V. Inland Waters Biodiversity

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1. Introduction

Inland water system

Water is important equally to life and non-life on earth. At the global level, inland waters amount merely 0.01 percent of the total water available in the world (excluding the ice caps at the poles). What is more astonishing is that this minute fraction of water is home to an extraordinarily high level of biodiversity and providing a vital range of goods and services essential for sustaining human well-being. Freshwater ecosystems are key component in food web and play an important role in nutrient recycling. Many communities depend on the freshwater ecosystems for food and livelihood source.

Fig V.1: Gersoppa (Jog) Falls, Karnataka – India's highest falls at 830 ft.

Inland water systems are spatio-temporally dynamic ecosystems that include very large lakes and rivers, floodplains, peat lands, marshes and swamps, to small streams, ponds, springs, cave waters, and even very small pools of water in tree holes and other cavities in plants and soil. They are also associated with an array of physical, temporal, chemical and biological characteristics. Temporally, inland water bodies can be perennial or ephemeral and can be running systems (i.e., rivers or lotic systems) and standing systems such as lakes and ponds (i.e., lentic systems) (Revenga and Kura 2003). Nearly 99 percent of the inland waters are freshwaters; hence freshwater and inland waters are used interchangeably in this document.

At global level, the area of fresh water wetland amounts to 1236.5 million ha, wherein the contribution from Asia accounts for 16.8 percent. India stands third among the renewable water resource countries in Asia, and the withdrawal of water from these sources are mainly utilized for the agriculture purposes. Though the withdrawal amount was estimated in the year 1975, it does

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not seem to have gone down, as there is a continuous increase in population and simultaneous increase in the demand and consumption of water.

Distribution of inland waters in India

India has totally 67,429 wetlands, covering an area of about 4.1 million hectares (MoEF 1990). Out of these, 2,175 are natural, occupying an area of 1.5 million ha and 65,254 man-made with 2.6 Mha and mangroves 0.45 Mha. Wetlands in India (excluding rivers), account for 18.4 percent of the country's geographic area, of which 70 percent is under paddy cultivation. About 80 percent of the mangroves are distributed in the Sunderbans of West Bengal and Andaman and Nicobar Islands, with the rest in the coastal states of Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Goa, Maharashtra and Gujarat.

Biodiversity and Status of global inland waters

We now know that majority of the world's freshwater ecosystems are being intensely modified and degraded by human activities. Dams, river and stream embankments, and the draining of wetlands for flood control and agriculture, have caused loss of freshwater habitats. Habitat loss has been accompanied by a decline and loss of freshwater species, which is far worse than that of forest, grassland, or coastal ecosystems (WRI 2000). These pressures occur all over the world, although the particular effects of these stresses vary among watersheds. The combination of pressures on freshwater systems has resulted in more than 20 percent of the world's freshwater fish species to become extinct, endangered, or threatened in recent decades (Moyle and Leidy 1992). Figure 2 depicts the population index in the three major ecosystem of the world.

Inland water system in India:

Fig V. 2: Mandagadde Bird Sanctuary, Karnataka

India has a total water surface area of 314,400 sq km with water resources in the form of numerous rivers, streams, wetlands, lakes, etc., and receives an average annual rainfall of 1,100 mm. In India, inland water bodies are distributed from the cold arid Trans-Himalayan zone to wet Terai regions of Himalayan foothills and Gangetic plains extending to the floodplains of Brahmaputra and swamps of northeastern India including the saline expanses of Gujarat and Rajasthan. Along the east and west coasts they occur from the deltaic regions to the wet humid zones of Southern peninsula and beyond, to the Andaman and Nicobar and Lakshadweep

Islands. There are several wetlands being shared with neighbouring countries too as in case of Ladakh and Sunderbans. The major river basins of the country are the Ganges, Brahmaputra, Narmada, Tapti, Godavari, Krishna and Cauvery.

Water utilization for irrigation purpose accounts for 92 percent and comprised of 380 km^3 in 1974 and is expected to rise to 1,050 km^3 by 2025. Rest of the balance is accounted for by industrial and domestic utilization. India's inland water resources comprising rivers, canals, reservoirs, wetlands, ponds and lakes and marine resources comprising the east and west coasts of the Indian ocean and other gulfs and bays. Table 3 gives the glimpse of the national freshwater resources in India. India has 12 major and 48 medium rivers and numerous small rivers and rivulets.

Table V.1.: National water resources at a glance

Water resources	**Quantity (km^3)**
Annual Precipitation Volume (Including snowfall)	4000
Average Annual Potential flow in Rivers	1869
Per Capita Water Availability (1997)	1967
Estimated Utilizable Water Resources	1122
(i) Surface Water Resources	690
(ii) Ground Water Resources	432

India accounts for 16 percent of the world's population in 2.42 percent of the earth's surface. About 74 percent of human population is rural (HDR 1999) and subject wetlands to stress from various anthropocentric activities. Human communities in India are closely associated with wetlands since the Indus valley civilization, which flourished along the banks of river Indus. The water bodies and their resources have been an integral part of the social and cultural ethos of human societies. Currently about 170 million people constituting 17 percent of India's total population in more than 3,800 coastal villages are scattered along the 7,500 km coastline. Communities living close to wetlands follow the natural cycle of floods and adjust to the seasonal movements of the fish and harvest them based on changing water levels. The coastal villages, due to poor resource base and livelihood insecurity force an unsustainable dependence on coastal wetlands and change their characteristics leading to their destruction. Marine fisheries in the Arabian Sea and the Bay of Bengal, export approximately 307,337 tons of fish annually and about two thirds of this export is made up of shrimp (Ministry of Fisheries 1999). In addition to the various ecological and economic values, wetlands also provide cultural value to societies. Most of the Indian villages are settled around dependable water sources for drinking and irrigation

Ramsar Sites in India

India has a total of 25 Ramsar sites covering an area of 648,507 ha. Many of the sites qualify on hydrological grounds, many for their birds and some for their sea turtles, others for their support for fisheries, and a few are considered to be sacred in one way or another. Under the national wetland conservation programme, 68 wetlands have been identified across India (MoEF 2000).

Biodiversity in Inland water systems

Fig V.3: Purple Moorhen at Malyadi Wetland, Karnataka

Indian region has 930 species of freshwater fishes of which 223 or 8.7 percent (Venkatraman 2003) are endemic; 220 species of Freshwater molluscs (Subba Rao 1990; Madhyastha *pers. comm.*), nearly 250 species of frogs and 242 of the Indian birds are wetland dependent (Kumar *et al.*2003). Western Ghats, one of the three biodiversity hotspots, is considered as one of the most important "*Freshwater hotspot for fishes, molluscs and crabs*" as designated by WCMC (1999).

In this section we assess our status and the issues within the Inland water systems in India with respect to the CBD Articles.

2. Status and Issues with respect to the CBD Articles

Sl No	CBD Articles	Capacity Status and Strengths	Capacity Gaps and weaknesses	Capacity Needs and Recommendations
1	**Article 6:** General Measures for Conservation and Sustainable Use	India has a total of 25 Ramsar sites covering an area of 648,507 ha (MoEF 2000). Many of the sites qualify on hydrological grounds; many for their birds and some for their sea turtles, others for their support for fisheries, and a few are considered to be sacred in one way or another. Under the national wetland conservation program, 68 wetlands of high importance have been identified across India. Asian mid winter water bird counts have been going on in India for last 20 years with the involvement of professionals, amateurs and students contributing to the water bird count. The strength being, involvement of lot of NGOs and local clubs. Community managed wetlands such as Malyadi and Kokkare Bellur in Karnataka, Keoladeo Bird Sanctuary in Rajasthan and Chilika in Orissa, etc where local community are involved in the conservation of wetlands and water birds. Sacred ponds and tanks: Temple tanks, ponds and rivers usually called sacred ponds harbour several unique biodiversity such as Mahaseer (*Tor kudree*), which are protected by religious faith. This is one of the traditional conservation methods.	Extensive research, information and data on water pollution is available, but information on impact of above on biodiversity especially those of invertebrates is lacking. Insufficient data on the specific pollutants (both types and quantity) that affect water quality is also lacking. Lack of trained taxonomists and funding hamper long term research especially of lesser known taxa such as invertebrates and lower vertebrates. More than 50,000 small and large Indian lakes are polluted to the point of being considered ‘dead’ (Chopra 1985). The primary sources of pollution are human sewage, industrial pollution and agricultural runoff that may contain pesticides, fertilisers and herbicides.	Need of the hour is to have a all India coordinated project to long term monitoring specific elements off biodiversity, especially invertebrates and lower vertebrates. Monitoring water quality for human and wildlife health Long term funding and capacity building to measure conservation success

2	**Article 7:** Identification and Monitoring	ZSI and BSI are involved in the documentation of aquatic biodiversity in India for very long time. Several threatened species of large animals are found in inland waters such as Gangetic dolphin, Otter, Gharial etc. However, the identification of the other lower and lesser taxa has not been possible due to lack of proper taxonomic keys and also taxonomic hurdles. Several studies especially in the Western Ghats have looked into the bio-monitoring potential of aquatic macro-invertebrates (Shivarama Krishnan et al 1996; Subramanian 2004). India has 17,853 species that are dependent on the wetland of which 6,956 are found in freshwater wetlands (Alfred 2000). AICOPTAX project of MoEF through ZSI is mainly aimed at the capacity building in taxonomy in lesser-known taxa of Indian region. Apart from this, several independent researchers in different institutions, universities and colleges are involved in the taxonomic research. BNHS is involved in the monitoring the incidence of Bird flu in Migratory birds in India. Also they are involved in studying migration of birds for than two decades now. Asian Mid-winter waterfowl census, which is going on for nearly two decades or	Systematic taxonomic review, identification keys of neglected freshwater flora and fauna needs to be done. Hardly anything is known about other group other than birds, mammals, fishes and freshwater molluscs. No long-term monitoring of freshwater systems and its biotic and abiotic components is done. Alien invasive species in inland water system are not documented except for few plants such as Water Hyacinth and Salvenia. We don't have any comprehensive information on the faunal invasive species in our inland water system. Very little information exists regarding microbial biodiversity (algae, fungi, bacteria and virus) of inland water systems.	A sustained long-term support to programme for monitoring elements of inland water system. Create centres for taxonomic research, training and capacity building for varied groups. Training of poor and marginalised communities in using Water Hyacinth in making handicrafts, furniture etc. Thus controlling this invasive weeds Revamping the collection at the National Museums with proper curation has to taken at priority

		more, is one of the very few long-term monitoring programs in the Indian region.		
3	**Article 8:** *In-situ* Conservation	PAs constitute around 4.74 percent of India's geographic area Of this, around 10 percent PAs is dedicated mainly to conservation of freshwater fauna such as water birds, Gharial, Dolphin etc.	No adequate manpower for efficient protection of the existing PAs. No adequate funding for management of the PAs. Revenue generated through the tourism from these PAs is not sufficient to meet the financial demand for the conservation and management of PAs.	Little government support to enforce protective measures. The legal protection in India has been described as "completely ineffective" (Sinha 2002), Community involvement in the conservation of the water systems has to be strengthened. Involve private companies in the conservation of wetlands. Privatization of ponds and tanks for conservation should be taken up, under strict monitoring from the concerned state and central government departments. Tax/cess (***Conservation Cess***) should be collected from private companies (where there is substantial use of fresh water like soft drink manufacturers, amusement parks, iron and steel plants, etc.)for conservation of aquatic biodiversity More PAs needs to be designated based on IBA and Ramsar sites to protect aquatic biodiversity Now the greater emphasis should be given to conservation of lesser known taxa such as amphibians, freshwater molluscs and other aquatic invertebrates
4	**Article 9:**	Gharial reintroduction program - there are 9 PAs for this species in India which are	Lack of comprehensive policy and law on recovery programmes of threatened and	Need to have national policy or legislation to recover the threatened species similar in

	Ex-situ Conservation	linked to both captive breeding and 'ranching' operations where eggs collected from the wild are raised in captivity and then released back into the wild. Till date more than 3000 animals have been released through these programs.	endangered species of flora and fauna. Very little basic scientific information on the biology, reproduction and habitat preference of the species makes the job of *ex-situ* conservation very difficult. No attempt of captive breeding and reintroduction for other threatened species such Ganges Dolphin. Zoo and aquaria in our country are not equipped to maintain healthy and genetically diverse population of aquatic biodiversity.	the line of US Endangered Species Act. Well trained human resources for the species recovery/captive breeding of the endangered flora and fauna. Creation of more zoo and aquaria to maintain genetic diversity of the aquatic flora and fauna.
5	**Article 10:** Sustainable Use of Components of Biological Diversity	In India, inland water systems provide employment to nearly 6 million people in the fisheries sector alone. As a consequence of water resources development works, apart from the major objectives there has been development in various other sectors as well. Among them, development in inland fish production occupies a prominent place. India has the distinction of being the seventh largest producer of fish in the world and second largest producer of inland fish after China. Amongst the States, West Bengal, Andhra Pradesh and Bihar produce about 50 percent of total inland fish production in the country. Ecotourism - PAs especially Bird sanctuaries in India are a source of income to the government and the local	In Andhra Pradesh and Karnataka costal wetlands for example, have been converted for shrimp farming. This illegal shrimp farms have led to large-scale intrusion of saline water resulting in the loss of aquatic biodiversity. No strict enforcement of law to regulate disturbance to flora and fauna due to tourism activities.	Enforcement of existing laws and regulations and monitoring by the concerned department needed. Training programme and sensitization of organisations working on community based organisations and the stakeholders.

		communities.		
6	**Article 11:** Incentive Measures	Watershed programmes being implemented all across the country act as incentive measure to the community.		
7	**Article 12:** Research and Training	Several institutes, universities and colleges are involved in various research activities. Extensive research has been carried out on several aspects of inland water system in India. Among biodiversity elements which have been studied most are fishes, aquatic insects, zoo and phytoplankton's, aquatic plants, water birds and mammals. Research on surface and ground water quality and also pollution has been studied extensively. SACON has done extensive research on the wetlands of India. All India Coordinated Project on Capacity Building in Taxonomy by MoEF is the one and only attempt to popularize and training in taxonomy of the lesser known fauna of India.	There is lack of capacity in state fisheries department and research institutions for improving quality and visibility of fisheries research especially focusing on resource and stock assessment and management, with a focus on integration of biodiversity and ecological elements. Information of breeding and spawning grounds of most fishery resources is not known Critical information such as impact and status of non target species, by-catch data, and impact on bottom fauna is extremely poor - all this despite the very direct visible livelihood significance and its contribution to the country's economy Little integration on freshwater biodiversity concerns into fishery and research.	Need to develop an integrated approach to revive biosystematics focusing on emerging fields and tools such as molecular taxonomy, computerization, digital databases and bioinformatics. Initiate a programme for study of the carrying capacity for different habitats such as lentic and lotic habitat. It is also important to assess the physico-chemical and biological parameters of these habitats. Comprehensive research programme and adequately trained research teams for conservation of aquatic biodiversity. Programme on Economic Valuation and Ecological Economics of freshwater biodiversity and ecosystem services along with training and capacity building of key institutions across the country. Rigorous management of aquatic alien invasive weeds.
8	**Article 13:** Public Education and	BNHS program on Flamingo festival, organized to create awareness among public, students and others.	There is poor sensitivity and awareness among judiciary, policy makers, decision markers and administrators on freshwater biodiversity.	Need for development of hands-on and field guides for use in research as well as education and tourism.

	Awareness	Centre for Environmental Education (CEE) has developed excellent educational material for school teachers and students on various aspects of environment including aquatic biodiversity. Other than above there are very few attempts to include freshwater biodiversity in the educational programme.	The integration of freshwater biodiversity, conservation and resource management in environment education, public awareness and outreach is very poor.	AICoPTAX should be more publicized so that a larger spectrum of biologists across the country benefit by them Compulsory course on aquatic ecosystems in the school and college curriculum should be introduced.
9	**Article 14:** Impact Assessment and Minimizing Adverse Impacts	MoEF guidelines suggest having EIA as a must before any development project is undertaken.	Micro-hydel projects in the Western Ghats are a bane on the aquatic biodiversity. Most of the recent micro-hydel projects do not consider EIA issues before it is commissioned. The “environment clearance” clause not clear as to whether it mandates an EIA -as per the format and various guidelines laid down by the EIA notification and the MoEF.	Strictly follow EIA report before commissioning the project.
10	**Article 15:** Access to Genetic Resources	Limited capacities with respect to fresh water systems in India.		
11	**Article 16:** Access to and Transfer of technology		There is very little interpretation and subsequent transfer to policy, of the landing site data vis-à-vis the implications management of the habitat/ecosystem, or species	Specific research and development programmes in the field are needed on ecosystem restoration and to develop manuals, training and capacity for the same. Training to forest department officials in this regard will be needed

12	**Article 17:** Exchange of Information	With the start of environmental science /studies courses in the past 15 years in many universities across India, there is considerable work on marine and coastal systems within these departments. The database on wetlands of India, which has been developed by SACON is a very good source of information which is available in the public domain	The translation of scientific research into policy and regulation is sometimes too slow. Robust mechanism of exchange of information related to freshwater biodiversity, between different stakeholders is required Information of research in academic institutions is not available.	Regular meeting coordinated by MoEF of the researchers, stakeholders and policy makers to exchange major finding, which could be relevant for policy and conservation. Develop extensive database of the traditional ecological knowledge regarding conservation and management of inland water system. Regular interaction with the communities dependent on the inland water system for livelihood regarding the sharing the information arising out of research.
13	**Article 18:** Technical and Scientific Cooperation	Hardly any Technical and Scientific Cooperation between institutions in the country regarding freshwater ecosystem.	Majority of our type specimens is located in other countries especially United Kingdom. The problem in access to these materials and exchange of new materials with the museums abroad has become a major issue due to stringent Biodiversity Law (2002). This has led to lack of scientific co-operation between countries for taxonomic research (Prathapan *et al.*2006). Very weak technical and scientific cooperation between institutes with in India.	MoEF should encourage and also facilitate exchange program between countries and institutes with in India so as to increase technical and scientific cooperation. Collections harbored in BSI and ZSI should be made easily accessible for the scientists and students NBA should relax rules for scientists for specimen sharing with other countries which has Indian type collections

14	**Article 19:** Handling of Biotechnology and Distribution of its Benefits	Limited work conducted in this sphere for Inland Water Systems.
15	**The 'Cartagena' Biosafety Protocol**	Not much information available on introduction of GMOs or LMOs within aquatic ecosystems and their influence on the latter.

3. Conclusions

a. **Capacity Status and Strengths**

India has a very strong research and monitoring potential especially for higher vertebrates such as birds, mammals and amphibians. Several national institutes, universities and non-governmental organization are involved in basic and applied research on inland water system. With the advent of Internet and Information Technology and GIS-RS techniques, technology has been made use in several ways in documenting the resources of India. For example, Wetlands on India portal of SACON is one such example. Similarly, Indian Bio-resource Information Network on National Bio-resource Development Board (NBDB) under Dept. of Biotechnology, Govt. of India, has an extensive database of flora and fauna of India including freshwater biodiversity. The All India Coordinated Project on Capacity Building in Taxonomy (AICoPTAX) is a welcome move from the MoEF in popularizing taxonomy and also documenting the biodiversity. The PA network forms around 4.75 percent of the country's geographical area. Of this approximately 10 percent is dedicated to the conservation of inland water biodiversity though this conservation measure is mainly biased towards birds, followed by mammals and *Gharial*. India has 25 wetlands of global importance also designated as RAMSAR sites.

b. Capacity Gaps and Weaknesses

The major lacuna in inland water ecosystems is the long term monitoring of biotic and abiotic elements of inland water system. Alien invasive weeds such as *Eichhornia* and *Salvenia* are a serious threat to our aquatic system. We hardly have any data to show its impact on native biodiversity. Sporadic studies have shown that *Eichhornia* can be made use for variety of purpose including furniture making. Funding for basic research such as taxonomy and monitoring is not adequate. Also there is lack of man power for management of PAs. Moreover species reintroduction/recovery programmes should be undertaken to recover the declining population of aquatic flora and fauna.

c. Capacity Needs and Recommendations

The capacity needs for conserving aquatic biodiversity mainly stem from the gaps listed above and can be briefly categorized as follows:

i. Individual Capacity Needs

There is an urgent need to spread awareness and knowledge among students, Departmental officials, field guides and tourists and orient them towards inland water ecosystems.

ii. Institutional Capacity Needs

Basic taxonomic research in the universities, institutes and other research organizations in the specialized area of inland waters need to be encouraged. Also, local community and private institutions can be involved in conservation of aquatic resources and biodiversity

iii. Systemic Capacity Needs

Long-term funding for taxonomic and monitoring programme for aquatic systems is required. An All India coordinated project for monitoring of freshwater biota involving many institutes should be introduced. Public awareness for aquatic biodiversity needs to be increased. Also, it is vital to address livelihood issues of people residing near aquatic water systems. The concept of a Conservation Cess on usage of freshwater, as proposed above can also be chalked out carefully.

4. Proposed Projects and Initiatives

i. **AICoPTAX of MoEF:** This project has to be extended to other freshwater groups such as crabs, shrimps, microbes etc.

ii. **Long-term monitoring of flora and fauna:** Multi-institutional, Long term monitoring project to assess the impact of anthropogenic disturbance on freshwater biodiversity

iii. **Impact of alien invasive species on biodiversity:** We have hardly any information on impact of alien invasive species on freshwater ecosystem and its biodiversity.

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Interview

We received critical information from Dr. S. Kaul (MoEF) on Inland Water Systems in India.