Sálim Ali Centre for Ornithology and Natural History

Biodiversity and Conservation of Riverine Ecosystems of India

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Vol.2 No.1 2006

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Introduction

The Sálim Ali Centre for Ornithology and Natural History (SACON) brings out the second issue of SAROVAR SAURABH, an ENVIS Newsletter on wetland ecosystems, sponsored by the Ministry of Environment and Forests, Govt. of India. The major goal of the Newsletter is to share information about wetlands with various users and, to highlight conservation issues of relevance to wetland community of professionals, managers, environmentalists and other stakeholders.

The newsletter is organized into five segments: Inventory of Wetlands, salient features of the findings from SACON, and wetlands of International significance e.g. Ramsar Sites, compiled list of threatened and near-threatened birds and Website of the month. In addition to monthly compilation of news items on Wetland Ecosystem, it is an attempt towards establishing linkages with information users, carriers and providers from among government, academia, business and Non-Governmental Organizations including that with the ENVIS.

To make this effort worth while the editorial team of SARVAR SAURABH seeks active participation of its readers in terms of providing information, news, views, photographs and articles on issues of wetland conservation.

We welcome your feedback on the Newsletter and its contents.

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Asian Rivers and associated wetlands were one of the cradles of human civilization. Great human cultures were nurtured and developed on the banks of rivers such as Indus (Misra, 2001). Asian rivers played a crucial role in determining the social, economic and political situation of the people ever since *Homo erectus* appeared 500,000 years ago in the Asian mainland. Since then, the terrestrial and freshwater ecosystems of the region are being modified by human influence. Currently, few Asian rivers remain in pristine condition, and most of the major rivers such as Indus, Ganges and Yangtze have been drastically transformed by human activities (Dudgeon, 2000).

Ever since the dawn of civilization, people of the region were totally depending upon the rivers and associated wetlands for their entire water requirement, from drinking to recreation. Currently, nearly half of the humanity resides in Asian countries. Life and future of these people, most of them poor, are inseparably linked with the well being of rivers and associated wetlands. The region, during second half of nineteenth and whole of twentieth centaury witnessed reclamation, draining, damming and diversion of freshwater bodies without due ecological consideration, rendering most rivers and associated wetlands of the region very vulnerable (Dudgeon, 2000).

A large number of people from this region depend upon the biological resources of rivers and associated wetlands for their livelihood. Unprecedented anthropogenic onslaught on the wetlands have rendered them biologically depauperated.

This biological impoverishment of rivers and associated wetlands has caused immense damage to the livelihood of a substantial number of people. Surprisingly, even at this alarming situation, there are local communities, which consider the specific river stretches sacred and conserve associated biota. This includes endangered fish such as the Deccan Mahseer (*Tor khudree*) (Gadgil *et al*., 2001) (Photo-1).

Deccan Mahaseer (Tor khudree) at Sringeri, a sacred stretch of Tunga river.

Such conservation traditions remind us of our past history, where ecosystems including rivers were venerated. Existence of such "carbon-practices" even at this modern "silicon-era" brings a new hope for the conservation and sustainable use of rivers and associated wetlands.

Recent conservation assessment at global and regional levels has shown that, freshwater ecosystems are most threatened through out the world. The situation is no different in India. About thirty eight percent of inland wetlands have disappeared since last ten years (Vijayan et al., 2005).

Inland wetlands such as rivers, ponds, lakes and marshes are important habitats for a diverse assemblage of flora and fauna, and provide water and food security to the community at the local scale. However, except for few vertebrates such as fishes and birds, we have little information the diversity, distribution and conservation status of bulk of the taxa. In this context, this article is an attempt to provide an overview of biodiversity and conservation status of riverine ecosystems of India.

Freshwater Biodiversity

The inland freshwaters encompass a diverse array of ecosystems as varied as lakes and rivers, ponds and streams, temporary puddles, thermal springs and even pools of water that collect in the leaf axils of certain plants. This is a small fraction of world's water resource. Despite this, inland aquatic habitats show far more variety in their physical and chemical characteristics than marine habitats and contain a disproportionately high fraction of the world's biodiversity.

Inland water habitats can be classified into stagnant (*lentic)* and flowing (*lotic*). They may also be classified into perennial or transient. Each of these has its own set of distinctive ecology and biological community. Lotic system encompasses rivers and streams (Photo-2).

Sharavati river with riparian forest.

A river system is essentially a linear body of water draining under the influence of gravity. Most of the river systems discharge into the sea; some into lakes. A few watercourses in arid regions enter inland basins where no permanent lakes exist and disappear into the dry plains.

Large rivers such as Ganges and Brahmaputra cross over many degrees of latitude and traverse a wide range of climatic conditions. Variations in water flow and underlying geology also create a wide range of habitats, often within a short distance. Because of this change in habitats, different organisms are typically present in different parts of any given river system. Even though rivers are physically very dynamic, large rivers rarely disappear, and there are indications that some of the large rivers are in existence for tens of millions of years. This is reflected in the fact that, all the taxonomic groups are found in running waters and some invertebrate taxa are exclusive or attain greatest diversity there.

Biodiversity at higher taxonomic levels such as Phylum, Class or Order in fresh water systems are much narrower than those in the terrestrial or marine systems. Only one extant eucaryote phylum (Gamophyta- green conjugating algae) is confined to freshwater habitats. The overall number of species (species richness) is also low compared to marine and terrestrial groups.

However, species richness in relation to habitat extent may be very high. For example, about 10, 000 (40%) of the 25,000 known fish species are freshwater forms. This high diversity of freshwater fishes relative to habitat extent is promoted by of isolation between freshwater systems. The species richness in the freshwater systems increases towards the equator as is the case with terrestrial habitats. There are many more species in the tropical freshwater systems than in temperate regions, but in some specific groups such as freshwater crayfishes this trend appears to be reversed (WCMC, 2000).

Freshwater Plant Diversity

Algae, fungi, bryophytes, pteridophytes and flowering plants represent freshwater flora. Algae from the groups, green, brown and red algae are known from freshwater. The green algae Chlorophyta include order Ulotrichales and Charophyta (stoneworts) with large number of freshwater species. Ulotrichales have about 80 freshwater species. However, the 440 species of stoneworts are almost entirely found in freshwater. Freshwater fungi are poorly documented when compared to other taxa, especially from the tropics. More than 600 species are currently recorded, more from temperate regions than from the tropics. Most of these fungi are Ascomycetes with few Basidiomycetes and Zygomycetes. They use vascular plants as their substrate. Freshwater fungi are important as parasites, endophytes and saprophytes of aquatic macrophytes; as decomposers of woody debris and as food source for invertebrates. Liverworts and mosses represent non-vascular plants of freshwater system. Many of the hygrophilous terrestrial mosses (eg. *Thamnium, Bryum, Mnium*) have aquatic forms. The family Ricciaceae, commonly known as liverworts have a number of species growing submerged in freshwater bodies. The ferns (Filicinophyta) representing lower vascular plants are very diverse in freshwater systems. Certain aquatic pteridophytes such as *Salvinia sp*. (Salviniaceae) are noxious weeds; others like the members of Azollaceae support symbiotic nitrogen-fixing bacteria *Anabaena azolla* (Phyllum Cyanobacteria).

Existing aquatic vascular plants are essentially derived from terrestrial forms. Most of the aquatic plant species are relatively widespread and many are cosmopolitan. It has been estimated globally that about 1 percent of angiosperms, i.e., about 2,500 species are aquatic. About 730 species of flowering plants with 115 endemic species are known from India. The family Podostemaceae is particularly interesting for its many monotypic genera and narrow endemics. Most of these endemics are restricted to a single river (Photos-3 & 4).

Rare *Willisia selaginoides* (Family:Podostemaceae) from streams of anamalai hills.

Undisturbed riparian plant community.

Freshwater Animal Diversity

Animal species are far more diverse and numerous in inland waters than plants. Apart from fishes, invertebrates form an important group. The important groups include sponges, flatworms, mollusks, polychaete worms, oligochaete worms, crustaceans, insects and numerous parasitic species in various groups. As on land, insects are the most diverse group of organisms in inland waters. Unlike terrestrial faunas, where beetles (Order Coleoptera) are the most diverse, flies (Order Diptera) appear to be by far, the most abundant group in inland waters. Invertebrate diversity of freshwater ecosystems of India is not properly documented. It is estimated that about five thousand species may exist in inland waters of India (Photo-5).

Niligiri Torrent Dart (Euphaea dispar) and endemic damselfly of Western Ghat streams.

Vertebrates of freshwater systems are very diverse. Of all fresh water vertebrates, fishes are the most well known and valued. World over, about 10,000 species of fishes are confined to freshwater. Another 1100 or so species occur in freshwaters but they are not confined to it. A significant proportion of freshwater fishes are from just four orders; the carps and their relatives (Cypriniformes); the characins (Characiniformes); the catfishes (Siluriformes); and the perches and their relatives (Perciformes). The first three of these are entirely freshwater forms, while the last has a significant number of species both in marine and freshwater systems (WCMC, 2000). Diversity of freshwater fishes especially in the rivers and streams is very high India. About 800 species of fishes are known from India. The rivers and streams of the Western Ghats are recognized as one of the global hotspots of fish diversity.

Amphibians, comprising about 5,000 extant species world over, have aquatic larval stages and wholly depend on freshwater for survival. About 250 species of amphibians are known from India, and most of them are depend on streams and rivers (Photo-6).

Black Torrent Frog (Micrixalus saxicola), an endemic frog of central Western Ghats streams.

Since 1990, there is worldwide decline in amphibian populations and species disappearances. Various factors have been attributed for this alarming trend, but the single factor that has been of worldwide importance is habitat loss (Klesecker *et al*., 2001 and Daniels, 2003). Crocodiles, water snakes, turtles and terrapins represent aquatic reptiles. Throughout the world, about 228 species are found in various freshwater ecosystems. Most of the reptiles are semi aquatic and they come to land to reproduce (WCMC, 2000).

Human Significance of Freshwater Biodiversity

Freshwater is essential for the survival of mankind, both for drinking and for the food production. Other uses include transport, industrial production, cleaning, waste disposal, power generation and recreation. In populous developing countries such as India, the limited availability, uneven distribution and growing demand makes freshwater a precious resource. About 70% of fresh water used for agriculture is drawn from rivers, lakes and ground water. Many of these uses are conflicting and create tremendous pressure on freshwater resources especially on freshwater biodiversity.

Primary use of freshwater species is as food. Wildly caught fish from freshwater habitats is the important source of protein, especially for the communities of developing countries (Photo-7).

Tradition fisherman at Udupi district collecting eels and crabs.

In addition to food, a substantial number of species are used as medicine, fiber and fertilizer. Many more species, particularly fishes are semi-domesticated and widely used for ornamental purposes. Inland capture fisheries form a staple part of diet particularly in land locked countries. For example, in Zambia and Malawi, freshwater fishes meet nearly 75% of protein requirement. Freshwater molluscs, crayfishes and shrimps are also exploited for food. Other groups of animals used in minor quantities for food include frogs, turtles, waterfowls, otters and beavers (WCMC, 2000).

Rice, the most important food crop of the world is a produce of freshwater ecosystem. Still a large number of wild relatives of rice species are found in freshwater habitats. These wild relatives of rice species are a source of genetic material for developing new varieties and improving the quality of existing ones.

Conservation of freshwater habitats is essential for the survival of these wild relatives. In addition to rice, members of edible aroid (Araceae) such as *Colocasia* and giant swamp taro (*Cyrtosperma chamissonis*) form important food crops (WCMC, 2000) in Africa, Asia and Caribbean Islands. A large number of aquatic plants are important in local health traditions for example *Nelumbo nucifera* and *Rotula aquatica* are commonly used in Ayurvedic health system in India.

Threats and Current Status of Freshwater Biodiversity

Physical alteration and destruction of the habitat is the single major cause for freshwater biodiversity decline. Diversion and containment of rivers is known in tropical Asia for centuries. For example, Cauvery Delta canals in India were constructed during second century A.D.; the Ifugaorice terraces of the Philippines are 4000 years old (Dudgeon, 1992). Explosive population growth in tropical Asia has caused significant environmental problems in drainage basins. Deforestation leads to an increase in sediment-rich surface runoff and stream-flood flow (Photos-8&9). This adversely affects freshwater organisms, especially fishes. For example, fish decline in Le Grand Lac on the Mekong is attributed to increased sediment load and decreased food availability due to deforestation (Photo-10).

Riparian deforestation along a stretch of stream at Dhakshin Kannada district.

Areca nut plantation along a stretch of stream at Dhakshin Kannada district.

Riparian deforestation for infrastructure development.

Similar cases were also reported from Thailand and Malaysia (Dudgeon, 1992). Destruction, habitat alteration and creation of new habitats by dams and reservoirs are the major threats to freshwater biodiversity. Dams, especially the large ones drastically affect the flow regimes. This can catastrophically disrupt the life cycles of species that migrate up and down the rivers (WCMC, 2000).

Change in water quality caused by pollutants is also a major threat to freshwater biodiversity. Data from Global Environmental Monitoring System water project (GEMS/ WATER) initiated in 1976 by WHO, UNESCO, WMO and UNEP show that Asia's rivers are most degraded in the wolrd.

Many rivers, especially from India have a low percentage of saturation by dissolved oxygen (<70%), accompanied by high BOD and COD (Dudgeon, 1992). Increasing population pressure accounts for much of this poor state. Major sources of pollution in Asian rivers are urban sewage, industrial effluents, mining operations and pesticides. For example, 40 of Malaysia's major rivers have been contaminated with industrial and agricultural wastes, and are said to be biologically dead (Dudgeon, 1992).

Urban wastes dump in Belthangdi Hole in Dhakshin Kannada distrinct.

Despite the efforts from law enforcing agencies pollution levels have not been contained in most of the Asian rivers. This is amply illustrated by Indian situation. Out of 3119 Indian towns and cities, only 217 have partial or complete sewage treatment facilities (Photo:11) (Dudgeon, 1992). A direct consequence of habitat loss or alteration and pollution is the decline in population and species loss. It is estimated that at least 20% of the world's freshwater fish fauna is already extinct or on the verge of extinction (Dudgeon, 2000a). A recent study on the fresh water fishes of India shows that 102 species were seriously threatened as a result of human activities (Vijayan et al., 2005). Alteration in natural flow regimes are damaging to fish stocks. For example, flood control embankments in the Jamuna River in Bangladesh have reduced the fish stocks by 50% since 1983. Similarly, after the construction of Farakka Barrage across the Ganges in 1975 the *Hilsa ilisha* population dwindled to virtually nothing (Dudgeon, 2000).

An exemplary case of impact of damming on invertebrate fauna is from Mobile bay drainage in USA. Historically, the gastropod fauna richness of the Mobile bay drainage was only second to the Mekong River. Nine families and 118 species were known at the turn of 20th century. Recent survey shows that 38 (32%) species are extinct and reduction in

All the snail species presumed extinct belong to the family Pleuroceridae. This family grazes on plants growing on the rocks in shallow oxygen-rich riffle and shoal zones. Damming and associated flood control structures removed the snail's former habitat (WCMC, 2000).

Introduced species are another major threat to freshwater biodiversity. A classic example is the impact of Nile Perch (*Lates niloticus*) on the haplochromine cichlids. When the top predator Nile perch was introduced 30 years ago, the lake Victoria supported some 300 species of haplochromine cichlid fishes as well as smaller numbers from other families. After 30 years, at least half and up to two-thirds of the native species are believed to be extinct. Predation by Nile Perch is thought to be the major cause for this decline. Additional factors include, over fishing and possible competition from tilapiine cichlids (WCMC, 2000).

The situation is not different in Asia. A study by Kottelat and Whitten (1996) has listed a wide range of non-native species that have negative impact on freshwater biodiversity. These includes, plants (*Ipomoea fistulosa),* snail (*Ampullaria gigas*), shrimp (*Macrobrachium nipponense*), American bullfrog (*Rana catesbiana*) and fishes (*Cyprinus carpio, Pseudorasbora parva, Gambusia holbrooki, Peocilia reticulata and Oreochromis mosambicus*). Asian example similar to the episode of Nile Perch at the Lake Victoria is from China. The artificial stocking of grass carp (*Ctenopharyngodon idellus*) in Donghu Lake, Wuhan, caused the virtual disappearance of submerged macrophytes and caused algal bloom. These conditions favoured silver carp (*Hypopthalmicthys molitrix*) and bighead carp (*Hypopthalmicthys nobilis*).

Fish yields increased but comprised only the stocked species: most of the 60 native fish species disappeared. In addition, the number of invertebrate species fell from 113 to 26, and zooplankton species fell from 203 to 171. Periodic algal blooms had deleterious impact on the drinking water quality and living conditions of the lakeside residents (Kottelat & Whitten, 1996).

The documented case of invertebrate population decline due to the introduction of non-native species is from Sri Lanka. The endemic Sri Lankan shrimp, *Caridina singhalensis* occurs only in streams above 1500m. The shrimp is endangered because of the introduction of predatory rainbow trout and forest clearance. Its range is now restricted to a single stream (Dudgeon, 1992).

Apart from invertebrates and fishes, other vertebrates such as amphibians, reptiles, birds and mammals are also affected by deterioration of freshwater ecosystems (Dudgeon, 1992 & Daniels, 2003). A recently concluded study by the Bird Life International (2001) estimated that 20% threatened birds of Asia depend on wetland habitats. These include highly threatened birds such as white-winged duck (*Cairina scutulata*), siberian crane (*Grus leucogeranus*) and masked finfoot (*Heliopais personata*). Dudgeon (1992 & 2000a) reviewed the status of threatened vertebrates excluding birds in Asia. These include: Giant salamander (*Andrias davidianus*); Crocodiles (*Crocodylus porosus, Crocodylus novaeguinae, Crocodylus mindorensis, Tomistomus schlegeli, Gavialis gangeticus* and *Alligator sinensis*); river dolphins (*Platanista gangetica, Platanista minor, Orcaella brevirostris and Lipotes vexillifer*); flat headed cat (*Felis planiceps*); fishing cat (*Felis viverrina*); otter civet (*Cynogale bennettii*); Indian rhinoceros (*Rhinoceros unicornins*); swamp deer (*Cervus duvaceli*); Schaumburg's deer (*Cervus schomburgki*) and brow-antlered deer (*Cervus eldi*).

The Living Planet Index methodology developed by WCMC/WWF applied to over 195 animal species of inland water ecosystems indicates that on average monitored populations have declined by 54% in the period 1970-2000. This compares with a decline over the same period of some 35% in 217 marine and coastal species, 15% in 282 terrestrial species. Though, not conclusive, these provide strong

indications that inland water ecosystems are suffering the greatest negative impact from human activities at present (WCMC, 2000 & WWF 2002).

Based on three water resource stress indices, reliability, use-to-resource and coping capacity a Water Resource Vulnerability Index (WRVI) has been developed at country level. This indicator is an indirect measure of the vulnerability or degree of threat to riverine ecosystems. Globally, vulnerability or impact values were calculated for 151 major river catchments. The results clearly shows that, the most stressed catchments are to be found in the Indian subcontinent, Middle East and western and north central Europe (WCMC, 2000).

This ecological vulnerability of Indian rivers is alarming. A recent study on the inland wetlands of India has shown that, most of India's wetlands are contaminated with pesticides and heavy metals. This is an alarming situation, as a large number of people depend upon these rivers for their entire freshwater requirement. There is an urgent need to intervene at this juncture and design mitigation measures to conserve the riverine ecosystems and associated wetlands of the region. The first and significant step towards this goal is the systematic scientific documentation of biological and social significance of these ecosystems. Such documentation, along with a record of its ongoing changes is essential to develop long term conservation and monitoring programme for the riverine ecosystems. A recent proposal to establish additional 199 Ramsar sites (Vijayan et al, 2005) is welcome change towards the conservation of Indian freshwater biodiversity and assuring long term water and food security.

WEBSITE OF THE MONTH

http://www.glomis.com/

GLOMIS-: "**GLO**bal **M**angrove database and **I**nformation **S**ystem" is a project of the International Society for Mangrove Ecosystems (ISME) with financial support from the International Tropical Timber Organization (ITTO) and of the Prefectural Government of Okinawa. GLOMIS is based at Okinawa, Japan and coordinates four Regional Centres located in Brazil, Fiji, Ghana and Malaysia.Extensive data and information on Mangroves is made available on the site.

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ISSN 0972-3153
SAROVAR SAURABH
ENVIS NEWSLETTER on Wetland Ecosystem

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Published by

Environmental Information System (ENVIS) Centre
Salim Ali Centre for Onithology & Natural History (SACON)
Anaikatty - 641 108. Coimbatore (TN), India.

Sponsored by

ENVIS, Ministry of Environment & Forests
Goverment of India, New Delhi.

Designed by: Madhu Routhu