State of Inland Fisheries and Inland Fisher Community of India

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Executive Summary

With exponential increase in human population, the food demand, shrinkage of cultivable land and decline in the agricultural productivity, role of livestock and fisheries sectors to fulfill growing demand for food is of paramount importance for nutritional security. In this context, significance of fisheries sector is enormous and well documented. Starting from a purely traditional activity in the early fifties, the fisheries sector has transformed into a significant commercial enterprise with impressive growth (over 10 fold increase in last six decades). The sector is employer of more than 14 million people. The environmental and social perspectives of inland open water fisheries provided them recognition as one of the major resources for fisheries development. These water bodies are defined as standing waters (lentic) such as lakes, swamps and running waters (lotic), viz, rivers, estuaries, backwaters. The fisher may be defined as a person whose traditional occupation is fishing and fish culture, so as to exclude the middlemen from leasing the Govt. ponds on priority. The fisher community is one of the poorest and unorganized communities in the society. The inland open waters in India are in form of rivers, mangroves, estuaries, estuarine wetlands, backwaters/lagoons, reservoirs, floodplain wetlands and upland lakes. They endow one of the richest fish species diversity in the world. The Gangetic system accounts for over 143 species of fish, while 126 species belonging to 26 families have been recorded from Brahmaputra system. The peninsular rivers reported to bear at least 76 fish species. The fish yield in rivers Ganga, Brahmaputra, Narmada, Tapti, Godavari, and Krishna, varied from 0.64 to 1.64 t per km, with an average of 1 t per km. Most of these waters either have sub-optimal water quality or impacted ecological conditions that limit their fish production and productivity. Water being the habitat for fish, their survival needs continuous acclimation with the environmental changes. In recent years the incidence of fish mortality are frequently being reported from various regions of the country. One of the major constraints towards appropriate policy and planning for development of fisher community is lack of information on socio-economic conditions. The investigations on age of the fisher, family size and composition as according to sex and age, literacy status and income structure confirmed the poor status of the community. Out of many alternative uses of aquatic system, anthropogenic activities (including the domestic and industrial) impacted the ecosystems and its fisheries the most. It is confirmed by their ecological characteristics, namely, salinity, siltation, contamination (of water and biomagnification) and impact of dams and fish passes. The fisheries development activities for different inland waters vary according to their use and fish stock availability. Therefore, fish stock conservation should be done in rivers and stock enhancements in culture-based fisheries resources, viz., reservoirs and floodplain wetlands. The technologies of fisheries enhancements documented success stories through increase in fish yield in reservoirs. These technologies have many challenges in implementation, which can be overcome through better management and capacity building. Similar to last few Five Year Plans, Inland open waters are recognized as one of the major fisheries waters for development. Many new initiatives are suggested in this plan for fisheries development of these resources, e.g. fisheries resource conservation, stock enhancements, in situ production or enclosure culture of fish seed and table size fish, environmental enhancements, framing of enabling policies, strengthening of institutional structures, revival of FFDA and BFDAs as Fisheries and Aquaculture Development Agency (FADA) and preparation of a sound database.
Introduction

Two major concerns of any country are food availability and environment sustenance, especially for a populous country like India. With exponential increase in human population, the food demand is expected to increase by 40\% by 2030 and shall almost be doubled by 2050. However, the agricultural productivity is declining, largely due to shrinkage of cultivable land and declining soil fertility. Under such circumstances, role of livestock and fisheries sectors to fulfill growing demand for food is of paramount importance for nutritional security. They play critical role in the socio-economic development and welfare of India's rural population not only as a source of nutrient-dense food, but also provide family income and generate gainful employment particularly among the landless, small and marginal farmers. For food security of the fast growing nations, significance of fisheries sector is enormous and well documented.

Starting from a purely traditional activity in the early fifties, when India initiated the First Five-Year Plan (1950-51-1955-56), the sector has now transformed into a significant commercial enterprise with impressive growth, registering about 11-fold increase over the last six decades. From 0.75 million t in the 1950s the fish production grew to over 8.3 million t in 2010-11 (3.2 million t from marine sources and 5.1 million t from inland sector). The detailed break up of fish production from marine, inland capture, aquacultures are shown in Fig. 1.

![Fig. 1 Trend in India’s fish production since the 1950s.](image)

On the whole, the fisheries sector in India contributed Rs. 67913 crores to the GDP during 2009-2010, which is 0.96 percent of the total GDP (Anon., 2011) and 5.41 percent of the GDP at factor cost from agriculture, forestry and fisheries. The share of fisheries sector in the total GDP at factor cost in current prices increased from 0.4\% in 1950-51 to 1.0\% in 2009-10. The fisheries sector has also been one of the major contributors of foreign exchange earnings. The sector has emerged as the largest single employer in the country for more than 10 million people, besides promoting equitable distribution of wealth and natural resources. More than 14 million people derive direct livelihoods from fishing and several more make their living through ancillary activities. Fisheries are next to agriculture in terms of providing employment and food supply.

Freshwater aquaculture has grown from 46\% in mid 1980s to 80\% in recent times. It is one of the fastest growing enterprises in agriculture. Success of aquaculture sector has important implications both in terms of food security, as source of income for a growing number of people. Although, marine fisheries constitute a valuable source of food and employment, its landings stand at 3.07 million t, and likely to stagnate in future. The increasing demand for water use, capital intensive nature, environmental concerns due to intensive practices and individual focused
profits are some of the major constraints in development of Indian inland aquaculture. These ground realities shifted the focus of planners and policy makers towards inland open waters fisheries in general and culture-based fisheries in particular. The gap between the existing and potential fish yield from reservoirs and floodplain wetlands is well documented by many researchers. The technology of culture-based fisheries in these waters is already perfected at many locations. Further, the environmental and social perspectives of inland open water fisheries in terms of eco-friendly fish production practices and equitable distribution of benefits of increased fish yield and income derive them in much advantageous position. Keeping these facts in mind during last three Five Year Plans evidenced paradigm shift in focus of national fisheries development and recognized inland open waters as one of the major resources for fisheries development.

**Defining inland open water resources and their characteristics**

Inland open water resources comprise aquatic habitats including rivers, reservoirs, lakes, floodplain wetlands, estuaries, backwaters and mangroves. These water bodies are defined as standing waters (lentic) such as lakes, swamps and running waters (lotic), viz, rivers, estuaries, backwaters. In principle, these water resources are characterized based on physical, chemical and biological parameters. For instance rivers can be extremely diverse in character that may differ in stream gradient, stream order, bottom substrate, and character of the stream channel (WDNR 2005), surrounding landscape, bottom substrate, history of human settlement and development, productivity, water depth, water chemistry, and size and aquatic biodiversity. Despite these varied characteristics, inland open waters are seasonally/perennially inundated and are related to common water sources such as ground water, precipitation, and surface drainage. In larger landscapes, all the water bodies are interconnected either hydrological or ecological or both. Flood provides a seasonal connectivity between different components of a watershed and locally available habitat patches (Petts and Calow 1996). Even during normal flow regimes, streams and rivers interact with the adjacent land, upstream reaches and watersheds, flowing watersheds downstream and people and communities along their course (Thompson and Luthin 2004).

In general, rivers are defined as a three dimensional structure having longitudinal, lateral and vertical connectivity. Longitudinal connectivity indicates the connective from the source of origin of rivers to the estuarine zone where it meets to sea. Lateral connectivity indicates the connectivity between tributaries or the floodplains wetlands and main river channel. The vertical connectivity implies with the groundwater resources. Under the standard classification of rivers the first order has no tributaries. Second orders are formed at the junction of the first order streams. While the third order river forms at the junction of two second order rivers.

Lakes are water bodies enclosed by lands and regarded as relatively closed systems. Mostly their hydrology is internal, though there is substantial inflowing and out flowing of waters. Based on their sources of origin these water bodies may be classified as glacial lakes, rift valley lakes, depression lakes, volcanic lakes and river lakes. While based on the nutrient richness these water bodies are classified as oligotrophic, mesotrophic, eutrophic and dystrophic lakes. In general, these water bodies are chemically and physically stable environment on a year to year basis.

Defining reservoirs is the combination of many features of rivers and lakes. These are the water bodies created by impoundments of rivers and streams for the purpose of flood control, irrigation, drinking water and power generation. The time of water transmit is generally short, so the nutrient cycle is more riverine than lacustrine.
The floodplain wetlands, swamps and marshes are often associated with the rivers as extension of their flooded areas. Many of the world’s greatest wetlands have riverine features either as internal or terminal deltas. Coastal lagoons are often associated with estuaries. These water bodies are formed as lakes separated from the sea by sandbars. They show a great variation in salinity, though fed from associated freshwater rivers.

**Defining inland fishers and their broad attributes**

The fisherman/fishерwoman are now commonly known as fishers. They are defined in many ways:

- Those person or group who engaged in fishing activity alone or in a group or cooperative in the inland open waters resources
- The person, who directly undertakes the trade such as marketing of fresh fishes, preserved fishes, etc.
- Someone whose traditional occupation is fishing and fish culture, so as to exclude the middlemen from leasing the Govt. ponds on priority

The fisheries acts of Assam, Bihar and Madhya Pradesh have defined fishermen or traditional fishermen. Mostly these fishers belong to the fishermen community, although, in many cases, the persons from other community also join the fishers for fishing. The broad attributes of inland fishers are as follows:

- From time immemorial the fishers have been fishing in open water resources (rivers, reservoirs, lakes, floodplain wetlands, tanks, derelict water bodies, etc.).
- Inland fishers are one of the important components of small scale inland fisheries. They may fish in more than one type of inland waters depending upon the fishing rights and suitability of fisher.
- Most of the fishers live in rural and remote areas, preferably in the surroundings of inland water body like river, reservoir, floodplain wetland, etc.
- The multiple use/ownership/stakeholder nature of the resources adversely affects their fishing efficiency, income and employment.
- The inland fisher community is unorganized. Even the fisher co-operatives in India are extremely weak.
- The access rights of inland fishers to the resources depend on fisheries law prevailing in the state.
- Entrepreneurship among inland fishers is very recent phenomenon.
- The socio-economic conditions of inland fishers are very poor with very low standard of living.
- The facilities for health, education, marketing, etc. are very poor in these areas.
- In past, joint fisher families were very common. But, over the year these families split into nuclear, thereby decreasing the family size.
- The fish catch of individual fisher is generally very less, so, he has to dispose it at the water body itself or at village market to local dealers at very low remuneration.
- Keeping the nature of fishing activity, ill habits of drinking, gambling, etc. are very common among the fishers throughout the countries. They tend to be involved in these activities particularly during the good catch period.
- Fishing from the early childhood is common in many fishing communities. This is important impediments in the child welfare due to early mental and physical stress on the children.
- The degradation and over exploitation of inland waters led to depletion of fish stock and decrease of livelihoods for the fishers. It forced them for occupational shift and to adopt
alternative employment like general wages, agricultural labour and other less preferred activities.

- The lack of other alternatives and capabilities to adapt to alternative enterprises are responsible for their falling into the poverty trap.
- Poor literacy rate is a general feature of fisher community. The reasons attributed for this were poverty and lack of opportunities for the child to go to school.

**Distribution of inland open water resources of the county**

Inland open water resources of our country comprise a maze of rivers, canals, estuaries, floodplain lakes, wetlands, lagoons, upland lakes and reservoirs (Table 1).

<table>
<thead>
<tr>
<th>Resource</th>
<th>Size (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivers (km)</td>
<td>0.03</td>
</tr>
<tr>
<td>Mangroves (ha)</td>
<td>0.36</td>
</tr>
<tr>
<td>Estuaries (ha)</td>
<td>0.30</td>
</tr>
<tr>
<td>Estuarine wetlands (ha)</td>
<td>0.04</td>
</tr>
<tr>
<td>Backwaters/lagoons (ha)</td>
<td>0.19</td>
</tr>
<tr>
<td>Large and medium reservoirs (ha)</td>
<td>1.91</td>
</tr>
<tr>
<td>Small reservoirs (ha)</td>
<td>1.51</td>
</tr>
<tr>
<td>Floodplain wetlands (ha)</td>
<td>0.525</td>
</tr>
<tr>
<td>Upland lakes (ha)</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Sharma, 2013

The river system includes 14 major and 44 medium rivers, innumerable tributaries and anabranches with a combined length of 45,000 km and 20,000 sq. km of catchment area.

The floodplains are primarily continuum of rivers and exist in the form of oxbow lakes, especially in the states of Bihar, West Bengal, Assam (Brahmaputra and Barak valleys), Manipur and eastern Uttar Pradesh. The country has an estimated 0.55 million hectare (m ha) of floodplain lakes and wetlands.

India has 3.42 m ha of reservoirs distributed under divergent geo-climatic, morphometric and edaphic environments. The reservoirs are predominantly located in the states, viz., Madhya Pradesh, Tamil Nadu, Karnataka, Andhra Pradesh, Uttar Pradesh, Kerala, Orissa, and Maharashtra. These states account for major reservoir area in the country.

In addition, seven major rivers contribute to the estuarine resource of the country. Besides, there are large numbers of smaller rivers on both the coasts, which end up in estuaries. The Hooghly-Matlah estuarine system, which is the largest and richest estuarine system in the country, encompasses the Sundarbans. The other important resources include the Mahanadi, Narmada, Tapti and some smaller peninsular estuaries.

Mangroves are usually associated with estuarine systems. Mangrove in India account for about 5% of the world’s mangrove vegetation and are spread over an area of about 4500 km² along the coastal states of the country. In 1960’s the total area of the Indian mangroves was about 681,976 ha in which 45% was in Sunderbans in West Bengal and 17 % in Andaman and Nicobar Islands.
and the rest was distributed in the maritime states of India. As per the recent estimates of Forest Survey of India, the present mangrove forest cover of India is about 4445 km$^2$ which is 0.14% of the total geographic area of the country. The very dense mangrove comprises 1147 km$^2$ (25.8%), moderately dense 1629 km$^2$ (36.6%) and open mangrove covers an area of 1669 km$^2$ (37.6%).

Besides, there are vast sheets of inland saline water bodies nearly 120000 ha lying unexploited in different States of the country, mainly in northern and central India.

**Species Spectrum, their distribution and broad distributional aspects**

The vast inland resources form one of the richest fish species diversity in the world and contribute to the country’s economy in terms of total fish production standing world’s 3rd position. Indian rivers and associated lakes and wetlands are known for their rich biodiversity. Hamilton (1822) and Hora (1929) reported about 265 and 272 fish species, respectively from the river Ganga and its tributaries alone. More recently, Payne et al. (2004) reported 140 freshwater fish species. NBFRGR (2009) reports 765 freshwater and 113 brackish water fish species from the inland waters of India. The Gangetic system alone accounts for over 143 species of fish. Similarly, 126 species belonging to 26 families have been recorded from Brahmaputra system. The peninsular rivers have been reported to bear at least 76 species fish species. The riverine scene, however, is a complex mix of artisanal, subsistence and traditional fisheries with highly dispersed and unorganized marketing systems, which frustrate all attempts to collect regular data on fish yield. A firm database on fish production trends of rivers is still elusive. Based on the information collected by CIFRI on selected stretches of the rivers Ganga, Brahmaputra, Narmada, Tapti, Godavari, and Krishna, fish yield from these rivers vary from 0.64 to 1.64 t per km, with an average of 1 t per km.

Ganga is the most important river and source of livelihood for countless fishers inhabiting on its bank. Upper reaches (origin to Haridwar) is practically a non-fishing zone, however, species available in the stretch are *S. richardsonii*, *Tor* spp., *L. dero*, *L. pangusia*, *G. gotyla*, *C. lattis*, *M. armatus*. The commercial fishing actually starts from district Bulandshahar (Uttar Pradesh). The fishery in the potamone zone of the river is mainly represented by the species belonging to Cyprinidae and Siluridae families. The fishery from the river has shown serious structural changes and decline over the years. During 1958-61 the yield rate in different stretches of river varied from 480.4 to 2339.5 kg/km, being maximum at Kanpur and minimum at Bhagalpur. In the middle stretches the major carps contribution was around 50% followed by large sized catfishes, but in Varanasi - Bhagalpur stretch the fishery was dominated by smaller species and hilsa. During 1961-69 the yield rate dropped slightly (929.8 kg/km) with maximum at Patna (1811.3 kg/km) and minimum at Ballia (876.0 kg/km) with no significant change in fisheries structure. From 1972 onwards fishery from river started declining with sharp changes in stock structure. At Allahabad the yield rate came down from 935.39 kg/km of sixties to 368.01 kg/km for the present with a drastic decline in catches of major carps and large sized catfishes (*A. aor*, *A. seenghela*, *W. attu*). On the contrary, the catches of smaller species showed a marginal increase (211.96 kg/km to 223.41 kg/km) with slight changes in catch composition.

It is obvious from the above Table that all economic species followed a constant declining trend from 1972 onwards. However, the major carps fishery showed some improvement during 1981-90, which was due to good catches of *L. calbasu*, but during 1991-00 contribution of *L. calbasu* declined drastically and major carps share slipped to merely 28.91 kg km-l. During 2001-06, the fishery showed a general improvement, mainly due to invasion of exotic species, specifically *C. carpio* which is constantly increasing over the years. During sixties hilsa fishery was the mainstay
Table 2  Fish yield rate (kg/km²) in different periods at Allahabad

<table>
<thead>
<tr>
<th>Period</th>
<th>Major carp</th>
<th>Large catfishes</th>
<th>Hilsa</th>
<th>Exotics</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961-68</td>
<td>424.91</td>
<td>201.35</td>
<td>97.17</td>
<td>-</td>
<td>211.96</td>
<td>935.39</td>
</tr>
<tr>
<td>1972-80</td>
<td>135.17</td>
<td>98.55</td>
<td>9.66</td>
<td>-</td>
<td>197.86</td>
<td>441.25</td>
</tr>
<tr>
<td>1981-90</td>
<td>155.73</td>
<td>99.40</td>
<td>4.31</td>
<td>-</td>
<td>247.59</td>
<td>507.03</td>
</tr>
<tr>
<td>1991-00</td>
<td>28.91</td>
<td>62.74</td>
<td>4.51</td>
<td>-</td>
<td>178.20</td>
<td>274.36</td>
</tr>
<tr>
<td>2001-10</td>
<td>38.58</td>
<td>40.56</td>
<td>1.20</td>
<td>64.27</td>
<td>223.41</td>
<td>368.01</td>
</tr>
</tbody>
</table>

(Vass et al., 2010, CIFRI, 2011)

at Buxar contributing 744 kg/km in 1112.89 kg/km of the total. Again after 1972 the hilsa fishery suffered a serious setback and came down to only 22.37 kg/km in 1981-86. However, due to shift in fishing effort the fishery of rest of the species showed some improvement.

Ganga bears the richest freshwater fish seed fauna of India ranging from the cultivable Gangetic (major) carps to Mahseers and other coldwater fishes of the Himalayas, the Hilsa. The Ganga system contributed to about 89.5 percent of the total fish seed produced in the country during 1964-1965. Bihar accounted for 2010 million fry, while West Bengal contributed 1200 million fry. As per CIFRI’s investigation two breeding grounds of major carps are located in Bihar, which have been found to be extremely rich in major carp seed resources, with 90 percent catla and 90 percent rohu. In the lower section of the Ganga and its tributaries in West Bengal, large-scale spawn collection was carried out by private fishermen. Recent studies on Hilsa survey observed that huge numbers of hilsa juveniles of size 30-60mm were caught by various destructive gears which are of major concern for the native species.

River Brahmaputra the might river of the North- East with its 42 tributaries and three forerunners Siang, Dibang and Lohit have diverse ecological features with tremendous fishery potential. Fishery in some of the major tributaries in the North bank like Jiabharali, Subansiri, Manas etc. have shown very interesting features. These tributaries are famous for mahseer angling and are good attraction for tourists. In fact 80 to 90% of the total catches from the upper stretches of these tributaries are represented by species like Tor putitora, Neolisochilus hexagonolepis, L. dero and L. dyocheilus but interestingly the fish landing from the down stretches of the above tributaries towards their confluence with Brahmaputra have not shown any contribution by the above mentioned species and almost entire catch is mainly comprised of catfishes major carps, minor carps, miscellaneous species and prawn. One of the most important tributary of North bank R. Subansiri supports a rich fish fauna. The average fish landings from upper stretch of the river in Gogamukh, Dhemaji and N. Lakhimpur markets are 40 to 60 kg/day. Fishes are mainly represented by Tor putitora, L. dero, L. dyocheilus and Barilius sp. Peak fishing season is October to December extended even upto February. The fish landing from the down stretch at Jorhat centre is on average 50 to 200 kg/day mainly comprised of L. calbasu, M. seenghala, W. attu, M. aor, P. sarana, L. gonius and prawn. The fishes dominant in the upper stretch have not been recorded in the down stretch good amount of miscellaneous species like Aspidoparia sp., Botia sp. have also been recorded in the total catch. Jiabharali tributary is one of the most important cold water stream of the state known for its annual angling competition in the Balipara forest range. Important cold water fishes recorded are Neolisochilus hexagonolepis, Tor putitora, Tor tor, L. dero, Barilius sp. The average fish landing at Tezpur and Biswanath Chariali markets is 30 to 50 kg day-I. The catch is maximum during winter when cold water fishes migrate downstream from Arunachal Pradesh (October-December). These fishes have not been encountered in the down stretch towards meeting point of river Brahmaputra. While river
Burgang a tributary with swift current and sandy belt is a good source of coldwater fishes Tor tor, L. dero and Barilius sp. Other species encountered in the down stretch of the river towards meeting point are W. attu, L. bata and Aspidoparia sp. Peak fishing season is post monsoon and earlier winter (September-November). Buroi is large and deeper than Burgang and supports rich fishery. Important species available in the commercial catches are Labeo dero (av. catch size 1-3 kg), Tor tor, Tor putitora and Barilius sp. A good quantity of catfishes W.attu and M. seenghala featherback N. chitala and miscellaneous sp. Aspidoparia are also caught fish yield is more during winter months (November-February) when cold water fishes migrate downstream. Dikrong and Ranganoi rivers are shallow with fast current and are characterized with low water temperature. They support poor fishery of cold water species. The fish catch is more during winter months. The fishery of river Manas has been reported to be rich in the upper stretch having main representation of Mahseer species. Earlier records show that when angling was done in the upper stretches almost 100 kg of mahseer mainly Tor putitora and Neolisochilus hexagonolepis were caught. Although a few big specimen of Mahseer are often caught but the main fishery in the lower stretch are major carps, catfishes and miscellaneous species.

Among the South bank tributaries Noadihing, Burhidihing, Dikhow, river Disang, Kulsi, Singra, Dudhnoi and Krishnoi plays important contribution to the fish distribution. Noadihing is the larger portion of Dihing river, shallow wide having fast current. October to December are the peak fishing seasons in the river and the main nets used are incircling dip nets etc. Important commercial species available in the total catch are cold water fishes L. dyocheilus, L. dero, Tor tor, Barilius sp. Other species encountered are L. gonius, L. rohita, C. mirgala and small catfish M. cavasius although the contribution of these species in the total catch is of less order. Burhiding river was once deep with large volume of water and fast current but after division into two parts old (Burhi) and new (Noa) a few years back the river has become comparatively shallower with lesser flow rate. It supports good fishery and large portion of the fish landing in Dibrugarh market is contributed by fishes from this river. The dominant species in the catches are L. rohita and C. mirgala among carps, M. seenghala and W. attu among catfishes. N. chitala among feather backs and some miscellaneous and trace fishes. October to December is the peak fishing months. The river Disang is comparatively less productive than Dikhow. The fish landing from the river mainly comprised of small miscellaneous species Puntius and Aspidoparia sp. The major carps L. rohita and C. mirgala and catfishes M. seenghala and M. aor and featherback N. chitala are also caught but their contribution is not much in the total catches. In river Kulsi the fish production is of low order peak fishing seasons are from October to December and nets in operation are largely castnets, chinese dipnets and small mesh size gill nets all in the marginal areas. The fishes caught are mainly minor carps and miscellaneous species C. reba, Puntius ticto, Colisa faciatus, A. mola etc.

Fisheries in some of the tributaries specially in the North bank e.g. Subansiri Jiabharali, Manas, etc. have shown very interesting pattern, the upper stretch being represented by Mahseer species Tor putitora and Neolisochilus hexagonolepis and cold water species L.dero and L. dyocheilus where as the down stretch towards the confluence of Brahmaputra is represented by major carps, minor carps, catfishes and prawn and miscellaneous species: The existence of two type of fishery in the same ecosystem clearly indicate the presence of some kind of natural barrier which is preventing one set of fishes in migrating from one stretch to other. There are probably two type of possibilities (i) the water temperature of these tributaries are comparatively much lower in the upper stretches than the down stretch as well as the main river. The difference in the water temperature may be working as a thermal barrier and not allowing the cold water fishes to enter the higher temperature zone (ii) the water quality parameters of tributaries like alkalinity, conductance dissolved solids, hardness etc. are totally different from river Brahmaputra e.g. Jiabharali has comparatively much lower values of the above parameters than the main river.
similarly Manas has much higher values than Brahmaputra. The drastic difference in the water quality parameters in the two systems may be acting as a density barrier in preventing one set of fishes to migrate and cross the natural barrier.

**Health of the aquatic environment as habitat for fish**

Most of the rivers and their tributaries, the floodplain wetlands and the lakes, reservoirs and small water bodies in India have either sub-optimal water quality or impacted ecological conditions that limit their fish production and productivity. The rivers, due to water extraction, siltation and, in many cases, sewage or factory effluents discharge have become degraded as fish habitat, and quite obviously there is mortality and decline in fish production. Water being the habitat for fish, their survival needs continuous acclimation with the environmental changes which occur due to alterations in the water quality and because of other anthropogenic factors. In recent years the incidence of fish mortality are frequently being reported from various regions of the country.

**Rivers**

Rapid urbanization, industrialization, and intensification of agriculture have affected the rivers in different ways in India. Most Indian rivers, at present, are highly regulated (Agrawal and Chak, 1991). Human settlements, deforestation, mining and other activities have degraded the river catchments and increased sediment loads of all rivers. Also, during the past few decades, rivers have received increasingly large discharges of industrial effluents, fertilizers and pesticides from agricultural practices and domestic wastes (CPCB, 2006). All this affected riverine biofa. It is pertinent to mention that out of the 30 world river basins marked as global level priorities for the protection of aquatic biodiversity by Groombridge and Jenkins (1998), nine are from India. These basins include Cauvery, Ganges-Brahmaputra, Godavari, Indus, Krishna, Mahanadi, Narmada, Pennar and Tapti. Sewage pollution is the major source of water quality deterioration of our rivers. It results in deoxygenation, high BOD load, rapid eutrophication and accumulation of heavy metals in the environment. Sharp fall in dissolved oxygen in water puts the biotic communities under severe stress. Discharge of toxicants from the paper and pulp mills into rivers very often result in mortality of fishes. Bleaching powder present in the effluents release free chlorine, which is highly poisonous with corrosive properties and is responsible for fish mortality. Exposure of fishes to suspended solids like fly ash produced from thermal power plants cause respiratory distress to fishes as is evident in river Damodar. Heavy metal contamination is often recorded in rivers. Fishes in the industrial effluent outfall area in river Haldi at Haldia are exposed to an average metal concentration (µg/l) of Cd (2-14), Cu (5-19), Mn (8-88), Pb (17-41) and Zn (22-37). The levels of Cd, Pb and Pb are alarming. If we generalize the data on pesticides generated from the Indian rivers, the observed range for HCH was 0-5000 ppt of which the 1000-5000 ppt were detected near the pollutant receiving areas. In case of DDT also, rivers exhibited similar levels (0-5000 ppt) and trend. Aldrin was not recorded in all the cases. Its reported range was 0-200 ppt. Dieldrin was recorded in still less number of cases. Abundance of endosulfan was however, noticed, in the range of 0-3000 ppt. Heptachlor was reported 0-412 ppt in river Ganga. Chlordane was found in traces.

**Reservoirs**

Industrial development and urbanization in the catchment of reservoirs has caused eco-degradation. Degradation due to domestic water resulting in fish mortality has been reported in Musi, Byramangala and Hussain Sagar. Industrial waters have also in many cases degraded the system resulting in fish kills. Several workers have reported water quality deterioration in reservoirs due to effluents viz. by heavy metals in Tungabhadra reservoir, by effluents from
Kanoria chemical plants containing high chlorine in Rihand reservoir, by coal washery effluents in Panchet Dam, by paper mill effluents into Hirakud Dam, by sugar mill effluent in Gorakhpur reservoir, by effluents from coffee curing plant in Harangi reservoir, by effluent from synthetic fibre company in Bhavanisagar reservoir, etc. Thermal power plants have also contributed in some cases in deteriorating the habitat status of reservoir by releasing hot water (40-45 °C) and fly ash in Rihand reservoir. Siltation has been a major habitat constraint reducing the production potential of the reservoir. Reservoirs like Govindsagar, Nizamsagar, Tungabhadra, Hirakud, Shivajisagar, Gandhisagar recorded siltation rates, much in excess of what was envisaged due to increased sediment load in the incoming waters (Sugunan, 1995).

**Flood Plain wetlands**

The floodplain wetlands (*beels and bheries*), are one of the important inland resource in India, located mostly in the states of West Bengal and Assam, are mostly in various stages of eutrophication, the majority of them are choked with submerged or floating vegetation and having sub-optimal water quality. This has affected the general fish health.

**Social and economic condition of fishers**

For past few decades the fish production from these waters observed declining trend both for quantity and its quality in terms of share of commercially important fish species. Further, impact of fisheries developmental activities could not be realized on traditional fisher community as per expectations due to common pool resource (CPR) nature of resource with multiple uses. One of the major constraints towards appropriate policy and planning for their development is lack of information on socio-economic conditions of this community. Therefore, it is pertinent to collect information on this impoverished fisher community. The parameters included in the study are: age of the fisher, family size and composition as according to sex and age, literacy status and income structure. The observations are based on investigations: CIFRI, 2011; Ekka, *et al.*, 2011, 2013, Katiha 2010, 2010a, 2012, Katiha *et al.*, 2013, Mahata *et al.*, 2010, Mondal, *et al.*, 2010, Pandit, *et al.*, 2011, 2013.

**Age of the fishers**

The age of the respondents are categorized into three sub groups viz, young (15-35 year), middle age (36-55 year) and old (>56 year). Fishing continued to be an activity mostly of fisher folk in the age group of 36-55 which constituted about 46.48 per cent of the respondents. The distribution also indicated the representation of young (age less than 35) at 35.47 per cent. The fisher folk with age more than 56 had the least share at 18 per cent in total. The continuation of old age fisher folk in fishing indicated the growing complexities of the fishing operation at old age. Considering the low income from this enterprise and high labour and risk, an occupational shift was observed for the younger groups.

<table>
<thead>
<tr>
<th>Resource</th>
<th>&lt;35</th>
<th>36-55</th>
<th>&gt;56</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir</td>
<td>139</td>
<td>227</td>
<td>49</td>
<td>415</td>
</tr>
<tr>
<td>Wetlands</td>
<td>61</td>
<td>58</td>
<td>41</td>
<td>160</td>
</tr>
<tr>
<td>River</td>
<td>148</td>
<td>171</td>
<td>87</td>
<td>406</td>
</tr>
<tr>
<td>Overall</td>
<td>348</td>
<td>456</td>
<td>177</td>
<td>981</td>
</tr>
<tr>
<td>% of overall</td>
<td>35.47</td>
<td>46.48</td>
<td>18.04</td>
<td>100.00</td>
</tr>
</tbody>
</table>
**Family size of the respondent households**

The average size of family in India worked out to be 4.68 ranging from 4.46 for reservoirs to 5.23 for floodplain wetlands. The family type and family size of the respondents exhibited quite similar pattern of distribution in which greater part (87 per cent) of the total respondents were from small to medium nuclear family having a size between 2 and 6. It confirmed shift in family type from joint to nuclear for most of the resources. It was found that 47.71 per cent of the respondents belonged to the category of family size between 2-4 and about 40 per cent in category 5-6. The number of families under extreme categories of <2 and >10 were rare at 0.2 and 1.12 per cent of total. The category 7-10 had only 11.71 per cent of total families. The results indicated that large families (>7) were comparatively higher in wetlands. The results indicated varied family size for the fisher community across different inland states.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Family Size (No. of members)</th>
<th>Total</th>
<th>Average family size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;2</td>
<td>2-4</td>
<td>5-7</td>
</tr>
<tr>
<td>Reservoir</td>
<td>2</td>
<td>201</td>
<td>160</td>
</tr>
<tr>
<td>Wetlands</td>
<td>0</td>
<td>68</td>
<td>60</td>
</tr>
<tr>
<td>River</td>
<td>0</td>
<td>199</td>
<td>165</td>
</tr>
<tr>
<td>Overall</td>
<td>2</td>
<td>468</td>
<td>385</td>
</tr>
<tr>
<td>% of overall</td>
<td>0.2</td>
<td>47.71</td>
<td>39.25</td>
</tr>
</tbody>
</table>

**Family composition of the respondent households**

The family composition of the respondents is given in Table 4. It indicated that the males outnumbered the females in all the inland open waters. The male – female ratio for the entire sample was 1.12 which indicated that for every 1000 females 1120 male. Their ratio was 1.03 in reservoirs and 1.24 in wetlands.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Sex ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir</td>
<td>937</td>
<td>913</td>
<td>1850</td>
<td>1.03</td>
</tr>
<tr>
<td>Wetlands</td>
<td>462</td>
<td>374</td>
<td>836</td>
<td>1.24</td>
</tr>
<tr>
<td>River</td>
<td>1003</td>
<td>866</td>
<td>1869</td>
<td>1.16</td>
</tr>
<tr>
<td>Overall</td>
<td>2402</td>
<td>2153</td>
<td>4555</td>
<td>1.12</td>
</tr>
<tr>
<td>% of Overall</td>
<td>52.73</td>
<td>47.27</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

**Age composition of the respondent households**

The age composition of the respondent households is represented in Table 5. The age composition is represented by adults (more than 15 years) and children (less than 15 years). The information was collected both for male and female. The overall number of adult males was 1479 as compared to 1282 females. It justifies the common notion of more of males than females. The percentage of adult females was maximum in reservoir children followed by reservoir adults. The adult-child ratio was found to be 1.51 for the total samples. It was highest for reservoirs (1.67). In concurrence to these results, the percentage of adults was maximum for reservoirs.
Table 5 Age composition of the respondent households

<table>
<thead>
<tr>
<th>Districts</th>
<th>Adult (&gt; 15 years)</th>
<th>Children &lt; 15 years</th>
<th>Total</th>
<th>No. of adult per children</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Reservoir</td>
<td>590</td>
<td>567</td>
<td>347</td>
<td>346</td>
</tr>
<tr>
<td>Wetlands</td>
<td>236</td>
<td>182</td>
<td>226</td>
<td>192</td>
</tr>
<tr>
<td>Overall</td>
<td>1479</td>
<td>1282</td>
<td>953</td>
<td>877</td>
</tr>
</tbody>
</table>

**Literacy status of sample respondent households**

The literacy status of the respondent households was analyzed through the literacy level and educational status. The illiterate indicates fisher folk without any formal education and doesn’t even possess functional literacy. The literacy status includes the level of education as indicated by primary, secondary and collegiate. The primary level indicated schooling till fourth grade, secondary level indicated by high school, secondary and vocational education. The collegiate level of education was denoted by collegiate and professional education.

The general literacy rate of India as a whole was 74.52 per cent (Census-2011) against the literacy rate of 71 per cent among the fisher folk (Table 6). The results indicated that among the literates 42 per cent were primary, 50 per cent were secondary and only 8 per cent reached college level. The analysis of resource wise literacy rate revealed highest literacy estimate for rivers (79 per cent) followed by wetlands (65 per cent) and reservoirs (63 per cent).

Table 6 Literacy status of sample respondent households

<table>
<thead>
<tr>
<th>Resource</th>
<th>Total</th>
<th>Illiterate</th>
<th>Literate</th>
<th>Primary level</th>
<th>Secondary level</th>
<th>Collegiate level</th>
<th>Literacy %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir</td>
<td>1426</td>
<td>523</td>
<td>903</td>
<td>46.4</td>
<td>47.73</td>
<td>5.87</td>
<td>63.32</td>
</tr>
<tr>
<td>Wetlands</td>
<td>745</td>
<td>259</td>
<td>486</td>
<td>38.48</td>
<td>57.61</td>
<td>3.91</td>
<td>65.23</td>
</tr>
<tr>
<td>River</td>
<td>1737</td>
<td>363</td>
<td>1374</td>
<td>37.48</td>
<td>52.55</td>
<td>9.97</td>
<td>79.10</td>
</tr>
<tr>
<td>Total</td>
<td>3908</td>
<td>1145</td>
<td>2763</td>
<td>42.35</td>
<td>50.05</td>
<td>7.60</td>
<td>70.70</td>
</tr>
</tbody>
</table>

**Income status of the sampled fisher households**

The major income sources of the respondent households comprised of income from fishery, business, agriculture, labour services, and other service sectors (Table 7). The highest annual average income generated by the total respondents across the resources was through fisheries sector with an average amount of Rs. 16005/- (52.15 per cent of the total income) followed by income from labour sector at Rs 6920/- (22.55 percent), business at Rs 4533/- (14.77 per cent) and agricultural sector at Rs 3568 (11.63 per cent). Similar trend was observed for all the resources except rivers, where income from business was higher than labour. The highest income was for reservoir fishers followed by rivers and wetlands.
### Table 7 Income status of the respondents (Rs/year)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Fishery</th>
<th>Labour</th>
<th>Agriculture</th>
<th>Business</th>
<th>Any others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir</td>
<td>20078.42</td>
<td>8510.39</td>
<td>3795.22</td>
<td>2638.48</td>
<td>1649.33</td>
<td>34696.43</td>
</tr>
<tr>
<td>Wetlands</td>
<td>9868.54</td>
<td>3279.49</td>
<td>1440.36</td>
<td>2575.8</td>
<td>218.75</td>
<td>15164.23</td>
</tr>
<tr>
<td>River</td>
<td>13207.32</td>
<td>6580.68</td>
<td>4127.04</td>
<td>7013.04</td>
<td>383.04</td>
<td>31311.12</td>
</tr>
<tr>
<td>Overall</td>
<td>16005.36</td>
<td>6920.4</td>
<td>3568.44</td>
<td>4533.36</td>
<td>891.96</td>
<td>30690.96</td>
</tr>
<tr>
<td>% of total</td>
<td>52.15</td>
<td>22.55</td>
<td>11.63</td>
<td>14.77</td>
<td>2.91</td>
<td>100.00</td>
</tr>
</tbody>
</table>

### Alternative uses of inland open waters and impact on fisheries (eco-system perspective)

**Alternative uses of inland open waters**

The inland open waters are among the earth’s most productive ecosystems. They can be put to number of alternative uses as per their features. The features of eco-system may be grouped into components, functions and attributes (Barbier et al., 1997). The components of the system are the biotic and non-biotic features which include the soil, water, plants and animals. The components include fish, forest products, wildlife, agriculture, water supply and water transport. The interactions between the components express themselves as functions, including flood control, storm protection, groundwater recharge, sediment/pollution retention, nutrient cycling, evaporation and preservation. The eco-systems also have attributes, such as bio-diversity, and cultural heritage.

Based on the components, functions and attributes these waters may be put to number of alternative uses. They provide large number of goods and services having direct and indirect benefits. In general direct uses included fisheries; agriculture; habitat for aquatic biomass; recreation and tourism; boating; swimming; water sports; waterways; domestic needs like bathing; washing clothes; tending cattle; dumping of domestic and industrial waste; sand and silt mining, hydro-power generation, fuel wood, fodder, etc. The indirect uses included ecological functions nutrient cycling, air pollution reduction, micro climatic functions, natural habitat biological/ecosystem support, groundwater recharge, etc.

**Impact on fisheries (ecosystem perspective)**

Out of many alternative uses of aquatic system, anthropogenic activities (including the domestic and industrial) probably impact the ecosystems the most. They directly affect the ecological characteristics. Some these are mentioned below.

**Salinity**

In river Hooghly, course modifications have played their part in estuarine fisheries. There has been a overall decline in the salinity of Hooghly-Matla estuary after commissioning of Farrakka barrage with gradient and marine zones pushed down towards sea. This has brought about distinct change in the species composition of fishes caught, with freshwater species making their appearance in tidal zone and a few heretic species disappearing. The likely impact of taming of river Narmada on its estuarine fishery is an example. In a desk review of the likely impact of Narmada Sagar and Sardar Sarobar on the fisheries downstream, carried out by CIFRI for Narmada Control Authority, it has been pointed out that as per the report of the Narmada Water Dispute Tribunal there would be 72.71 % reduction in water availability downstream at 30 years.
of commencement of construction. It may not change the salinity regime during non-monsoon months by the annual event of dilution during months shall not be maintained. This shall effect the migratory fauna, particularly *Tenualosa ilisha* and *Macrobrachium rosenbergii*, and accordingly the fish yield downstream will decline. Stage attained at 45 years from the commencement of construction, when freshwater release from Sardar Sarovar shall cease, will be very critical as it shall be associated with steep hike in salinity and in absence of compromising factor (Freshwater flow) the tidal ingress shall be more towards river side. It is more likely that the whole estuary shall undergo a transformation into a biotope characterized by hypersaline condition with salinity tongue further invading inland. Fishery shall drastically change. CIFRI has also reported similar changes in river Krishna.

**Siltation**

Land use patterns in a watershed influence runoff, river hydrography and sediment load. Deforestation is a reason for the excessive silt load in most of the Himalayan river tributaries, a load which has increased rates of siltation downstream in oxbow lakes, floodplain sloughs and backwaters. Reduction in forest cover has led to a great increase in both the dissolved and particulate solids in Ganga river system. The sediment loads of the Ganga and Brahmaputra are the highest in the country with 586 million tons and 470 million tons respectively. Of the major basins studied in the country, more than one third carry sediment loads of 100 million tons or more, which is very high. In Chilka lagoon regulated decreased discharges in coming rivers have made considerable negative impact on its fishery. Siltation of lagoon bed and its connecting channel with sea, profuse weed infestation, decrease in salinity and qualitative and quantitative decline in the fishery of this lagoon has been observed.

**Impact of dams and fish passes**

Major irrigation structures on rivers such as dams, weirs and barrages form solid obstruction to the migratory path of fish for spawning or feeding. Majority of these hydraulic structures in India have no provisions of fish pass resulting in significant reduction of fish species and yield. Hilsa is a classical example of fishes being affected due to obstruction of their migratory pathways by dams. The natural migratory range of these fishes is 1500 km from the Hooghly estuary to Allahabad on the Ganga. The 1975 construction of the Farrakka barrage at the head of the Bhagirathi and Padma tributaries of the Ganga, some 470 km from the river mouth, has not affected the hilsa fishing in the tidal stretch of the delta. However; the barrage has nearly dominated the riverine fishery upstream of Farrakka on the main stream of the Ganga, a fishery which was based on runs of both Padma and Hooghly stocks. Similarly hilsa ceased to migrate up to Damodar river, a tributary of the Hooghly after construction of dams (DVC), a barrage (Durgapur), and a weir (Anderson weir). The migration of the fish is also restricted to 40 km in the Rupnarayan River. Dams in the upper stretches of the river obstructed migration of mahseers (*Tor spp.*) that move from low land to upland reaches for breeding. Decline of *Tor tor* along with other fishes following construction of a barrage at Tribeni on the Gandhak river, Barrage at Son, Okhla and Farrakka are also known to impede major carp migration for breeding. For example the yield of major carp is reported to have been reduced about 50% of the 1964 level in the lower Ganga following construction of Farrakka.

**Contamination**

Water quality: Sewage pollution is the major source of water quality deterioration of our rivers and floodplain wetlands. The major adverse impacts of sewage pollution are deoxygenation, high BOD load, rapid eutrophication and accumulation of heavy metals in the environment. Sharp fall
in dissolved oxygen in water puts the biotic communities under severe stress. While some species can tolerate a wide range of dissolved oxygen, many communities are highly sensitive to this parameter. For instance, complete absence of zooplankton during January to August and its reappearance in September represented by *Keratella* sp. have been observed in the downstream of sewage effluent outfall on the Ganga and Yamuna. Bacterial population in river water and river bed gives a direct indication of the organic waste load. The mean concentration of total coliform organisms in Ganga water shows considerable seasonal and sectoral variations. The count is low in the sectors from Rishikesh to Kanauj (normally less than 2400 MPN/100 ml) and higher concentrations are noticed at Uluberia, Dakshineswar, Patla, Kalyani, and Darbhanga Ghats (Patna). It is estimated that domestic wastewater contains 100 million coliform per 100 ml and 7000 viral particles per 100 ml. Synthetic detergents being absorbed into the body system of fish impair their growth and reproduction capacity. Detergents mixed with oil may be 60 times more toxic than oil alone. Synergistic action of detergents with insecticides has also been recorded. Its sub-lethal concentration causes thinning and elongation of respiratory epithelial cells.

Bio-magnification

In the Hooghly estuary, studies were conducted to determine the bio-concentration factor of DDT. The observed levels of DDT in different components of the food chain show bio-concentration factor of 7500 for fish and 15833 for bivalves indicating the risk associated with the terrestrial consumers including human being. The ecological malady afflicting the inland aquatic resources and the consequent decline in fisheries can be traced to the anthropogenic activities associated with population growth in the river basins. Irrigation projects, flood control measures have nearly destroyed floodplains, sloughs, inundation zones, and oxbow lakes, all of which are breeding habitats of the major carps. The impairment of recruitment in these fishes has set into motion changes and readjustments of fish populations at the second and third trophic levels. The Major carp populations are now declining, while minor carps and other less economic species are increasing in relative abundance. The impact of irrigation project on fisheries is compounded by land use practices, pollution, exploitation, and fishing. Hydraulic structures have all eliminated the fishery for anadromous fishes *Tenualosa ilisha*.

Technological challenges in management of inland capture fisheries and open water resources

The inland open waters are mostly natural aquatic resources with multiple uses and stakeholders with conflicting interests. Therefore, the implementation and success of any technology in these waters is itself a challenge. Further, these are largely influenced by the climatic factors. Considering the nature of resources, technologies for fish stock conservation (river and estuaries) and enhancements (reservoir and floodplain wetlands) may be implemented. The potential of these resources particularly for fisheries enhancements is given in Tables 8 and 9.

Table 8 Fish yield projections for Indian reservoirs

<table>
<thead>
<tr>
<th>Category</th>
<th>Present yield (Kg/ha)</th>
<th>Potential yield (Kg/ha)</th>
<th>Yield gap (Kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>100</td>
<td>500</td>
<td>400</td>
</tr>
<tr>
<td>Medium</td>
<td>50</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>Large</td>
<td>30</td>
<td>100</td>
<td>70</td>
</tr>
</tbody>
</table>
Table 9 Fish yield projections for Indian floodplain wetlands

<table>
<thead>
<tr>
<th>State</th>
<th>Area (Lakh ha)</th>
<th>Existing yield (Kg/ha)</th>
<th>Potential yield (Kg/ha)</th>
<th>Yield Gap (Kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Bengal</td>
<td>0.425</td>
<td>800</td>
<td>2000</td>
<td>1200</td>
</tr>
<tr>
<td>Bihar</td>
<td>2.54</td>
<td>450</td>
<td>1500</td>
<td>1050</td>
</tr>
<tr>
<td>Assam</td>
<td>1.00</td>
<td>400</td>
<td>2000</td>
<td>1600</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>1.52</td>
<td>175</td>
<td>1200</td>
<td>1025</td>
</tr>
<tr>
<td>N.E. States</td>
<td>0.192</td>
<td>75</td>
<td>750</td>
<td>675</td>
</tr>
<tr>
<td>Total</td>
<td>5.252</td>
<td>168</td>
<td>1400</td>
<td>1232</td>
</tr>
</tbody>
</table>

Following technologies may be implemented for fisheries development in these waters.
- Fish stock management of small reservoirs
- Fish stock management floodplain wetlands
- Culture of prawn in pens in floodplain wetlands
- Pen culture for raising of fish seed in floodplain wetlands
- Pen culture for raising fish seed in reservoirs
- Cage culture for raising of fish seed in floodplain wetlands
- Cage culture for raising fish seed in reservoirs
- Production of table size fish in cage in reservoirs

The results of fish stock enhancements in reservoirs gave very encouraging results (Table 10) revealing significant positive shift in fish yield.

Table 10 Present status of fish yield in reservoirs in India*

<table>
<thead>
<tr>
<th>Category of reservoirs</th>
<th>Average yield kg/ha (1990)</th>
<th>Average yield kg/ha (2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>11</td>
<td>33</td>
</tr>
<tr>
<td>Medium</td>
<td>12</td>
<td>96</td>
</tr>
<tr>
<td>Small</td>
<td>49</td>
<td>174</td>
</tr>
<tr>
<td>Overall</td>
<td>33</td>
<td>110</td>
</tr>
</tbody>
</table>

Source: Sharma, et al., 2012, *Samples size >3000 reservoirs

Major challenges for adoption and proper implementation of these technologies may be
- Proper assessment of gap between existing and potential fish yield from water body
- Estimation of exact stocking rate
- Appropriate prescription of species composition
- Availability of desired quality of stocking material in time and space
- Availability of desired quantity of stocking material in time and space
- Enabling fishing policy
• Favourable institutional arrangements
• Proper follow up of the technological practices
• Capacity building of adopters
• Proper implementation of recommended scientific practices
• Maintenance of cages and pens
• Good input quality
• Financial/credit support
• Natural calamities

National Initiatives for inland open water resource conservation

Developmental programmes and strategies for inland fisheries during the XII Five-Year Plan aim at inclusion of all available resources for augmentation of fish production (Anon., 2011). The schemes include a judicious mix of production enhancement and resource conservation programmes for ensuring sustainability. In inland capture fisheries, the rivers and their tributaries (including cold water resources), the floodplain wetlands and the estuarine resources have been overlooked in the past Plans leading to resource deterioration and fall in production and productivity. As the future of these resources largely lies in conservation and habitat restoration (wherever permissible), the focus will be on the following activities:

• Identification of riverine stretches for conservation as sanctuaries, primarily for maintaining brood stock populations and genetic biodiversity;
• Replenishment of depleted stocks through river ranching in selected stretches;
• Conservation/protection of breeding grounds of commercially important fish species;
• Regular monitoring of exotic fish species in riverine catch
• Habitat improvements in floodplain lakes and wetlands and supplementary stocking in identified water bodies for stock enhancement; and
• Community mobilization for increased participation of local communities in implementation of conservation and habitat improvement programmes.
• Policy and inter-Ministerial/Departmental initiatives to reduce pollution load into the inland capture fisheries resources, promote forestation programmes in the catchment areas to reduce siltation, conduct vulnerability assessment of these water bodies for climate change, enhance the involvement of community participation in developmental processes and strengthen the legal base to meet the growing requirements of the inland fisheries sector.

The reservoirs have large water-spread area and most of them are located in tropical to sub-tropical climate zones. They are likely to be main fish production centers in the years to come. The input-output ratio in reservoir fisheries vis-a-vis other production sectors such as marine fisheries or aquaculture is the best. In reservoirs, with minimum capital inputs and with appropriate management norms, production levels can be highly remunerative. The proposed interventions for the reservoirs during the ensuing Plan period are aimed at:

• Supplementary stocking with quality seed of Indian Major Carps;
• Creation of adequate rearing space for ex-situ/in-situ seed production;
• Efficient fish harvesting gear and craft;
• Support for creation of improved fish marketing paraphernalia;
• Bringing more and more reservoirs under scientific fisheries management practices;
• Framing enabling policy, sound management and technology support
• Mobilizing active participation of resource user communities in the management of the resource
• Ownership and leasing of reservoirs on long-term; and
• Continuous programmes for HRD of reservoir fisheries managers and fishers.

The floodplain wetlands or lakes of the Ganges and Brahmaputra River systems have a water spread of about 5.25 m ha and are located in the states of Assam, northern Bihar, West Bengal and eastern Uttar Pradesh. Their water spread area is shrinking fast and their fisheries depleting due to heavy encroachment, siltation, eutrophication, weed infestation, broken connections with the main rivers, etc. Considering the importance of floodplains in fisheries and other eco-services, it is necessary to conserve these resources both towards ecosystem benefits and fisheries. Some of the important steps in this direction would be:

• Restoration of connecting channels, desiltation and weed clearance,
• Identification of breeding grounds in wetlands, etc.
• Production enhancements through culture-based fisheries and
• Integration of activities such as eco-tourism, horticulture and afforestation in the catchment areas through community-based management approaches.

The XII Plan Programmes aim at revival of the Fish Farmer’s Development Agencies (FFDAs) and the brackish water Farmer’s Development Agencies (BFDAs). These agencies are proposed to be merged into one district-level agency (Fisheries and Aquaculture Development Agency or FADA) to attend to the developmental needs of the sector and provide a single-window source for assistance to the fishers and fish farmers. The FADA will also meet the extension needs of the fish farmers and fishers (especially the reservoir fishers), which is so far very weak. Adequate funding would be required for setting up of FADAs and their operation during the XII Plan.

The database on inland fisheries and aquaculture resources and their fish production is very weak and despite efforts made during the last three and a half decades. The picture on resource size, resource use as well as production is still hazy (Anon. 2011). The resources under inland fisheries are highly dispersed and mostly located in inaccessible and difficult terrain. Therefore, a multipronged strategy would be necessary to fulfill this important requirement and _inter alia_ would include:

• Resource mapping through GIS;
• Regular building and updating of the database;
• Manual survey of water resources, etc. Like marine fisheries, census may also be undertaken for inland fisheries during the Twelfth Plan.

In case FADAs are set up, these agencies could be useful coordinators in undertaking the task at the district-level.

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