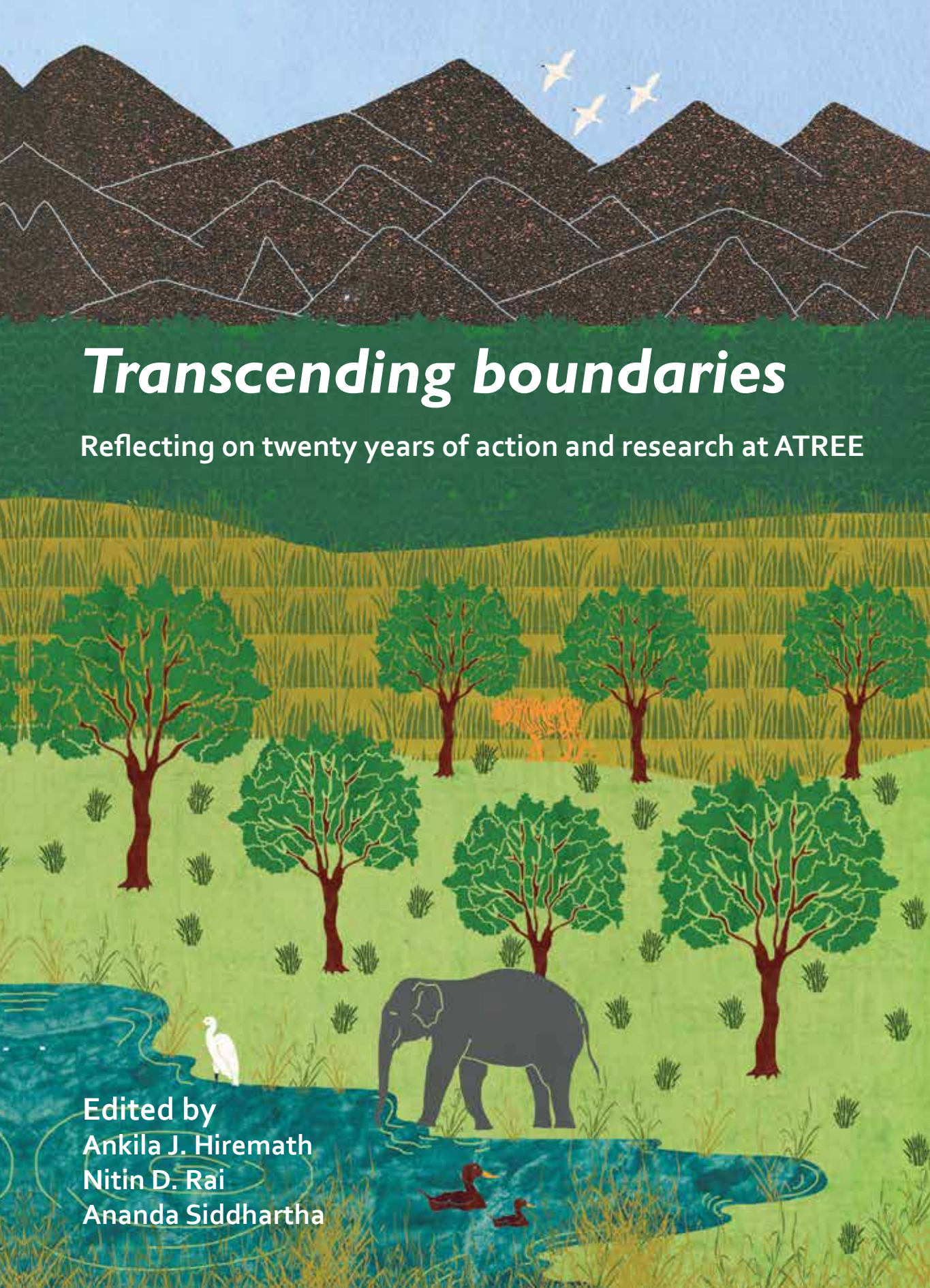




Transcending boundaries

Reflecting on twenty years of action and research at ATREE

Edited by
Ankila J. Hiremath
Nitin D. Rai
Ananda Siddhartha

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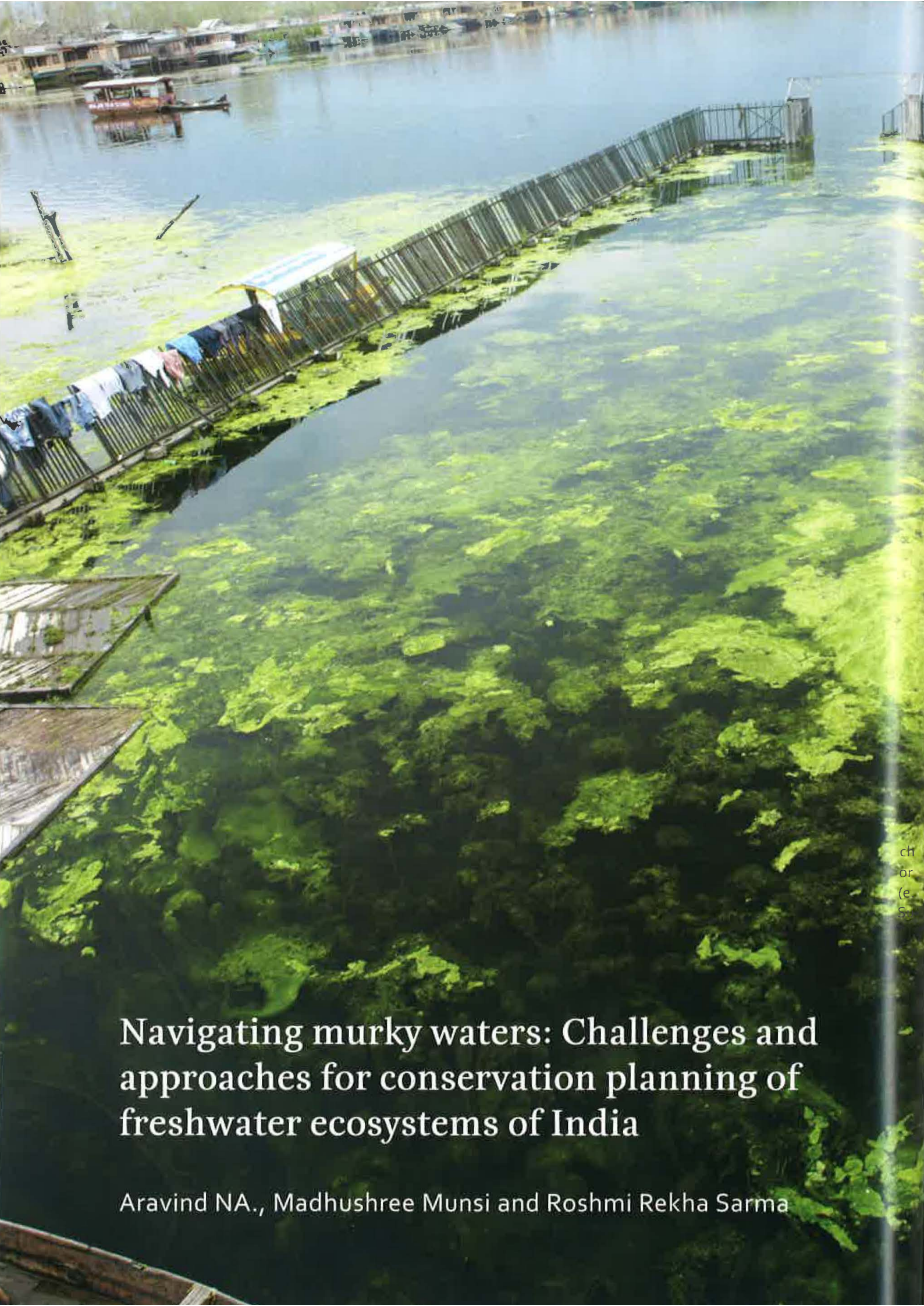
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Navigating murky waters: Challenges and approaches for conservation planning of freshwater ecosystems of India

Aravind NA., Madhushree Munsu and Roshmi Rekha Sarma

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INTRODUCTION

India has varied freshwater habitats ranging from rivers to high altitude lakes to man-made ecosystems such as paddy fields, ponds and reservoirs. Freshwater ecosystems are unique habitats for endemic and fragile flora and fauna, e.g., large Indian rivers harbour small populations of endangered river dolphins, gharial, freshwater oysters, etc., and streams and waterfalls harbour endemic snails such as species in the genera *Paracrostoma* and *Cremnoconchus*. These freshwater ecosystems also provide a range of ecosystem services. People depend on these systems for domestic water requirements, food, livelihood, navigation, waste assimilation, health, and for various cultural practices. Over the years, human dependence on freshwater ecosystems has rapidly increased, making these ecosystems and their biodiversity among the most threatened in the world. Conservation of freshwater biodiversity in India is still in its infancy.

The Western Ghats and Eastern Himalayas, with their high species richness and endemism across both terrestrial and freshwater habitats, are considered biodiversity hot-spots. However, the freshwater habitats in these regions, as elsewhere, are threatened by over-exploitation, poaching, pollution, habitat degradation and destruction, species invasion, and flow modification. Only 13% of the geographical area of the Western Ghats is conserved in the form of Protected Areas

(PA), but these are mostly biased towards charismatic terrestrial animals like the tiger or elephant¹. There are traditional practices (e.g., associated with TodiKan Temple near Sullia and Sringeri Temple, in Karnataka) that

help in protecting endangered fish like Mah-seer, but there are no conservation efforts specifically focused on freshwater habitats in this biodiversity-rich region.

For the country, as a whole, there are a few freshwater-specific conservation efforts. But these, like terrestrial PAs, are also biased towards larger animals: the Vikramshila Gangetic Dolphin Sanctuary in Bhagalpur, Bihar, is the only existing sanctuary specially designated to protect the Ganges river dolphin; the Ken-Gharial and Son-Gharial Sanctuaries are managed for conservation of gharial and mugger; and there are a few aquatic bird sanctuaries across India, e.g., Keoladeo National Park, Ranganatittu Bird Sanctuary, and Attiveri Bird Sanctuary. Our review suggests there is need for extending the scope of conservation towards better representation of freshwater ecosystems and their biodiversity. We review challenges and approaches in conservation planning for freshwater ecosystems of India based on our experience of working on freshwater ecology and conservation, especially in the Western Ghats.

THREATS TO FRESHWATER HABITATS IN INDIA

Although accurate data on freshwater habitat loss across the country are not available, there are estimates for certain regions. The Wildlife Institute of India's survey of the Gangetic flood plains reveals that 70–80% of freshwater marshes and lakes have been lost in the last five decades. A notable example is from Bengaluru, which was once dotted with a large number of lakes; these have been reduced by 70% in the last five decades (from 262 in 1960 to just 81 in 2010).

Pollution is a growing threat to freshwater ecosystems. Much of the pollution is from

¹ Uma Shaanker, R., NA. Aravind and KN. Ganeshai. 2004. Forest management for conservation. In: *Encyclopedia of Forest Science* (eds. Burley, J.J.L., J. Evans and J. Youngquist) Volume II. Pp: 215–224. London, UK: Elsevier Science.

Facing page: Eutrophication of Dal lake ecosystem in Srinagar due to excessive organic pollution from houseboats and urban runoff. (Photo: Aravind NA)



Cremnoconchus syhadrensis, an endemic freshwater mollusk found in waterfalls of Northern Western Ghats. (Photo: Aravind NA)

domestic sewage. For example, the waterfalls near Mahabaleshwar, which is supposed to be the type locality of *Cremnoconchus conicus* (a freshwater snail) are filled with city sewage². A similar situation is seen in Gokak falls in Karnataka, and it is no different with other water bodies across the country. Apart from this, countless tanneries, chemical plants, textile mills, distilleries, slaughterhouses, hospitals, and idol submersion during festive seasons contribute to the pollution of freshwater habitats by dumping untreated toxic and non-biodegradable waste into them. This is causing irreparable damage to these ecosystems and their biodiversity. According to a recent study, pollution affects 50% of fish, 20% of molluscs (snails, clams, etc.) and 21% of odonates (dragonflies, damselflies).

Dams are another threat to freshwater ecosystems. There are nearly 5,000 large dams (height of 10 m or more) across the country. Impacts of dams on biodiversity and hydrology are well studied. Recent increase in the dam height across River Thunga, near Shimoga, has submerged one of the only five surviving population of the endangered freshwater

clam, *Pseudomulleria dalyii*. The impacts of mini hydel projects, supposedly 'environmental friendly,' also need to be assessed.

With growing urbanisation, land conversion is increasingly threatening freshwater habitats. Wetlands, which are considered as "wastelands," have been drained and transformed, e.g., to create a special economic zone in Kolkata, or for shrimp farming in estuarine wetlands in coastal Karnataka. Illegal sand mining to cater to the growing demand for development also impacts aquatic life, especially bottom-dwelling (benthic) organisms, e.g., clams (*Arcidopsis footei*, *Parryesia* spp, *Lamellidens* spp), fish (loaches) and shrimps. Indiscriminate harvesting of fish, soft-shell turtles, freshwater molluscs (snails and clams), and aquatic plants are also a major threat.

Invasive species are considered one of the biggest threat to biodiversity. However, detailed information about the impacts of invasive species on aquatic biodiversity is lacking in India. Some localised examples are available from different parts of the country, e.g., we have found that the introduced grass carp has replaced native trout in the Dal Lake, in Kashmir, and now forms 70% of the total catch.

CONSERVATION CHALLENGES

The challenges for prioritising freshwater conservation areas in India are complex. Systematic conservation planning was pioneered for terrestrial ecosystems, but studies have shown that terrestrial conservation planning might not work all the time for freshwater ecosystems. One significant way in which these ecosystems differ is in the connectivity of freshwater systems—the river continuum. Any upstream disturbance will have ramifications for downstream stretches. Hence, a comprehensive plan is required which includes a full range of species, processes, ecosystems, and human elements in a study region.

² Reid, DG., NA. Aravind and NA. Madhyastha. 2013. A unique radiation of marine littorinid snails in the freshwater streams of the Western Ghats of India: the genus *Cremnoconchus* W.T. Blanford, 1869 (Gastropoda: Littorinidae). *Zoological Journal of Linnean Society* 167: 93-135.



Tsogmo Lake, a high altitude lake in Sikkim. (Photo: Aravind NA)

Further, the methods used to identify important sites for conservation of freshwater environments are based on species richness and endemism. Ironically, vertebrate communities (e.g., birds and amphibians)³ have traditionally been used to identify priority areas for conservation of freshwater ecosystems, even though invertebrates (e.g., snails, clams, insects, worms, etc.) represent around 86% of known freshwater fauna. Finally, much of the biodiversity of freshwater ecosystems comes from many range-restricted species like freshwater molluscs and amphibians and separate approaches are required to conserve them as compared to large-ranging animals like tigers and elephants. We examine some of the main challenges to conservation planning for freshwater ecosystems in India.

Data deficiency

Data deficiency is the major hurdle for any efficient conservation. Except for certain groups, for the majority, information on the distribution and threat status is seriously lacking. For example, the Western Ghats and Eastern Himalayas are unique places for amphibian diversification with unique lineages and endemism of almost 90%. But inventories are either lacking,

or incomplete, for all other groups of aquatic species, especially lower invertebrates and plants. The highest number of 'Data Deficient' species is found in freshwater molluscs, arthropods and other lower taxa. A recent Red-List assessment for the Western Ghats and Eastern Himalayan freshwater biodiversity showed that, for freshwater molluscs, 60% of species were assessed as data deficient and this figure is even higher for other invertebrate taxa. Many species are known only from their type locality or from a few locations⁴. Only 2,846 freshwater species from India have been assessed for The International Union for Conservation of Nature and Natural Resources (IUCN) red listing. Out of these, 1,146 species are from the Western Ghats, and 16% are threatened with extinction. The highest numbers of threatened species are represented in fish and the lowest in freshwater molluscs. Much less is known about other freshwater taxa.

Policy gaps and implementation

There are 128 water related policies in India at central and state levels, most of which are

³ Das, A., J. Krishnaswamy, K.S. Bawa, M.C. Kiran, V. Srinivas, N.S. Kumar, and K.U. Karanth. 2006. Prioritisation of conservation areas in the Western Ghats, India. *Biological Conservation* 133: 16–31.

⁴ Aravind, N.A., N.A. Madhyastha, G.M. Rajendra, and A. Dey. 2011. The status and distribution of freshwater molluscs of the Western Ghats. In: *The status and distribution of freshwater biodiversity in the Western Ghats, India* (compilers. Molur, S., K.G. Smith, B.A. Daniel, and W.R.T. Darwall) Pp. 59–72. Cambridge, UK and Gland, Switzerland: IUCN, and Coimbatore, India: Zoo Outreach Organisation.

biased towards extracting services for human use without considering the role of biodiversity in maintaining those services. There are a few policies that deal with biodiversity conservation, but these mostly focus on terrestrial habitats. The Indian Wildlife (Protection) Act, 1972, which lists species that need protection, is either outdated or biased towards charismatic taxa. Many threatened and endemic freshwater species are not included. Hence, there is a need to update this act to include threatened freshwater taxa as well.

Effective implementation of existing laws and policies on the ground is another major issue that needs to be addressed. The main reason for hurdles to this are the multiple stakeholders involved in managing freshwater resources in India. For example, freshwater systems within PAs are under the forest department, whereas those outside PAs are used as common pool resources; all those freshwater systems in revenue lands, such as ponds, tanks, and marshes, are under the control of the revenue department; reservoir fisheries are under the fisheries department, and so on. Given this, there is a lot of ambiguity about who does what and who is responsible for what, thus hindering implementation of policies. Our recent review of some of the policies shows that there are contradictions between state and central laws, which could also affect

policy implementation. For example, the Wetland Rules, 2010, at the central level and the Wetland Acts at state levels have separate aims. While the Wetland Rules, 2010, talks about conservation of all wetlands and lists prohibited and restricted activities, the wetland policies of Kerala and Manipur promote paddy fields (as wetlands) to improve paddy cultivation for food security.

Economic value

Freshwater habitats provide a range of ecosystem services and benefits, both direct and indirect. There are several global studies that have shown that biodiversity plays an important role in maintaining these ecosystem services and thus livelihoods. Economic valuation of these services, especially indirect services (e.g. regulation of biogeochemical cycles, food webs, nutrient cycling, etc.) is difficult. Understanding the economic value of the goods and services provided by freshwater systems could help in managing these resources and could be incorporated into conservation planning.

APPROACHES TO CONSERVATION PLANNING

Following are the steps ideally followed in any conservation planning effort worldwide. We have followed some of the approaches listed below for prioritising freshwater habitats in the Western Ghats, which can be applied for other parts of the country as well.

1) Plan for effective and sustained implementation

Freshwater ecosystems are largely modified to suit human needs; thus, it is essential that cultural, economic, political and social (livelihoods) aspects be considered while planning. The aim is to create a balance between biodiversity conservation and livelihoods through sustainable use of resources.



Harvesting of weeds from Dal lake to make organic manure. (Photo: Aravind NA)



Myristica fatuva is an endemic tree restricted to *Myristica* swamps of southern and central Western Ghats. (Photo: Aravind NA)

Institutions play an important role in implementation, monitoring and management of resources. Involvement of local stakeholders is very crucial for better management. Incentives for sustainable resource use can help in managing resources and improve livelihood options. Studies in Bengaluru have shown that involving communities can also help in better implementation of these legal frameworks and monitoring of resources. A notable example is Kaikondrahalli Lake in Bengaluru, which is managed by local residents along with a variety of stakeholders to maintain the lake for both conservation and social activities. This has been seen as a new approach for management and governance in the urban context⁵.

Community Conservation Areas or Community Reserves (both of which are categories of community managed reserves) can be better options to conserving freshwater ecosystems than strictly protected areas because alienating communities can be counterproductive to conservation, as has been shown in the case of terrestrial PAs. The Tiruvudaimarudur

Conservation Reserve, and ATREE's work in setting up the Vagaikulum Community Reserve for aquatic birds, both in Tamil Nadu have shown the possibility for coexistence between wildlife and humans. For other areas, one can think of a catchment-based approach, which encompasses both terrestrial and freshwater habitats.

2) Evaluate current impacts and future threats

One of the biggest gaps in our knowledge is the lack of quantitative information on threats that freshwater ecosystems are experiencing. We have made a beginning in mapping the threats to freshwater habitats at the national level⁶. We have mapped all major dams across rivers in India. We have also developed a resource-use map for the whole country. We have assessed the impact of different threats at the level of the Western Ghats, for freshwater molluscs, especially those that are found in streams and waterfalls⁷; for other taxa, information is not available.

There is not much information on the distribution of invasive species and their impact on local biodiversity. At ATREE we are trying to overcome this lack of information using a citizen science initiative implemented via the India Biodiversity Portal to determine the distributions of six aquatic invasive species: water hyacinth, *Pistia*, *Salvinia*, *Potamogeton*, *Myriophyllum*, and *Tilapia*. We have used a species distribution modeling approach to predict both current and future distributions of these species. This information can help us to identify regions of high vulnerability to invasion for better management.

⁶ Munsli, M. 2017. *Prioritizing freshwater habitats for biodiversity in India*. Ph.D. thesis. Manipal University, Manipal. India.

⁷ Aravind, NA., RR. Sarma, and NA. Madhyastha. 2016. Conservation of *Cremnoconchus*, an iconic freshwater gastropod genus of the Western Ghats India. *Current Science* 111(6): 1097-1113.

⁵ Nagendra, H. 2016. *Restoration of the Kaikondrahalli Lake in Bangalore: forging a new urban commons*. Pune, Maharashtra: Kalpavriksh.

Data on existing water use or water abstraction for the entire country is lacking. Water abstraction seems to be one of the greatest threats to sedentary biodiversity, especially endemic clams (e.g., *Arcidopsis footei*, and *Pseudomulleria dalyii*, both endemic to Thunga and Bhadra rivers in the Central Western Ghats). We have seen hundreds of dead clams in Thunga and Bhadra rivers due to check dams and water abstraction. We have also seen numerous dead clams in lakes in Bengaluru that have been drained for desiltation.

3) Set quantitative conservation targets

For conservation of biodiversity, targets need to be identified based on quantitative criteria that can be applied consistently across landscapes or regions. We assessed the status of freshwater biodiversity of Eastern Himalaya and the Western Ghats for the IUCN Red List. The assessment shows that India has nearly 340 threatened freshwater species. The most threatened group of species is fish and the least threatened is freshwater molluscs. Using this information and information for other freshwater biodiversity, key biodiversity areas have been identified in the Western Ghats and Eastern Himalaya. In addition, recently, we developed a protocol and identified regions (river sub-basins) of high conservation value using species richness and species status (i.e., numbers of threatened and endemic species), along with physical and threat maps, for identifying conservation targets for the entire country.

4) Plan for persistence

Long-term persistence of species and habitats is one of the key features of any conservation planning exercise. It is important to incorporate upstream-downstream connectivity to ensure animal movement and gene transfer. For example, for *Cremnoconchus* species and stream dwelling frogs (e.g., the genus *Nyctibatrachus*), which spend their entire life-cycle in a single



Jog falls, in the central Western Ghats, is one of the largest waterfalls in South India. The water flow during summer months is reduced due to the dam in upper reaches of the river Sharavathi. (Photo: Aravind NA)

water body, this connectivity becomes crucially important to maintain genetic diversity, as it is the only avenue for gene flow. We are studying how connectivity is critical in maintaining genetic diversity between upstream and downstream populations in a stream dwelling frog. Restoration of key habitats in the landscape, such as *Myristica* swamps, will also enhance the connectivity between upstream and downstream stretches and thus help in maintaining genetic diversity between populations.

5) Plan for representation of freshwater biodiversity

Terrestrial protected areas are typically inadequate for the conservation of freshwater biota even though there is some degree of concordance between terrestrial and freshwater biodiversity. Conservation area networks should try to integrate terrestrial and freshwater conservation plans. For example, Aganashini Conservation Reserve, near Jog Falls in Central Western Ghats, dedicated to the charismatic Lion-tailed macaque, has a large number of threatened freshwater *Myristica* swamps and is also the type locality for a freshwater mollusc (*Cremnoconchus*) and the Kumbara night frog (*Nyctibatrachus kumbara*).

WAY FORWARD

A holistic approach to conservation and management of freshwater habitat is needed for India. The condition of freshwater ecosystems and their biodiversity is declining at an alarming rate due to lack of data and informed policy making. Given the severe limitations on resources, conservation actions must be carefully planned to ensure maximum impact. Freshwater systems form a part of complex socio-ecological systems and thus, the challenges for conservation of freshwater biodiversity are more numerous than for conservation of terrestrial biodiversity. In data- and resource-constrained countries like India, expert judgment coupled with a target-driven systematic conservation planning approach could lead to very substantial planning and conservation gains. Also, actively engaging stakeholders is important. Community involvement needs to be promoted, thereby empowering and motivating resource users to conserve and wisely use biological resources. This could be in the form of reinforcing existing efforts and increasing the capacity of various stakeholders. For example, fish sanctuaries, known as *Matsyathavalams*, have been set up in Vembanad Lake in Kerala to facilitate breeding of native fish by small groups of local fishermen in a public-private participatory model, an initiative by ATREE that has been well received.

The high biodiversity outside the PA network should also be targeted. Integrating several disciplines, including ecology, conservation biology, socio-economics, hydrology, water quality, and engineering would be the key to

success for any conservation planning exercise. Finally, a watershed or catchment-based approach for planning and resource management would be an effective protection and restoration strategy for aquatic ecosystems, as they are interconnected.

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Celebrating 20 years
of Ashoka Trust for
Research in Ecology
and the Environment

Over the last 20 years, the geographic spread of ATREE's work has expanded from the Western Ghats and Eastern Himalayas, to almost the entire country, and from forests, to grasslands, wetlands, and peri-urban landscapes. Alongside, the focus of our work has expanded from studying biodiversity to analyzing the biophysical and socioeconomic drivers of ecosystem change, and their implications for conservation and sustainable development. Yet the core of what we do has remained the questioning and interrogating of prevailing paradigms, and the production of rigorous interdisciplinary knowledge that can inform civil society and policy makers. The present volume is an effort to share this 20-year history of ATREE.

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