µg/l) such as HCH (α, γ & δ), DDD, DDE, heptachlor, and some others, chlorpyrifos (0.019–2.73 µg/l), dichlorvos (0.647 µg/l). Residues of OP and OC pesticides were not recorded in the sediment sample, but one synthetic pyrethroid (SP) pesticide was recorded (Nag et al., 2020).
Santragachi lake, West Bengal	Latitude: 22^{o} 35’ N Longitude: 88^{o} 16’ E	Both biodegradable waste such as vegetables, paper, etc. and nonbiodegradable waste such as plastic are dumped into the lake (Roy et al., 2011). Because water containing petroleum and other wastes is mixed with the lake's water, train washing at Santragachi station poses a threat to Santragachi Lake (Roy et al., 2011). People from the slum are bathing, washing clothes, and also congregating near the lake's approximately 21 toilets. The drainage from the toilets directly opens into the lake (Roy et al., 2011). establishment of non-native species of hyacinth (*Eichhornia crassipes*), which cover the whole lake. the dissolved oxygen and light penetration decline, which ultimately affect the water ecosystem (Roy et al., 2011).
Loktal lake, Manipur	Latitude: 24^{o} 33’ N Longitude: 93^{o} 48’ E	In Loktal Lake, phumdis is a floating mat. It has some ecological importance, but rapid proliferation of phumdis can affect lacustrine fisheries. A lot of fertilizer is used in the catchment area, which increases the nutrients in the water and causes phumdis to grow quickly. Phumdis nutrient extracts are to blame for declining fish production. The rotting of phumdis also reduces water quality, emitting a foul odour and eventually causing many diseases in fish and local communities (Singh & Khundrakpam, 2011).

Some Other Major Problems of Lacustrine Fisheries in India:

Unplanned urbanization:

Rapid urbanization is an important problem for lacustrine fisheries. Unplanned urbanization can destroy small or medium lakes and make multi-story buildings, such as apartments, shopping malls, hotels, etc. This destroys the natural environment and affects the species that inhabit it, leading to a decrease in local fishery production. The destruction of the natural environment can lead to the depletion of fish stocks and the destruction of their habitats, leading to a decrease in local fisheries production. Furthermore, the release of untreated wastewater from factories and residential areas into the lake water can lead to a further decrease in the quality of the water, impacting the health and populations of fish as well as making it difficult for aquatic vegetation to survive. Because of its geographically advantageous location, the lake has recently been transformed into bungalows or hotels. Lake destruction causes ecosystem imbalance, resulting in more landslides and habitat fragmentation, which is a problem for Uttarakhand's Tehri Dam (Singh, 2018). This further worsens the situation for fish populations in the lake as well as other species relying on the lake for their survival.

Heavy metal:

In metropolitan cities, environmental pollution is a major source of toxic metals that are entering the ecosystem through geo-accumulation, bio-accumulation, and biomagnification. This environmental pollution is having a devastating effect on the environment, poisoning wildlife, damaging habitats, and threatening human health. Industrialization and urbanization near the lake are another source of heavy metal deposition into the lake. The metal contaminants are introduced into the environment through various industrial and urban activities such as metal plating, tanning, smelting, sewage, and water runoff. Some heavy metals, such as Fe, Cu, As, Zn, Ni, and Cd, affect lake ecosystems. These pollutants are absorbed by organisms and biomagnified up the food chain, impacting the health of humans and other species. For example, excessive Cu content can affect aquatic flora by damaging the root and preventing its growth. It also reduces the offspring production capacity of animals as well as plants. Secondary roots are also brown in colour, and a high amount of Zn can cause necrosis and chlorosis in plants (Singare et al., 2010).

Conservation Strategies for Indian Lacustrine Fisheries:

Laws:

The Water (Prevention and Control of Pollution) Act was established in 1974. The purpose of this act was to control and prevent water pollution. This Act established the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs), which are responsible for implementing the legislation. This act was also performed to restore useful water in this country. The Water (Prevention and Control of Pollution) Act also mandated that industries would have to obtain a licence before being allowed to release pollutants into water bodies.

This act provides a rule to collect taxes for water consumption in industrial activities (CPCB, 2019). By providing such a framework, the Water (Prevention and Control of Pollution) Act of 1974 was designed to promote a cleaner environment in India. The Ramsar convention was held on February 2, 1971, in the Iranian city of Ramsar. This convention was signed by representatives from 18 countries and was aimed at preserving wetland habitats for wildlife as well as providing recreational opportunities for humans. This act was enacted for the purpose of conservation and sustainable utilisation of wetlands and their resources (Benstead & JoseJosé, 2001).

Sacred lakes:

SNS, or sacred natural sites, are the lands or bodies of water that have spiritual importance to a particular community. For centuries, SNS have been respected and protected by the people of the community, who believe that these places are connected to their cultural history and spirituality. Sacred Lake is one type of SNS where fishing, washing clothes, and bathing are restricted. As a result of this protective action, these sacred natural sites remain undamaged and are maintained as part of the local community's spiritual beliefs and practices. In India, many sacred lakes are situated, such as Bindu Sarovar in Gujarat, Narayan Sarovar in Gujarat, Pampa Sarovar in Karnataka, Pushar Saraver in Rajasthan, etc. These sacred natural sites hold immense value for the people of the community, and their protection ensures that the local cultural practices, which are closely intertwined with the sacredness of these sites, are preserved for generations to come.

Phytoremediation:

Phytoremediation is a promiscuous and cost-effective tool for lacustrine pollution remediation. Phytoremediation is a process that uses plants and trees to absorb pollutants from the environment, making it an effective and cost-efficient solution for cleaning up contaminated lakes. In this method, pollutants are removed and degraded by aquatic plants and their associated microorganisms (Flathman & Lanza, 1998). Phytoremediation is a sustainable method of pollution remediation that can help reduce the environmental impact of pollutants, improve water quality, and protect aquatic ecosystems. This method occurred through several mechanisms, including phytostabilization (the stabilisation of soil contaminants), rhizofiltration (the removal of pollutants from water bodies), volatilization (the extraction of heavy metals and their release into the atmosphere through plants), and phytoextraction (the accumulation of heavy metals in the shoots) (Saha et al., 2022b). Phytoremediation is not only cost-effective but also a low-maintenance method of dealing with environmental contamination. The introduction of some macrophytes such as *Typha spp., Paspalidium geminatum, Eriochloa spp.,* and *Nymphaea spp.* can prevent heavy metal accumulation (Amare & Workagegn, 2022).

Prevention of illegal fishing:

To prevent illegal fishing, the government will set up a licence facility for fishermen and implement a rule that only validly licenced fishermen will be allowed to fish in conserved lakes. This will ensure that only fishermen who are certified and trained can access the lakes, preventing illegal practices like dynamite fishing and over-harvesting of species (Sarkar et al., 2018). This approach will also allow the government to monitor the number of fish in each lake, which can be used to ensure that the lake's populations remain stable. The Indian government also organises training and workshops for fishermen to learn better techniques for catching large quantities of fish. This will enable them to be more efficient and successful in their fishing, as well as reduce any potential damage that their techniques may cause to the lake's ecosystem. Furthermore, the government has increased its efforts to encourage conservation and sustainable fishing practices.

Avoiding invasive species:

Any kind of invasive species introduction should be restricted in lake ecosystems. Introducing a non-native species into a lake ecosystem can have a devastating effect on the environment, as these organisms may outcompete native species for resources, leading to an imbalance in the food chain and the displacement of many native plants and animals. *Azolla* is a type of exotic flora that can destroy native flora and fauna, and its rapid proliferation in Dal Lake has also contributed to eutrophication (Mir et al., 2022). In lacustrine fishery introduction, some invasive fish, for example, Tilapia, and some ornamental fishes such as the Red Piranha (*Pygocentrus nattereri*), *Osphronemus goramy*, *Xiphophorus maculatus*, and *Trichogaster trichopterus* must be prohibited (Knight, 2010). In order to protect a lake's ecosystem, all kinds of introductions of non-native species should be closely monitored, and any introductions should only occur after an extensive risk assessment. Therefore, a responsible approach to managing aquatic ecosystems should include the implementation of rigorous risk management policies that prohibit any introductions of non-native species into the lake environment.

Conclusion:

Indian lakes not only act as a protein hub but also have some medicinal, economical, conservational, and aesthetic values. We should try to expand the spectrum of lacustrine fisheries by organising some workshops and training for fishermen. Women are also seeking employment in this fishery industry, which contributes to gender equality (SDG 5). Some other strategies, such as integrated fish and poultry farming and sewage water management, will be used for better production and economic growth. As a responsible citizen, we should maintain the water quality of lakes and also maintain the ecosystem of the lakes. Through this chapter, we try to express the important role of lacustrine fisheries in achieving not only the SDGs but also greener development, social reform, and women's empowerment.

References:

Amare, T. A., & Workagegn, K. B. (2022). Phytoremediation: A Novel Strategy for the Removal of Heavy Metals from the Offshore of Lake Hawassa using Typha Latifolia L. *Soil and Sediment Contamination: An International Journal*, *31*(2), 240-252.

Andriamahefazafy, M., Touron-Gardic, G., March, A., Hosch, G., Palomares, M. L. D., & Failler, P. (2022). Sustainable development goal 14: To what degree have we achieved the 2020 targets for our oceans? *Ocean & Coastal Management*, *227*, 106273. https://doi.org/10.1016/j.ocecoaman.2022.106273

Armstrong, C. (2020). Ocean justice: SDG 14 and beyond. *Journal of Global Ethics*, *16*(2), 239–255. https://doi.org/10.1080/17449626.2020.1779113

Barik, N. K. (2016). Potential in improving nutritional security through aquaculture development in India: a regional level analysis. *Agricultural Economics Research Review*, *29*(347-2016-17243), 99-109.

Benstead, P., & JoseJosé, P. (2001). Wetlands restoration. In *Encyclopedia of Biodiversity* (pp. 805–822). Elsevier. https://doi.org/10.1016/B0-12-226865-2/00283-2

Cisneros-Montemayor, A. M., Ota, Y., Bailey, M., Hicks, C. C., Khan, A. S., Rogers, A., Sumaila, U. R., Virdin, J., & He, K. K. (2020). Changing the narrative on fisheries subsidies reform: Enabling transitions to achieve SDG 14.6 and beyond. *Marine Policy*, *117*, 103970. https://doi.org/10.1016/j.marpol.2020.103970

Cooke, S. J., Arlinghaus, R., Johnson, B. M., & Cowx, I. G. (2015). Recreational fisheries in inland waters. *Freshwater Fisheries Ecology*, 449-465.

CPCB. (2019). *Central Pollution Control Board*. Central Pollution Control Board; Ministry of Environment Forest and Climate Change Govt. of India. Retrieved January 11, 2023, from https://cpcb.nic.in/water-pollution/#:~:text=The%20Water%20(Prevention%20and%20Control,Act%20was%20amended%20in%201988

Flathman, P. E., & Lanza, G. R. (1998). Phytoremediation: current views on an emerging green technology. *Journal of Soil Contamination*, *7*(4), 415-432.

Forel, F. A. (1901). *Handbuch der Seenkunde: Allgemeine Limnologie* (Vol. 10). *J. Engelhorn*.

Holčík, J. (1998). Lacustrine fishes and the trophic efficiency of lakes: prelude to the problem. *Italian Journal of Zoology*, *65*(S1), 411-414.

Kent, G. (1987). Fish and nutrition in India. *Food policy*, *12*(2), 161-175.

Kleespies, M. W., & Dierkes, P. W. (2022). The importance of the Sustainable Development Goals to students of environmental and sustainability studies—A global survey in 41 countries. *Humanities and Social Sciences Communications*, *9*(1), 218. https://doi.org/10.1057/s41599-022-01242-0

Knight, J. M. (2010). Invasive ornamental fish: a potential threat to aquatic biodiversity in peninsular India. *Journal of Threatened Taxa*, 700-704.

Kumar, S. T., & Shivani, P. (2014). Marine fisheries; its current status, sustainable management and socio-economic status of the marine fishers of Odisha, through Indian Marine Policy: A case study. *Research Journal of Animal, Veterinary and Fishery Sciences*, *2*(7), 10-19.

Lynch, A. J., Elliott, V., Phang, S. C., Claussen, J. E., Harrison, I., Murchie, K. J., ... & Stokes, G. L. (2020). Inland fish and fisheries integral to achieving the Sustainable Development Goals. *Nature Sustainability*, *3*(8), 579-587.

Mir, S. A., Ojha, S. N., Ananthan, P. S., Qureshi, N. W., Argade, S. D., Gul, S., & Thangavel, V. (2022). Assessment of fisheries and management- insights from dal lake, kashmir. *Indian Journal of Extension Education*, *58*(4), 60–65. https://doi.org/10.48165/IJEE.2022.58413

Mohanty, R. K., Mohapatra, A., & Mohanty, S. K. (2009). Assessment of the impacts of a new artificial lake mouth on the hydrobiology and fisheries of Chilika Lake, India. *Lakes & Reservoirs: Research & Management*, *14*(3), 231-245.

Molony, B. W., Ford, A. T., Sequeira, A. M. M., Borja, A., Zivian, A. M., Robinson, C., Lønborg, C., Escobar-Briones, E. G., Di Lorenzo, E., Andersen, J. H., Müller, M. N., Devlin, M. J., Failler, P., Villasante, S., Libralato, S., & Fortibuoni, T. (2022). Editorial: Sustainable development goal 14 - life below water: towards a sustainable ocean. *Frontiers in Marine Science*, *8*, 829610. https://doi.org/10.3389/fmars.2021.829610

Mukherjee, P., Sarkar, G., Saha, A., & Sanyal, T. (2022). Extensive study and data collection on the pituitary gland: A promising prospect revealed by surveying the fish market during the monsoon season. *International Journal of Experimental Research and Review*, *29*, 73–79. https://doi.org/10.52756/ijerr.2022.v29.008

Nag, S. K., Saha, K., Bandopadhyay, S., Ghosh, A., Mukherjee, M., Raut, A., & Mohanty, S. K. (2020). Status of pesticide residues in water, sediment, and fishes of Chilika Lake, India. *Environmental Monitoring and Assessment*, *192*(2), 1-10.

Ngasotter, S., Panda, S. P., Mohanty, U., Akter, S., Mukherjee, S., Waikhom, D., & Devi, L. S. (2020). Current scenario of fisheries and aquaculture in India with special reference to Odisha: A review on its status, issues and prospects for sustainable development. *International Journal of Bio-Resource & Stress Management*, *11*(4), 370-380.

Noble, M., Duncan, P., Perry, D., Prosper, K., Rose, D., Schnierer, S., & Pittock, J. (2016). Culturally significant fisheries: keystones for management of freshwater social-ecological systems. *Ecology and Society*, *21*(2).

Paul, T., Palaniswamy, R., Manoharan, S., Unnithan, U., & Uk, S. (2017). Management strategies for reservoirs fisheries. *Journal of Aquaculture Research and Development*, *8*(06).

Postel, S., & Carpenter, S. (1997). Freshwater ecosystem services. *Nature's services: Societal dependence on natural ecosystems*, *195*.

Qadri, H., & Yousuf, A. R. (2007). Dal Lake ecosystem: conservation strategies and problems. In *Proceedings of TAAL2007: The 12th World Lake Conference* (pp. 1453-1457).

Roy, U. S., Banerjee, P., Pal, A., & Mukhopadhyay, S. K. (2011). Conservation, Restoration and Management Plan for Santragachi Jheel: An Urban Wetland in west Bengal, India. *Proc. JCI*, *47*, 1-f1.

Saha, A., Mukherjee, P., Roy, K., Sen, K., & Sanyal, T. (2022b). A review on phyto-remediation by aquatic macrophytes: A natural promising tool for sustainable management of ecosystem. *International Journal of Experimental Research and Review*, *27*, 9–31. https://doi.org/10.52756/ijerr.2022.v27.002

Saha, A., Samadder, A., & Nandi, S. (2022a). Stem Cell therapy in combination with naturopathy: Current progressive management of diabetes and associated complications. *Current Topics in Medicinal Chemistry*.
https://doi.org/10.2174/1568026623666221201150933

Sarkar, U. K., Sandhya, K. M., Mishal, P., Karnatak, G., Kumari, S., Panikkar, P., Palaniswamy, R., Karthikeyan, M., Mol, S. S., Paul, T. T., Ramya, V. L., Rao, D. S. K., Khan, M. F., Panda, D., & Das, B. K. (2018). Status, prospects, threats, and the way forward for sustainable management and enhancement of the tropical Indian reservoir fisheries: An overview. *Reviews in Fisheries Science & Aquaculture*, *26*(2), 155–175. https://doi.org/10.1080/23308249.2017.1373744

Sarkar, U. K., Sharma, J., & Mahapatra, B. K. (2015). A review on the fish communities in the Indian reservoirs and enhancement of fisheries and aquatic environment. *Journal of Aquaculture Research & Development*, *6*(1), 1.

Singare, P. U., Lokhande, R. S., & Naik, K. U. (2010). A case study of some lakes located at and around thane city of Maharashtra, India, with special reference to physico-chemical properties and heavy metal content of lake water. *Interdisciplinary Environmental Review*, *11*(1), 90-107.

Singh, A. L., & Khundrakpam, M. L. (2011). Phumdi proliferation: a case study of Loktak lake, Manipur. *Water and Environment Journal*, *25*(1), 99-105.

Singh, H. (2018). Habitat fragmentation due to Tehri dam construction reduces fish species diversity among Bhilangana river, Uttrakhand, India. *The Asian Journal of Animal Science, AJAS*, *13*(2), 62-67.

Sreenivasan, A. (1964). Limnological studies and fish yield in three upland lakes of Madras State, India. *Limnology and Oceanography*, *9*(4), 564-575.

Sugunan, V. V. (1997). *Fisheries management of small water bodies in seven countries in Africa, Asia and Latin America*. Food and Agriculture Organization of The United Nations. https://www.fao.org/3/W7560E/W7560E03.htm

Tacon, A. G. (2020). Trends in global aquaculture and aqua-feed production: 2000–2017. *Reviews in Fisheries Science & Aquaculture*, *28*(1), 43-56.

The State of World Fisheries and Aquaculture, 2020. (2020). FAO. https://doi.org/10.4060/ca9229en

Vernberg, W. B., & Vernberg, F. J. (1972). Estuaries. In W. B. Vernberg & F. J. Vernberg, *Environmental Physiology of Marine Animals* (pp. 162–230). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-65334-6_4

Welch, P. S. (1952). Limnology. (2nd Edition). United States: McGraw-Hill Book Company.

Welcomme, R. L., Cowx, I. G., Coates, D., Béné, C., Funge-Smith, S., Halls, A., & Lorenzen, K. (2010). Inland capture fisheries. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 2881-2896.

Youn, S. J., Taylor, W. W., Lynch, A. J., Cowx, I. G., Beard Jr, T. D., Bartley, D., & Wu, F. (2014). Inland capture fishery contributions to global food security and threats to their future. *Global Food Security*, *3*(3-4), 142-148.

HOW TO CITE

Pronoy Mukherjee, Aloke Saha, Koushik Sen, Hadi Erfani, Nithar Ranjan Madhu and Tanmay Sanyal (2022). Conservation and prospects of Indian Lacustrine fisheries to reach the Sustainable Developmental Goals (SDG 17). © International Academic Publishing House (IAPH), Dr. N. R. Madhu & Dr. B. K. Behera (eds.), *A Basic Overview of Environment and Sustainable Development*, pp. 98-116. ISBN: 978-81-957954-2-0 DOI: https://doi.org/10.52756/boesd.2022.e01.010